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Architectural Analysis of the First Major Rehabilitation in the 21st Century of Olbrich's Secession Building in Vienna

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Abstract: The recent rehabilitation, reconstruction and adaptive reuse of Joseph Maria Olbrich's Vienna Secession Building, completed in 2018, has brought the building into a contemporary age. This research article analyzes the only extensive rehabilitation carried out on the Secession Building so far in the 21st century. It studies what was accomplished during this specific rehabilitation process, and in particular emphasizes the reasons why such a process is crucial for culture heritage buildings in the city of Vienna. The purpose of this research is to evaluate the rehabilitation procedures used for the Secession Building and to identify any weaknesses to be resolved in the next rehabilitation. It provides an example of rehabilitation for any future similar initiatives, demonstrating both its positive and negative aspects.

Keywords: culture heritage buildings; Vienna Secession Building; rehabilitation; historical buildings reconstruction; adaptive reuse; materials

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1. Introduction

In the contemporary urban environment, heritage buildings play a significant role in boosting competitiveness within global cities [1]. City authorities are working actively on the rehabilitation of heritage areas, aiming for effective strategies to compete in the global prestige race [2]. Innovative approaches to built heritage are crucial to ensuring future sustainability. Heritage buildings both shape and define the character of a city and its urban spaces. The understanding that cultural heritage is a powerful contributor to sustainable societal stability, place-making [3,4] and economic development is the new reality of contemporary cities and modern urban settings [5]. Cultural heritage is a vital part of any society, which can significantly enhance the understanding of community identity. Studies are becoming more and more oriented towards aspects of culture, cultural heritage and heritage buildings, with a strong interest in their role in sustainable development [6–10].

The rehabilitation of architectural heritage in certain locations, in some cases, is not sufficiently included in the context of comprehensive urban development [11]. However, a sustainable approach to the rehabilitation of heritage buildings is likely to become increasingly important in the future, as many buildings of this type are becoming pillars of urban centers around the world [12,13].

Alongside traditional contents such as exhibition, research, conservation or administrative spaces, other new types of activities and spaces have emerged in heritage buildings. These new types of spaces and services are largely focused on entertainment and education, covering different categories. These include conference rooms, workshops, bookshops, playrooms, cafeterias and restaurants. Such new functional categories refer primarily to large cultural heritage properties, such as museums, while some categories are also present in smaller heritage buildings [14,15]. Consequently, this new reality has made the maintenance of heritage in the built environment much more difficult. The adaptation of heritage buildings today requires a number of issues to be resolved in order to improve access, user experience and energy efficiency while maintaining the basic function of the building [16].

To achieve this requires an adequate balance between several sophisticated environmental parameters. The advanced maintenance of heritage buildings involves improved control of light, indoor air temperature, relative humidity and pollutants in order to reduce energy loss and achieve long-term control of the indoor environment. These environmental factors often require the use of lighting and air conditioning systems [17], resulting in high energy consumption.

Efforts to promote the adoption of strategies to mitigate the negative effects of climate change, such as energy savings and the reduction of greenhouse gases, are providing impetus for the development of technologies for the rehabilitation and adaptation of heritage buildings. The literature on the energy efficiency of heritage buildings is constantly growing and features both successful and less successful examples, with the aim of advising and educating practitioners [18–22]. While scientific and technological research related to this topic is making rapid progress, the reality on the ground often does not meet expectations, even in the most developed countries. However, the topic is of great importance for world heritage, and every example is useful. The aim of this article is to outline the essential components of the rehabilitation, reconstruction and adaptation process for the Vienna Secession Building.

2. The Vienna Secession Building

2.1. Historical Background and Its Uniqueness

The historical background section provides an overview of the historical development of the Secession Building and a brief summary of its major structural features, as well as the construction activities that have shaped its evolution from the time of its foundation until the 21st century. Comprehending the fundamentals of this building is an essential part of understanding its first major rehabilitation in the 21st century.

The sustainable nature of this heritage-listed building is quite unique, considering that it has been around since the end of the 19th century and has now undergone its first rehabilitation of the 21st century. The Secession Building is not a typical heritage object, and its demolition to the ground and rebuilding according to the original plan in the 20th century proves how much the Viennese and world cultural scene appreciate its relevance.

Founded by a group of visionary Viennese artists, architects and designers who refused to be restricted in their creative freedom by official state institutions, the Vienna Secession was established with the clear aim of promoting and encouraging artistic independence and innovation. The Secession group initiated construction of the Secession headquarters in Vienna, completing it in 1898, once all the complicated administrative procedures that accompanied the whole process had been resolved. This included selecting a site for the Secession Building, being granted a building permit, making changes to the urban plans and also making several modifications to the original architectural design of the building itself, followed by numerous conflicts caused by the atypical design for that period in Imperial Vienna.

The Secession Building marked the spirit of the time at the turn of the 20th century, with all the changes that such a phenomenon brought with it, while the artists of the Secession movement led by Gustav Klimt [23], Josef Hoffmann, Joseph Maria Olbrich, Koloman Moser and Carl Moll were persistent in carrying out all their ideas to completion, starting with the construction of their administrative building. Joseph Maria Olbrich was the architect of the Secession Building, which was designed as a venue for the exchange and presentation of new ideas to a national and international audience in the form of temporary exhibitions and events, with the primary aim of impacting the wider cultural life of Vienna and Europe. Today, it is recognized as one of the defining buildings of the century, and it holds an important place in the history of architecture and art [24].

The Secession Building is structured around a central ground plan, with a floor area of approximately 990 m^2, of which approximately 600 m^2 is available as exhibition space. The dominant features of the building are interlocking square and rectangular forms.

The exterior walls are largely closed, which gives the impression of a homogeneous cube. Above the main entrance is a slogan coined by the leading art critic of the time, Ludwig Hevesi: "Der zeit ihre Kunst, der Kunst ihre Freiheit", in translation: To every age its art, to every art its freedom. This leitmotif, in the spirit of the period that defines the character of the building, is designed to lead visitors in a very particular way.

The distinctive dome is enclosed by a set of four pylons. However, the closed ceiling of the reception area under the dome prevents visitors from gaining a view of the dome structure from the reception lobby. The magnificence of the dome, only seen from the street, is contrasted by the simplicity of the reception lobby. The reception area has a square floor plan that evokes a Greek cross because of the protrusions created by each of the four pylons. The exhibition section is formed by a square central core surrounded by two lower wings (naves) joined by a transept at the back, creating the impression of being in a basilica-style building. Underlining the sacredness of the space, the glass ceilings above the exhibition areas bathe the interior in consistent light. Many authors have written about the origin and the construction of this building and its exhibitions but also its importance for culture at the turn of the 20th century [25–28].

This heritage building is of importance for more than simply the events that took place in its interior and the distinguished figures who envisioned it and formed its programming, who were among the most influential creators of the period. The building has also withstood a number of turbulent political challenges in 20th-century Europe, as well as the years of war and societal destruction which followed and left their mark. The Secession therefore provides insight into changes within the collective and urban environment throughout the 20th century.

Despite everything, the Vienna Secession Building has continued to exist to this day, and even celebrated its 125th anniversary in 2023. The building has undergone several renovations, adaptations and rehabilitations throughout its turbulent existence. The first modifications were already undertaken in 1901, when Josef Hoffmann radically redesigned the vestibule. Since then, there have been numerous structural, decorative, functional and organizational adaptations, reconstructions and rehabilitations. Some of these were intentional, others were inevitable. This paper will only cover the key years for the Secession Building, since a more detailed analysis would require a considerable length of writing, and the focus of the research is the first rehabilitation of the Secession Building in the 21st century.

During the first renovation in 1907/1908, the entire facade underwent a complete renewal and several decorative elements were removed. Even Hevesi's celebrated slogan above the entrance portal was removed, together with the inscription Ver Sacrum. Koloman Moser's glass rosette in the vestibule was dismantled and bricked up, and his frieze "Dance of the wreath-wearing maidens" on the rear facade was painted over. Using historical photographs of the original frieze that were archived, the same frieze was created during the most recent restoration in 2017/2018. The building was converted into the Red Cross Reserve Hospital in 1914 with a reception barrack built behind the building. Exhibition operations resumed in September 1917 and continued until 1921. At that point, a new series of adaptations and renovations to the building began, temporarily halting regular exhibition activities. These were not the last renovations inside the building before it was severely damaged in the Second World War. By 1930, the building was practically overgrown with vegetation due to neglect, while in 1937 the facade and all the doors and windows were again rehabilitated.

After being heavily damaged by bombing in the final days of the war and set on fire during the Nazi withdrawal, beginning in 1945 the building was rebuilt by the artists themselves. It lasted several years before all the rooms were completed. The work of clearing and securing the Secession began in 1946 under the supervision of architect Rössler, while plans for the expansion and adaptation of the original building from 1948 were not implemented. In the following period, Josef Hoffmann took charge of rebuilding the

Secession, which was also undertaken by the Secessionists on the site. The renovation was completed in 1951 with limited resources, resulting in a lower-than-expected performance.

At the beginning of the 1960s, several key developments occurred in connection with restoring the Secession Building, which was still far from the original. The inscription "Der zeit ihre Kunst, der Kunst ihre Freiheit" was reinstalled on the entrance portal by Rudolf Schwaiger, following the decision of the City Council to carry out a thorough renovation of the building, restoring its exterior to as close to its original state as possible. The next spatial reorganization took place in 1963/64 under the direction of architect Ferdinand Kitt. At this time, the facade was once again rehabilitated. However, for a number of reasons, the genuine gilding of the dome and the use of white paint for the facade walls, as in the original version, were abandoned [28].

New deteriorations of the building and problems with the operational organization meant that new renovation plans had to be initiated as early as the middle of the following decade. The architect Adolf Krischanitz was commissioned in 1981 to compile an expert report on the state of the building, in which he concluded that a general renovation was necessary. The entire renovation process was carried out by the same architect in 1984/1985. This was the largest renovation in the 20th century and also the last until 2017/2018. The cellar was enlarged, and any additions and adaptations that altered the original were eliminated. Most of the original decoration was also restored, and an additional floor was added beneath the vestibule as a gallery space. Since then, the basement area under the main exhibition room has served as a permanent display area for the Klimt frieze [28].

2.2. Introduction to the First Major Rehabilitation in the 21st Century of Olbrich's Secession Building in Vienna

Particularly noteworthy is the case of Vienna, where the historic city center (1st district) and other central districts are predominantly defined by historical housing stock from the Wilhelminian period (Gründerzeit). This historical stock is subject to rapid legal and structural change [29–31]. At the same time, the entire first district is listed by UNESCO as an area of special cultural importance, and therefore any renovation is subject to monitoring by the Office for the Protection of Historical Monuments. Housing, universities (or other scientific institutions) and government buildings in the 1st district are regularly completely reconstructed, rehabilitated and adapted to suit the requirements of the space.

The restoration of any heritage building in Vienna is a complex and specific topic in its very own unique manner. The rehabilitation, reconstruction and adaptation of such historically delicate buildings as the Secession Building involves an interdisciplinary approach, preceded by a multi-stage research process [32]. Work on the Secession Building (Figure 1) called for very close coordination between the Office for the Protection of Historical Monuments and architects, conservators and engineers, alongside the two-way understanding that is essential for this type of multi-disciplinary construction project. The most recent comprehensive reconstruction of this museum building was conducted in 2017 and 2018.

This new general rehabilitation, reconstruction and adaptive reuse—in other words, the complete modernization of one of Austria's most important cultural heritage buildings—was undertaken more than thirty years after its previous general reconstruction. The decay of several sections of the building indicated the urgency of the work, while the celebrations for the 120th anniversary of the founding of the Secession Building coincided with the year in which this major renovation took place.

A year before the important founding anniversary of the Vienna Secession, a detailed inspection of the building's condition was carried out, for which the architect Adolf Krischanitz, who had been in charge of the previous general renovation from 1985–1986, was hired. Krischanitz was the person most knowledgeable about the building's structure, as the reconstruction he headed in the 1980s was the most extensive Secession reconstruction of the 20th century. Following a general review of the condition of the facility from 2016–2017, the urgent need for renovation and modernization became evident. An interdisciplinary commission of experts consisting of artists and the management of the Secession

Building, under the leadership of architect Adolf Krischanitz, prepared a comprehensive list of urgently needed measures and a detailed cost estimate. This information was submitted to the relevant institutions of the City of Vienna, as the building is of exceptional cultural and historical significance, as well as being important to the media.

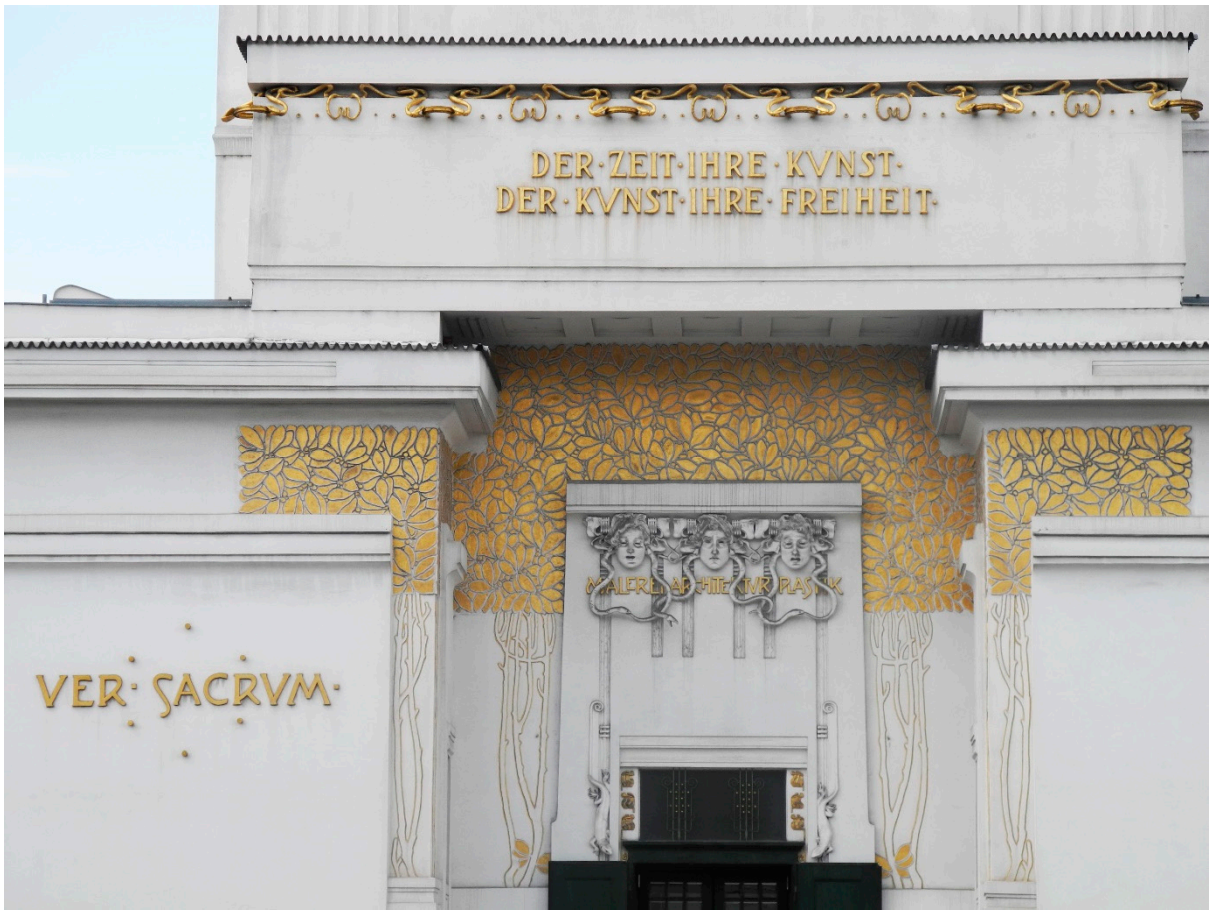

Figure 1. The photograph depicts the entrance facade of the Vienna Secession before it underwent renovation, in 2013. Photography: Biljana Arandelovic.

The project to reconstruct the Secession encompassed several different areas of operation, which demanded the involvement of experts from a wide range of disciplines. Such requirements made a multi-disciplinary team of experts imperative. The Association of Visual Artists of the Vienna Secession actively participated in all arrangements with Krischanitz. The renovation works were scheduled to be carried out during the museum's opening hours without interruption, from December 2017 to the beginning of September 2018, in order to be completed for the commemoration of the 120th anniversary of the Secession.

Financing is usually among the most challenging aspects of renovating any historic building. After having insight into available documents and a discussion with Dr. Annette Südbeck, Managing Director of the Secession, it was established that the initial cost estimate for the overall rehabilitation project was around EUR 3.1 million. However, the budget had to be revised after it became apparent that the dome and facade were more severely damaged than originally assumed. Furthermore, additional costs arose from considerable price increases resulting from price changes in the construction industry, as well as administrative obligations and supplementary heritage protection requirements. Working as joint project partners with the Secession, the Federal Office and the City of Vienna agreed to cover the increased costs of rehabilitating the Secession Building. Construction cost projections were revised, leading to total net costs of around EUR 3.5 million. The additional costs were

divided between the federal government, the City of Vienna and the Secession. The Artists' Association, as representative of the Secession, provided the support of individual donors and patrons. The entire reconstruction project was successfully delivered on time and on budget.

3. Objectives and Methodology

Reading historical maps is fundamental for understanding building transformations in the context of urban development, as heritage mapping provides valuable insight into the original period of the historical building and exposes information left unseen due to previous changes. The cartographic and other visual data, therefore, reflect the overall historical development and illustrate dynamic changes in the recent past. Written records, photographs, drawings and other archive materials are equally important for understanding the past and comparing it with the present. The study is based on research data. The methodology for this research is in the form of a mixed study combined with qualitative research. On-site assessments to determine the material and the current status, after seeing visual documentation of previous deterioration, are the most valuable parts of the study.

Recognizing the unique characteristics and challenges of preserving a historic building of such prominence as the Secession Building, it was essential to establish a comprehensive interdisciplinary methodological approach that ensured the feasibility of this research on the 2017–2018 restoration. Throughout its long history, the Secession Building has undergone many alterations, as well as damage and rehabilitations. However, the present research does not cover all of these aspects, and we focus on the first comprehensive rehabilitation in the 21st century. Although Olbrich's Secession Building in Vienna is directly linked to the history and theory of art and architecture by cultural parameters, this research deals with the technical optimization and modernization, which is its main objective. Extensive work on the reconstruction of the Secession Building involved the building's external features and design, accessibility and technical infrastructure, along with a reorganization of the basement and its premises.

There is growing awareness and concern in the field of preventive conservation of cultural heritage. Therefore, this paper will help to increase awareness in this area and foster the development of appropriate solutions to the rehabilitation of heritage buildings. It will also stimulate interest in the effects of climate change on historic buildings.

4. Analysis of Reconstruction Activities

4.1. Reconstruction of the Exterior of the Secession Building

The Secession architects revived traditional craft practices and the use of local materials, initially on the exterior and then in the interior of the buildings, deliberately linking them with regional building traditions. Olbrich opposed the typical building technique of historicism, which was commonly used in Vienna at that time when producing ornamentation on building facades. As a result, the ornamentation, as well as complete architectural components such as columns and capitals, were molded in masses and then plastered onto the buildings, before being painted with natural stone paint to create the effect of solid stone architecture. He intended to revive traditional craftsmanship and the use of local materials common in the Baroque and Biedermeier periods, in which ornaments were created on site by hand. The Secession movement led to a debate about the authentic use of plaster in Vienna from 1900 onwards. Traditional craftsmanship was revived, and the Vienna Secession Building appears to be an early example of a revival of regional building techniques [33]. The original plastering of the facades of the Vienna Secession Building was made with sand from a local source, the Türkenschanze. Sand from this same pit was also used for the Viennese facades of the Baroque period. The relevant technical literature from that period describes that this soft, yellowish Cerithian sand was often used for the production of mortar. However, it should be noted that this sand was not entirely suitable for this purpose. In any case, Olbrich wanted to achieve a pure white color, which was

not feasible. The plaster structure became uneven and blotchy, necessitating painting with white paint, including the plinth areas, and consolidation with water glass [28].

With the exception of the Beethoven Frieze, which has been in the building since 1985, all the display room settings are temporary and continuously changing according to the spirit of the times, while the main architectural structure is enduring. The Secession Building is a good example of when a particular architectural object is also a valuable work of art and a sculptural form adorned with numerous decorative elements. For this particular reason, it is essential that every single ornamental element on the facade undergoes regular, comprehensive and specialized restoration. Since they are located outdoors and are exposed to weather conditions and unpredictable environmental influences of the future, the use of state-of-the-art materials and conservation techniques that are capable of repairing all possible damage, to the metal elements especially, is a necessity. The more frequently repairs are performed on damaged facade elements, the more effective maintenance can be achieved in the future. Given that the time between two extensive rehabilitations was excessively long and the damage significant, the results of the first 21st century rehabilitation are exemplary, while the materials used in the rehabilitation were of the highest standard. The following sections include details on some of the materials used during the exterior rehabilitation of the Secession.

4.1.1. Reconstruction of the Secession Dome

The dome on the very top of the Secession Building has been its distinctive landmark and symbol since its construction in 1897. Conservators discovered it to be in a deteriorated condition, since the iconic gilded dome was threatening to rust in multiple places. This state required a comprehensive restoration, which also necessitated regilding. In preparation for the conservation process, a thorough survey was carried out, mapping damage to each of the 3000 leaves and 700 laurel trees.

Work on restoring the dome began after the project was commissioned in November 2017. The contractor, the Association of Fine Artists Vienna Secession, commissioned Austrian contractor Schmiedetechnik Steiner with the complete execution of the restoration, as well as all technical work, the substructure and all logistics. The project was undertaken based on the findings and specimen work conducted by restorer Ms. Elisabeth Krebs in the period from 2015 to 2017. The restoration of the gilded dome was successfully completed by the end of May 2018. All the steps in the process can be easily understood on the basis of the expert opinion from the dome damage analysis.

The dome was restored by renovating the historic steel girders, welding where necessary and improving the supporting structure; its rehabilitation involved disassembling the wrought-iron structure measuring 8.5 m in diameter over a period of approximately six months. Over the course of the renovation process, it became apparent that the dome was more deteriorated than originally suspected. Its anchoring structure with four supporting pylons was practically fully detached. After a detailed examination, the supporting structure was reattached using 800 original rivets and historically proven techniques, and the weld seams were also repaired. In addition, the leaves and the berries that were damaged or missing due to heavy rusting were reforged. Finally, all 2500 laurel leaves and 342 berries were repainted and gilded.

4.1.2. Reconstruction of the Secession Building Facade

While materials have always been susceptible to decay processes, the climate emergency may trigger new manifestations or worsen common decay mechanisms. Some areas may witness accelerated decay processes, while others experience delays in specific phenomena [34]. Cultural heritage property may eventually be affected or even eradicated by a number of physical, chemical, biological and other factors [35]. Therefore, monitoring the rehabilitation of the most sensitive heritage components is of the utmost importance. In the case of the Secession Building, this includes the exterior surface with all its ornamental elements, the facade surface and the dome, its signature feature.

Post-damage repair is generally a significant financial and human expense if the risks are not preventatively identified and managed at their source. Lately, a growing area of interest has emerged in the risk assessment of cultural heritage, with the aim of proactive heritage conservation [36,37].

The author was given access to both reports on the Secession: the one from 1985 and the report on the renovation of facade structures from 2017–2018. The expert opinion from 1985 was used in the restoration of the facade surface, which means that the most recent restoration followed the findings from that year for the base wall surface. The base plaster, facade plaster and facade decoration were analyzed in detail in 1985 and were used as a basic model for the latest restoration. Experts from the Vienna Department for Restoration and Monument Conservation performed an analysis that provided clear evidence of the deterioration of the individual parts of the facade and the urgent need for comprehensive renovation. Work was carried out on the facade in the period from January to July 2018. Several subsequent examinations established that removal of the all-over cement coatings from the 1985 renovation work would be the most appropriate and sustainable method of conservation in order to protect the underlying lime plaster from being destroyed. For economic reasons and because of the tight time frame for the repair work (as the scaffold had to be dismantled by June 2018 for the EU Presidency), the client waived the need for removing the remaining scratch marks. Based on the preliminary conclusions of Mr. Goriany and the various follow-up findings, the subsequent work was conducted by Mag. Scherzer and Mag. Duda.

The basic old plaster of the facade surface had fallen off, and the coating layers had to be replaced. The experts advised sandblasting to remove the old coatings completely, however, they warned against damaging the surface. Since the main intention of this research was to analyze the restoration execution of work on the exterior facade surfaces of the Secession Building from 2017–2018, the new report was the main object interest. The expert report created for the restoration of the facade surfaces in 2018 is divided into separate units, due to the number of decorative details on the facade. Each part was analyzed individually and a proposal was made for its restoration, namely: *Conservation and restoration of the metal object, the Serpentine Frieze above the main portal, the massive rings, the snakes and two poles with a laurel wreath decoration at the back of the building.*

Details include the stereomicroscope examination of color samples taken from various areas of the masts and laurel wreaths, which revealed that no original paint remained, indicating that the existing layers of paint were a second and subsequent repaint. The following color scheme was maintained in both phases: the pole and the decorative rings were painted with white NCS S 0500-N, the laurel wreath was painted with green NCS S 5010-G50Y, the laurel wreath tie was painted with white NCS S 0500-N and the laurels were painted with gold leaf. The wreaths were colored to match the green tone of the dome leaves and the color of the laurel leaves on the dome (NCS S 2030-G10Y), as well as the gold leaf friezes on the facade. The restoration work was executed as a result of research within the framework of metal element findings carried out by the Federal Office for the Protection of Monuments in Vienna (BDA), under the direction of conservator Wolfgang Salcher. This report, and all other information concerning the comprehensive work on the facade, metal element and dome was provided by the Secession director for review.

The report is extensive and contains all the details, from the smaller ring to the poles adorning the back of the building. Everything had to be analyzed in depth and prepared for any future renovation of the Secession Building. By the end of June 2018, the entire facade area, including all decorative elements on the outside of the building, had been completed. For this specific process, local manufacturers of paints and other necessary conservation materials were employed (Figure 2). Local restorers and craftspeople were also involved, which indicates that the conservation process was a sustainable operation.

Figure 2. The exterior rehabilitation of the building of the Vienna Secession (wall coverings, metal elements and details of the dome). The material provided by the Vienna Secession.

Loose cement coatings were removed, except for the original lime plaster, which was structurally strengthened with water glass. The fine plastering was carried out using NHL fine plaster. In areas with larger hollow layers (especially in the interior flanks of the building in the entrance area), anchor points were set with Ledan along existing cracks. The Novotny Construction Company performed the facade works, which included cleaning the surface using hot steam technology, removing modern and loose plaster sections and reinforcing the plaster flanks with lime sinter water. They utilized cleaning supplements from Baumit's NHL product range. The color shade was chosen in cooperation with all project participants and the Federal Office for the Protection of Monuments. During this process, a tone of white was selected by the client for the final coat of paint. The paint coatings applied followed the NCS color chart for the facade, with the white tone coded as S 0300-N and the green for the leaf contours coded as S 2050-G20Y.

During an inspection of the facade with the conservator Karl Scherzer, it was established that the applied slurry had a relatively low abrasion resistance. The applied slurry is

an NHL slurry, which was mixed in situ with Baumit NHL filler (Baumit NHL Spachtel) and Baumit NHL fine plaster (Baumit NHL Feinputz). As a final coat, Baumit SanovaColor was mixed with Baumit SanovaPrimer and quartz wall and applied with a brush in two layers. After the final coat had dried, the NHL slurry was given the required firmness. The high resistance properties were clearly visible on the completed areas of the facade.

The in situ stone plinth was coated with a new layer of material during the course of the plinth renovation. The previous coating was removed and the substrate cleaned. The new coating was applied with Baumit Renovierspachtel W, which was painted with Baumit Silikoncolor after complete drying. As preparation of the substrate, the surface was first cleaned and then coated with an adhesive mortar. Baumit Renovierspachtel W was then applied to the wet adhesive mortar. Approximately five days later, the imperfections were filled. Subsequent to this, the surface was recoated with Baumit Renovierspachtel W and then rubbed down. Finally, Baumit Silikoncolor was applied in two layers as a final coat.

4.1.3. Reconstruction of the Secession Glass Roof

In addition to the dome, which is the central emblem and symbol of the Secession Building, the glass roof is another striking external structure with a distinctive shape. The dome dominates the area of the main front entrance of the building and symbolically welcomes visitors, while the glass roof covers the back of the building and is not visible from the main entrance. Its function is extremely significant as it provides cover for the ceiling of the largest exhibition space on the ground floor (Figure 3). It is composed of several parts made up of regular geometric shapes. The glass roof retained a beautiful aesthetic solution in the reconstruction, in harmony with the rest of the building.

Figure 3. A photograph of the roof structure taken in 2013, a few years before the comprehensive rehabilitation of the Vienna Secession Building. Photography: Biljana Arandelovic.

Nowadays, the juxtaposition between the pyramid-shaped structures on the glass roof and the golden laurel crown appears to be less unusual than it did in 1898. The Secession Building's glass roof has undergone several changes over the past 125 years of its existence. For his original construction, Olbrich used standard industrial elements for the roof trusses over the exhibition rooms. The riveted iron profiles formed triangular truss girders, connected lengthwise and braced by lattice girders. He covered the skylights with tent-like glazed structures, below which were plasterboard and louvred glass lanterns, and underneath the skylights, white fabric was stretched to improve light diffusion. Galvanized corrugated sheet metal covered the roof surfaces and cornices [28].

The contrast between the ornamented front part of the building and the rear part of the property is clearly evident, emphasized by the iconic glass roof, which consists of several pyramid shapes. The glass roof effectively highlights the rear part of the building, which has no decoration, in contrast to the decorative front part. The glass roof was destroyed along with the rest of the building during the Second World War but was later rebuilt. The steel roof truss with the glazed skylights was rebuilt in the same style and dimensions as the original Olbrich version. The history of the building includes several rehabilitations of the glass roof construction. While noteworthy, it is not the focus of this research.

The renovation in 1984/1985 was a crucial step in ensuring the stability of the roof structure. The entire roof covering was reconstructed and the skylight above the exhibition space was reglazed, which greatly improved the overall condition of the facility. Before proceeding with the renovation, a comprehensive analysis of the facility's condition was conducted to determine the best course of action. The wooden grid, controversial from the beginning, was destroyed during the conversion of the main hall for a theater performance and had to be replaced with a temporary solution made of canvas panels. This involved improving the thermal insulation of the masonry and, in particular, the roof structure. It incorporated the thermal glazing of the skylight, the installation of additional thermal insulation under the sheet metal roof surfaces and the insertion of a lowered, light-diffusing glass grid ceiling under the iron roof structure, resulting in a thermo-technical buffer zone between the roofing and the exhibition hall. As a result, the conditions for natural and artificial lighting became more consistent than before [28].

The proper selection and assessment of sustainable architectural glass materials is a vital step when it comes to minimizing energy consumption and enhancing the sustainability of buildings [38]. Glass is a brittle construction material that can provide dynamic design options that result in more energy-efficient buildings, maximizing the use of natural light and solar energy, while protecting the environment and saving energy [39]. Progress in state-of-the-art glass products and their use in creating building envelopes that can reduce the carbon footprint of buildings has resulted in modern rehabilitation concepts for heritage buildings. Glass, despite being a highly fragile material, is one of the most sought-after construction materials available thanks to its wide range of usage possibilities. Its structural performance [40,41] provides building engineers with significant challenges when designing the load-bearing glass elements needed in energy-efficient building envelopes. Traditionally, the construction industry has utilized glass in buildings primarily as window panes, but with recent advances in glass technology, its use in construction is also encouraged from the environmental, sustainable and structural aspects [42]. Utilizing glass for building well-lit and spacious interiors and buildings is gaining widespread acceptance, in fact it has become a highly favored modern construction material due to its distinctive mix of optical, chemical, thermal and physical characteristics [43].

In contemporary gallery spaces like the Secession interior, it is important to avoid excessive solar gain, high illuminance, glaring and inconsistent daylighting. Solar control in the Secession was a crucial aspect of rehabilitating the deck-ceiling of the central showroom and it was one of the rehabilitation priorities. To achieve a positive outcome, specially designed glass was used to regulate solar energy. The general challenge for designing daylight within the overall building energy strategy is to find a balance between performance goals, including thermal envelope performance, lighting and HVAC energy demand,

alongside human factors such as visual comfort, daylight accessibility and connectivity to the external environment.

For the Secession's rehabilitation, the interlayer material used in laminated glass meets the basic requirements of transparency and adhesion to glass, as well as the capacity to transmit shear loads [44–47]. The intermediate layer composite, which is used for bonding glass layers to form laminated glass panels, was also used for bonding composite glass elements to another substrate. Laminated glass boosts energy efficiency by providing an insulation barrier while also reducing noise. In the case of the Secession Building, this method met the requirements for rehabilitating the glass roof.

It took years before the glass roof-ceiling could be reconstructed. Prior to 2017/2018, the glass roof had been in urgent need of renovation as the last time the glass elements were replaced was in 1985, and it was becoming a serious problem during adverse weather conditions. The glass deck had been compromised by a serious problem of leaking, endangering the artworks in the central exhibition space and the interior of the building itself. The construction of four lanterns was replaced with an OKALUX laminated panel assembly [48] during the latest reconstruction. It proved that this sophisticated lighting solution, designed to utilize daylight to maximum effect while simultaneously creating adequate solar shading and glare protection, is a good strategy toward the sustainable indoor reconstruction of culture heritage buildings.

5. Modernization of the Building and Technical Infrastructure within Its Organizational System

Following its reconstruction, the Vienna Secession Building now comprises two basement levels, a ground floor, two floors above ground and a roof area. The second basement level is situated at a depth of 6.31 m. The Klimt Frieze Exhibition Room is located in the central space of the deepest level of the building, with a surface area of 89.64 m^2 and a total height of 5.26 m.

On this level of the building there are other rooms and essential structural elements, some of which have been reconstructed and adapted according to 2018 building regulations. For example, a secure waiting area with an emergency call system linked to the fire department control panel and safety lighting systems are now incorporated into this particular section. Additionally, this level of the building is now wheelchair accessible, with a width of 90/120 cm. The lobby of the Klimt Room, with an area of 26.12 m^2 and a height of 2.7 m, is in use as an exhibition area as well. Models of the original Secession Building and an exhibition on the history of its architectural development are on display there. Access to the secondary entrance, the depots and their lobbies, the laundry, the building services and machine rooms, as well as the emergency exit, are all positioned at the lowest level of the building.

After viewing the architectural plan of the Secession Building following its reconstruction from 2017–2018, the reorganization of the first basement floor is evident. As part of the redevelopment, a new event room was designed as an extension to the already-existing gallery rooms, and it is ideal for exhibitions, conferences, book launches and members' meetings. The storage rooms were also reorganized, and in the basement, the facilities for members of the Artists' Association were renovated. The first basement level of the Secession Building is crucial for its proper functioning. It houses various important rooms, including an entrance hall, a showroom (67.41 m^2), other exhibition halls of different sizes, office rooms and technical and cleaning rooms. Additionally, this floor has adapted toilets, a stock catalog room, a social zone, an entrance to the depots and temperature control systems.

The ground floor, which serves as the zero-reference level, is 2 m above street level. The main exhibition room, covering an area of 603.67 m^2 and with a total height of 6 m, is a part of this floor. Furthermore, there is an opening in the floor for potentially removing Klimt's frieze from below it. After the main exhibition room, the foyer is the most impressive area of this part of the Secession Building, from both a historical and constructional point

of view. It is positioned directly behind the main entrance, under the iconic dome, with an area of 71.95 m^2 and an immense ceiling height of 9.75 m. On the ground level there is a shop, then several offices, wardrobe rooms, kitchenettes, various depot rooms and an exit from the main hall to the garden. Additional emergency exits were added during the major renovation in the 1980s.

On the first upper floor is the famous historical Graphic Cabinet, along with a staircase, as well as a staff meeting room and archive rooms. Access to the dome is possible from the first floor. The second upper floor is visually distinguished by its uncovered inner galleries, typical of ecclesiastical buildings, where open covered galleries are more common.

One of the main tasks of the adaptive reuse measures was to improve barrier-free accessibility [49,50] throughout the building. This included the installation of a new elevator, enabling barrier-free access to the Beethoven Frieze in the basement for the first time. In addition, a barrier-free toilet was installed, and barrier-free access to the building was provided, which had not been previously available. The entire existing elevator system was completely renovated.

The technical refurbishment of the Secession Building included a completely renewed air conditioning system, a heating system, ventilation technology and refurbishment of the sanitary facilities. All exhibition rooms were equipped with state-of-the-art LED lights with individually controllable light intensity and a color scale. State-of-the-art technology suggests the use of LED lamps as a response to solving lighting problems in exhibition spaces. LED lamps provide designers with the ability to achieve the highest performance in terms of both aesthetics and energy consumption [51].

The addition to the second basement is an elevator shaft with a surface area of 2.9 m^2 and a total height of 7.31 m. The newly installed elevator, which makes it possible to enter the Klimt Room, is Type 2 according the Austrian regulation ÖNORM [52]. The cabin dimensions are 110/149 cm, the shaft 164/177.5 cm and the door measures 100/200 cm; the elevator can carry a nominal load of 630 kg. It complies with the EN 81-70 standard [52] for wheelchair and walking aid accessibility.

There is also an air reservoir with a 100 × 30 cm channel located in the second level of the basement. The shaft wall in contact with the ground was constructed using a lost formwork method. This involves a screwed formwork structure made of L120 × 10 steel angles and t = 5 mm sheet steel, h = 500 mm, spread out in situ at a distance of 50 cm. The execution of the waterproof concrete was in accordance with the guidelines for the white tank.

The building has an integrated fire and smoke ventilation system, with a minimum FQR of 0.5 m^2 and three manually operated tilt sashes. In the event of a fire, these sashes are coordinated with MA68. The technical infrastructure on the first basement floor underwent modernization work, including the repair of the lifting platform to ensure barrier-free access to UG1. Two platforms with a length of 145/89 cm each and a clearance height of 84 cm were also built. The waiting area for people requiring wheelchair access now enables emergency evacuation to street level by the emergency services.

The dilapidated terrazzo tiles (30 × 30 cm), floors and all carpentry work were restored, and all the building's fire protection measures now meet the latest standards, despite heritage buildings being built before modern fire protection regulations were introduced. Consequently, they do not usually meet the demands of the current legislation, in addition to the fire hazards that frequently affect heritage buildings [53]. The Secession Building is now completely safe with these measures and prepared to welcome visitors of the modern age.

Because of their weak thermal insulation capability, and the formation of thermal breaks and air pockets, the original windows in historical buildings are a major factor in their energy loss, which is why it is possible to maximize energy savings by renovating or completely replacing them. Replacing the windows is the most frequent form of renovation, even in heritage buildings [54]. This part of the modernization process was carried out in the Secession Building in accordance with contemporary standards.

The data provided pertain to the Construction Plan for the Rehabilitation of the Secession Building located at Friedrichstraße 12, dated 8 August 2018, property number 1221/2 within the Inner City cadastral district. The Association of Fine Artists Vienna Secession (original name Vereinigung bildender KünstlerInnen Wiener Secession) was the building developer, while the construction plan was authored by Architect Krischanitz ZT GmbH, and the construction engineers were Ing.Kurt Hammerl GmbH. The plan was made accessible for examination for this research by Dr. Annette Südbeck, Managing Director of the Secession.

6. Protection of Gustav Klimt's Beethoven Frieze throughout the Reconstruction from 2017–2018

The idea of installing Gustav Klimt's Beethoven Frieze in the Secession Building was officially adopted in 1984 [28], which symbolically signaled a new epoch for the building and this iconic work of art by Klimt. Embracing a national cultural artefact of this level was a challenging task, as spatial and technical optimization was required while maintaining the building's original function. Klimt's Beethoven Frieze was relocated to a specifically equipped room in the basement of the Secession Building, with a plan for it to become an integral element within the building. The conservation of Klimt's frieze will always be complex and risky, because, in addition to classical artistic conservation, it requires the constant improvement of technical solutions that must follow innovations, bearing in mind that it is situated in a basement on a specific static base and that every renovation of the building poses an additional risk.

The use of hybrid technology and the supervision of all supporting devices, ranging from thermal insulation, cooling, illumination and the other demands of sophisticated systems, are going to play a key role in the future [32]. It was important not to turn the Secession into a classic museum and change the historical function of the building, which was accomplished since the frieze is its only permanent art display. There are no further plans to change the building's function in the future. The sustainability function of the Secession Building in terms of its artistic concept has remained unchanged since its foundation in 1897.

Due to the ongoing reconstruction work, the Beethoven Frieze Room had to be closed to the public from Monday, 26 February to Friday, 9 March 2018. During the modernization and barrier-free accessibility work [55], a new elevator was installed, making the Beethoven Frieze accessible to wheelchair users for the first time. At the same time, a new illuminated ceiling with LED lights [56] was also installed. Before any work was carried out on the elevator itself, it was imperative to perform a test with highly sensitive vibration measurements [57,58] to secure the safety of the highly sensitive artefact, which was in the immediate vicinity of the construction work.

Gustav Klimt's masterpiece is a cycle of paintings created in 1901 dedicated to the composer Ludwig van Beethoven in the form of a frieze. Each individual panel of the frieze consists of a wooden slatted frame, which is coated with plaster and on which a genuine painting is applied.

The background of a single panel is a wooden slatted grid that is connected to a steel frame and then anchored to the wall or ceiling (one part of the frieze is in the wall, the other in the ceiling). The reconstruction of the Vienna Secession Building included modernization work in the exhibition rooms, such as changing the lighting on the ceilings, renovating and implementing air conditioning and heating, replacing the flooring, renovating the toilets and all the work required for fire protection. The work involved chiseling and removal operations, during which the transmission of vibrations/shocks affecting the building fabric could not be ruled out. For this reason, the Secession management commissioned a monitoring program to continuously monitor the vibrations. The experts Karoline Alten from AIT Austrian Institute for Technology and Dr. Michael Österreicher from iC consulenten were commissioned to carry out the study, which was submitted on 15 December 2017.

Test measurements were performed based on varying construction activities in order to establish the vibration limit values and assess the vibrations caused by different construction activities. In addition, a zero measurement without any construction work was carried out over a period of approximately 1 week. The technical report includes a detailed description of the investigations and measurements carried out and their results. According to the findings of the study "Vibration analysis of the Beethoven frieze in the Vienna Secession", it was concluded that all measurement findings indicated that the work on the reconstruction of the Secession Building could begin and that it would not be harmful to or jeopardize the Beethoven Frieze in any way.

The study carried out was an extensive one and included vibration testing throughout the entire Vienna Secession Building. The main objective was to assess the extent to which future construction work would affect the frieze, situated at the lowest level of the building.

Vibration measurements were performed during simulation of the construction work and were measured both on the bearing structure of the painting panels and on the front of the painting using a laser vibrometer. Based on these tests, the findings indicated that cutting and demolition operations caused the highest vibration emissions on the paintings. The cutting work was hardly perceptible but caused a significant noise disturbance (secondary airborne noise) in the frieze showroom.

7. Evaluation

With the restoration of the Secession Building, the high expectations of the national and international public are now being fulfilled. Since this is a building that was constructed as the headquarters of the Secession movement, a movement which has fostered the spirit of avant-garde thinking since its foundation and has always been ahead of its time, the building was also architecturally ahead of its time. We are now well into the 21st century, and the technological advances and challenges are unpredictable. The only certainty is that the Secession Building was modernized in its first general renovation in the 21st century according to contemporary standards.

Indoor cooling is the most rapidly expanding source of energy consumption in buildings, and it is expected to represent a large proportion of total energy usage in the very near future [59]. A cooling demand increase of between 28% and 98% was calculated by Berger et al. for Austrian office buildings by 2050. These increases are particularly evident in urban environments, as the materials and structures employed significantly increase the summer temperatures, creating so-called urban heat islands and raising cooling demands enormously [60]. As the Secession Building is situated in the historical center of Vienna, in the first district, there might be many effects on the interior atmosphere inside the building in the near future. The problem of cooling systems is one of the biggest issues needing to be resolved at the earliest opportunity.

The ventilation system was not expanded during this rehabilitation; however, the already-existing ventilation systems were renewed and accordingly had no impact on the structural strength of the building. The decorative features of the facade and its overall aesthetics were not changed, which was an essential prerequisite for the original appearance of the building not to be damaged. All safety and security requirements were properly implemented, and all requirements made by the competent authorities were respected as closely as possible. The building was assigned emergency exits in accordance with the law, accompanying the fire alarm system which was designed and installed properly.

It would seem that the sustainability principle has been achieved for the Secession Building, as its state of repair guarantees the continuity of its function and the option of future maintenance, as well as the sustainability of the building's safety in the long term. Detectors and fire extinguishers are located on all levels of the building in appropriate places, with no impact on its authenticity or heritage. Also, the emergency evacuation routes are appropriately designed to facilitate safe movement. Indeed, the evaluation of this research establishes that the reconstruction of the building has been carried out to all modern standards.

8. Conclusions

In terms of life cycle assessment (LCA) [10,61–63], a rehabilitated listed building will have an environmental as well as socio-economic advantage over a newly constructed building. Such a building will have significantly lower overall emissions as there are no new emissions associated with the building's footprint, i.e., production of the material or its construction. The reason for this lies in the fact that the building has already been constructed. These are all factors in favor of the Secession Building. With the right use of modern technology in future renovations, it will remain an invaluable cultural treasure for generations to come.

Heritage buildings were clearly not designed to be equipped with modern HVAC systems [64], but they were constructed with traditional mechanisms to control the indoor environment. Such characteristics have led to obvious consequences in terms of potential problems associated with the incorporation of modern building systems into heritage buildings.

In addition, modern equipment can be visually inappropriate for a historic building, and the installation of pipes, cables or ducts can also pose serious risks in terms of losing the original material. Moreover, the historical hygrothermal system within a cultural heritage building can be significantly affected by the modern system and lead to the deterioration of some of the building's inestimable elements. Passive climate control strategies are still widely used in heritage buildings, as they have been for centuries, and many properties have survived with uncontrolled indoor environments [65]. Passive energy measures [66–69], such as properly insulated building surfaces, high-efficiency windows or cooling and heating solutions, affect the building's aesthetic character, unless implemented with considerable attention to detail. Any approach to heritage buildings, therefore, needs to incorporate the architectural principles of conservation alongside both environmental aspects and financial factors. Not all countries can achieve the highest standard of maintenance for buildings of historical importance. This is the current reality on the ground and the challenge is to develop accessible solutions for wider world communities. All future rehabilitations of the Secession Building will be able to follow the most modern technology, as this world cultural heritage object is located in a technologically sophisticated country, which provides a unique opportunity to monitor the future impacts of how state-of-the-art technological achievements are applied in relation to historical cultural heritage objects. This is a great advantage, but it might also be a risk if a particular modern method, during future rehabilitations, is experimental in its implementation.

The thickness of the building envelope on heritage buildings is often limited due to architectural constraints, making it impractical to add a thick layer of insulation [70]. As a result, choosing insulation materials that make the building energy efficient while preserving its historic character is demanding. For this reason, the energy rehabilitation that will follow in the course of the first follow-up renovation of the Secession Building will be particularly challenging due to the large number of decorative metal elements that are incorporated into the facade of the building and that have an inestimable artistic value. The question will arise concerning how to visually harmonize the historical decoration with modern devices that will have to be installed in a way that does not disturb or damage the cultural heritage. Everything that has been performed during the first major redevelopment in the 21st century is very much in line with present conditions, with the reality that there are preconditions for upgrades that will follow any accelerated, unforeseeable climate changes.

In the case of the Secession Building in Vienna, equipping the building with a modern HVAC system was not a high priority on the list of rehabilitation goals from 2017–2018, as there were more urgent parts of the building that needed to be urgently rehabilitated to prevent further deterioration. Such heritage buildings from the past usually have a limited sustainability that meets modern standards to a certain extent, suggesting that this issue is likely to need a better resolution in the future.

Usually, all elements of the historic interior (as well as exterior) are already acclimatized to the daily, seasonal and annual hygrothermal fluctuations [71–73] due to their

architectural features. The impact of traditional techniques and materials on the museum climate has only been given serious attention recently. Natural ventilation systems to control air exchange, buffer spaces ensuring thermal stability, screens or greenery to reduce heating gains and moisture absorption, as well as wall surfaces to retain moisture, will be an increasingly binding requirement for all future restorations of heritage buildings. As fuel prices and carbon dioxide emissions are rising, so too are the costs.

Possible negative effects related to climate change in the time immediately following the first major reconstruction of the Secession Building in the 21st century do not constitute a threat to the Secession Building itself or the comfort of its visitors, especially considering that it is a relatively small building compared to traditional historical museums and that there are no permanent museum artifacts that require special protection—with the exception of Klimt's Frieze, whose climate in its gallery is under maximum protection and regular control. Endeavors are already in progress to further upgrade the Secession system to entirely sustainable, hybrid and climate-controlled heating and air-conditioning systems, with full control of the physical environment in the Secession Building and with the ultimate goal of eliminating any damage to the historic architectural structure.

During the Secession's restoration from 2017–2018, all work was purposefully performed to respond to the parts of the building that required an immediate response. The Secession Building has been refurbished to the highest standards and under the strictest supervision of the local heritage conservation authorities. During the renovations and rehabilitation work on the building, not a single part of the facade was damaged. The heritage gems on all surfaces of the exterior and interior of the Secession Building have now been completely renovated and preserved for the time until the next renovation.

Although it is clear that rehabilitating protected heritage buildings to today's energy standards is a complex and demanding task, it is feasible. This has already been proven by a number of projects in the field of architectural and urban conservation. Previous experience with the rehabilitation of the Secession Building in the 1980s has demonstrated clearly that the architectural authenticity of this landmark building does not have to diminish as a result of rehabilitation. In any future rehabilitation and modernization of the Secession Building, more work is needed to address any outstanding energy efficiency concerns and eliminate possible obstructions, so that this category can be fully brought up to the latest standards. While technology is advancing rapidly, the challenges are advancing even faster. This is a fundamental reason why it is currently impossible to talk about the potential future challenges which interdisciplinary teams of experts will face. However, the first major reconstruction in the 21st century has been completed successfully.

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