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AN ANALYSIS OF THE WINDOW REHABILITATION PROCESS TOWARDS ENERGY EFFICIENCY AT THE BAUHAUS DESSAU

Abstract

Considered a monument of early Modernism and one of the pioneering examples of modern academic architecture, the Bauhaus Dessau is a World Heritage Site that experienced three main phases of renovations: in 1976, between 1996-2006 and 2009-2012. This thesis examines the alterations of the building's windows as part of these renovations in order to explore challenges related to sustainable retrofits in modern architecture. Specific emphasis is given on windows based on their critical role in energy performance as well as their extensive use throughout the building, making them characterdefining elements for the Bauhaus. Preservation strategies are identified and analyzed from the perspectives of historic preservation and sustainability, following an overview of Modernism's relationship to sustainable preservation and an introduction of the history of the site as well as its climate conditions. Changes of window elements in three major building parts, the Studio Wing, the Workshop Wing and the North Wing, are discussed to demonstrate the challenges of achieving improved energy efficiency with the least possible compromise from character-defining elements. Through the analysis of historic documentation, existing literature and energy management plans in addition to interviews with multiple stakeholders, this study explores the preservation decisions that were critical in the renovations of the windows. The results of the study illustrate that, although challenges common in preserving modern architecture were creatively overcome at the Bauhaus Dessau, there is still a need to consider future climate change scenarios.

Keywords

sustainable preservation, modernism, window rehabilitation, energy conservation, glass façades

Disciplines

Historic Preservation and Conservation

AN ANALYSIS OF THE WINDOW REHABILITATION PROCESS TOWARDS ENERGY EFFICIENCY AT THE BAUHAUS DESSAU

Basak Siklar

A THESIS

in

Historic Preservation

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MASTER OF SCIENCE IN HISTORIC PRESERVATION

2021

Advisor Pamela Hawkes Professor of Practice in Historic Preservation

Program Chair Frank G. Matero Professor "Tomorrow belongs to those who can hear it coming." David Bowie

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PART 1: INTRODUCTION

A. THESIS STATEMENT & THE RESEARCH PROBLEM

i. Research Problem

This thesis examines the three main phases of interventions at the Bauhaus Dessau designed by Walter Gropius in order to explore the challenges of sustainable retrofits in modern architecture. In early Modernism, achieving to meet current thermal comfort standards and improving energy efficiency is challenging without compromising on character-defining features such as transparent glass façades. What this study aims to show, through focusing on changes applied to the windows of the Bauhaus Dessau, is that forming a balance between historic preservation and sustainability principles in modern architecture requires careful consideration of original conditions as well as former interventions on buildings.

ii. Hypothesis

Preservation of modern heritage to meet sustainability goals proposes unique challenges. The common language of Modernism--such as the extensive use of glass and open plans--creates a number of problems related to the energy demand of modern buildings, especially considering the impacts of climate change. Although the challenges are universal, the solutions are usually site-specific, partly due to the architects' selection of materials that were uniquely new in their period of installation and partly in the way they were used in design.

This study aims to analyze strategies applied to the windows of the Bauhaus Dessau by various stakeholders throughout its history, demonstrating a range of preservation attitudes as well as sustainability solutions.

- iii. Methodology
- a. Interviews

Written as well as video interviews generously contributed to this study. Unpublished company data related to the 2009-2012 phase of interventions provided by the climate engineering company TransSolar were used to analyze the energy efficiency upgrades. Correspondence with Brenne Architekten and Monika Markgraf, the Preservation Manager of the Bauhaus Foundation and author of a number of academic resources that were utilized in this study, helped to understand the Bauhaus Dessau from the perspectives of multiple stakeholders. Interviews with architect and professor of architecture David Fixler and Charles M. Sullivan, the Executive Director of Cambridge Historical Commission, gave first-hand knowledge on the preservation of another major Gropius project, namely the Harvard University Graduate Center and dormitories. It was an important step for this research process as it supported the author's claim that similar preservation challenges arose at these buildings.

b. Archival & Historical Research

Due to the physical limitations and travel restrictions created by the pandemic, visiting historical archives was not possible. However, thanks to the vast online presence of the Bauhaus Archives as well as the generosity of Harvard Art Museums, a significant amount of historic documentation helped constitute this body of research, such as historic

photographs and original floor plans in addition to Gropius' documentation of the construction period. The existing literature on the building as well its preservation processes were also used to gather necessary information.

c. Analysis of Drawings & Energy Management Plans

Elevation drawings and floor plans were essential to understanding how the building works, especially detail drawings related to the original construction and modifications of the windows of the Studio Wing, the Workshop Wing and the North Wing provided the author with evidence related to the work done. The energy management plan developed by TransSolar including the existing and post-construction numerical data associated with the energy demand of the Bauhaus Dessau was another key document.

iv. Limitations

In the process of this thesis, the author had to adapt to the limitations brought about by the COVID-19 pandemic. The inability to visit the building or physical archives limited the research to what is available digitally. These conditions eliminated the possibility of monitoring efforts, such as solar radiation tests or physically document the ongoing problems on site. Therefore, the generation of numerical data related to energy performance was not possible. The information provided to the author by the stakeholders of the latest phase of interventions was taken as the basis for analysis throughout the study.

v. Delimitations

Though the Bauhaus Dessau has undergone some changes since the closing of the school in 1932, alterations to the building before 1976 are not in the scope of this thesis.

Due to limitations in time and software available to the author, a detailed energy model or a 3D sun orientation model could not be created.

The author originally hoped to compare preservation of the Bauhaus with that of the Harvard University Graduate Center, also by Gropius. Although the author was given access to original drawings and rehabilitation drawings of the Harvard University Graduate Center and dormitory buildings, the author decided to focus on the Bauhaus. This data set, however, offers a tremendous opportunity for further study and/or preservation planning and design at the Graduate Center. The findings of this thesis will hopefully help as well.

PART 2: PRESERVATION, MODERNISM & SUSTAINABILITY

A. PRESERVATION OF MODERN ARCHITECTURE

Modern architecture undeniably influenced the course of architectural design in the 20th century, especially after World War I. The trauma of the war, combined with the availability of new, industrial materials, brought about a new aesthetic in architecture as well as the concept of "the machine".¹ Architects took upon a new, holistic design approach that aimed to appropriate architecture in alignment with the needs of the new society created by industrialism. Architects and artists abandoned traditional forms of art and architecture; simple and abstract forms without ornamentation dominated the language of modernity. These principles of modern architecture were introduced by prominent architects such as Frank Lloyd Wright, Le Corbusier, Philip Johnson, Ludwig Mies van der Rohe and Walter Gropius.

After the 1932 exhibition Modern Architecture: International Exhibition organized by the Museum of Modern Art in New York City, "International Style" became the term for architecture which included design elements such as geometric building forms, flat roofs, pilotis, ribbon windows and open plans. Between the two world wars, the impact of modernism grew to a global scale with the emigration of European architects from continental Europe to countries such as Israel, Brazil, Turkey and most significantly, the United States. This influenced the future of urban development and commercial building design in large cities, of which New York City is a significant example.

¹ Inês D. D. Campos and Luís F. A. Bernardo, "Architecture and Steel. Reflection and Analysis on the Use of Steel Structures (in Sight) as a Concept in the History of Architecture," *Designs* 4, no. 3 (2020), <u>https://doi.org/10.3390/designs4030030</u>.

Modern architecture did not come to the center of attention of the historic preservation movement until the beginning of the 1980s, when its character as heritage asset first emerged among scholars and practitioners, as David Fixler wrote in *Repair of Modern Structures: Stepping Back and Looking Forward.*² The need to preserve Modernism emerged partly from the maintenance needs of the buildings and partly on financial grounds, given the degree to which Modern architecture forms such a large part of current real estate assets. The value of modern buildings as cultural heritage has also grown significantly as the buildings age, with modernist buildings becoming "historic".

Preserving modern architecture requires different conservation techniques as well as a new attitude in terms of preservation philosophy. In contrast to methods of architectural conservation used for traditional historic buildings, the conservation of modern heritage may not always be based on maintaining original fabric.³ Even if conservation of original fabric is the most significant aspect of the preservation process, innovative methods may be necessary due to the original fabric's historically unprecedented and/or rare character, such as treatments of plate glass frequently used in Modernism. A review of existing literature on preserving Modernism shows that there is a great variety in opinions about the most correct approach. According to Theodore Prudon, the debates around preserving modern architectural heritage are centered mostly around "what should be saved and how that is to be accomplished culturally, regulatorily and

² David N. Fixler, "Repair of Modern Structures: Stepping Back and Looking Forward," *Change Over Time* 1 (2011): 80–108.

³ Geoff Rich, "Renewing Modernism: Emerging Principles for Practice," *Journal of Architectural Conservation* 23, no. 1–2 (May 4, 2017): 116–40, <u>https://doi.org/10.1080/13556207.2017.1326552</u>.

economically."⁴ These questions are particularly valid for the case of the Bauhaus Dessau, as the answers changed over time with the evolution of preservation philosophy adopted by stakeholders. Thus, it is useful to examine late 20th century preservation standards as they relate to Modernist buildings, since despite the variety of projects and/or cultures, it is these standards that have been used as common grounds for preservation since the second half of the 20th century.

The key standards used as the framework for this thesis are those established by the International Council on Monuments and Sites, as the Bauhaus Dessau is a designated World Heritage Site. It is also essential to mention the Venice Charter, which was established in 1964 by ICOMOS. Articles 9 and 11 of the Charter specifically speak to the subject of this thesis that examines multiple phases of restorations in a modern icon, while maintaining their validity for a major part of 20th century architecture, especially in Europe, where the damages of war and conflict as well as changes in political structures had significant impact on the built environment. The two articles are important to understand as they emphasize the buildings' value as historic evidence in addition to addressing to the accumulation of change in a building as part of its heritage value.

Article 9 of the Venice Charter states that "The process of restoration is a highly specialized operation. Its aim is to preserve and reveal the aesthetic and historic value of the monument and is based on respect for original material and authentic documents. It

⁴ Theodore Prudon, "Preservation, Design and Modern Architecture: the Challenges Ahead," *Journal of Architectural Conservation* 23, no. 1-2 (April 2017): pp. 27-35, https://doi.org/10.1080/13556207.2017.1327193.

must stop at the point where conjecture begins, and in this case moreover any extra work which is indispensable must be distinct from the architectural composition and must bear a contemporary stamp. The restoration in any case must be preceded and followed by an archaeological and historical study of the monument."⁵ Additionally, article 11 asserts that "The valid contributions of all periods to the building of a monument must be respected, since unity of style is not the aim of a restoration. When a building includes the superimposed work of different periods, the revealing of the underlying state can only be justified in exceptional circumstances and when what is removed is of little interest and the material which is brought to light is of great historical, archaeological or aesthetic value, and its state of preservation good enough to justify the action. Evaluation of the importance of the elements involved and the decision as to what may be destroyed cannot rest solely on the individual in charge of the work."⁶ These two articles specifically respond to the complexity of consecutive phases of renovations in Modernism.

The preservation of monuments, or *Denkmalpflege*, started in West Germany as an organized field in 1951 under the Association of State Conservators in the Federal Republic of Germany, with East Germany joining the association in 1989. There are a number of other organizations devoted to preserving Germany's cultural heritage, such as *Deutsches Nationalkomitee für Denkmalschutz* (the German National Committee for Conservation), the *Arbeitsgruppe Kommunale Denkmalpflege des Deutschen Städtetages* (the Working

⁵ IInd International Congress of Architects and Technicians of Historic Monuments, Venice, 1964. <u>https://www.icomos.org/en/participer/179-articles-en-francais/ressources/charters-and-standards/157-thevenice-charter/</u>

⁶ IInd International Congress of Architects and Technicians of Historic Monuments, Venice, 1964. <u>https://www.icomos.org/en/participer/179-articles-en-francais/ressources/charters-and-standards/157-thevenice-charter/</u>

Party for Urban Conservation of the Association of German Cities and Towns), the *Deutsche Stiftung Denkmalschutz* (the German Foundation for Conservation), to name a few. Although the particular interests of these organizations are different, they all base their practices in the Wartburg Theses that were constituted by the Association of State Conservators in 1990. The establishment of The European Heritage Heads Forum in 2006 was another key point for Germany's historic preservation, as it proposed global interaction among preservation professionals and a reorientation towards a more standardized understanding in historic preservation.

Organizations such as the International Committee for Documentation and Conservation of Buildings, Sites and Neighborhoods of the Modern Movement, which are explicitly dedicated to the preservation of modern architecture, provide another important resource for ensuring the appropriate maintenance of 20th century architecture.⁷ identification of modern architecture's numerous urgent problems has contributed to protecting the modern built environment. The organization's emphasis on the innovative character of Modernism and their advocacy efforts in protecting this character has led to a more widespread acceptance of modern architecture as part of cultural heritage.⁸

⁷ "How to Evaluate Modern," Docomomo (Docomomo.), accessed May 27, 2021, <u>https://www.docomomo-us.org/explore-modern/explore-the-register/how-to-evaluate-modern</u>.

⁸ Anne-Laure Guillet, "Docomomo International," *Journal of Architectural Conservation* 13, no. 2 (January 1, 2007): 151–56, <u>https://doi.org/10.1080/13556207.2007.10785002</u>.

B. MODERNISM, ENERGY & SUSTAINABILITY

Given that the construction industry is responsible for approximately 40% of the energy consumption in the world, minimizing the energy demand of the existing built environment is essential.⁹ Thus, within the context of environmental sustainability, Modernism's relationship to energy efficiency has been a major point of interest for scholars, especially in the past decade, in alignment with the increasing emphasis on academic research related to climate-responsive architecture. The common conception of modern architecture is that designers' focus on aesthetics and function--rather than the impact of environmental conditions on buildings--disregarded environmental concerns. The availability of fossil fuels, especially coal, led designers to rely heavily on these non-renewable resources of energy, contributing to the increase of buildings' carbon foot prints.

However, the architects of the International Style were most certainly responsive to human needs created by climatic conditions: The frequent use of *brise-soleil* and other shading devices, jalousies and other non-mechanical methods to decrease the impact of sunlight on building habitants proves that modernists did, in fact, consider the climate conditions in their designs, as Daniel Barber explains in his book *Modern Architecture and Climate: Design Before Air Conditioning*. Barber also stresses that, in the decades since most modern buildings were created, climatic science and information regarding climate change have evolved quite significantly. ¹⁰ Additionally, thermal comfort standards have

⁹ Mónica Calero et al., "Energy Consumption Reduction Proposals for Thermal Systems in Residential Buildings," *Energy and Buildings* 175 (September 15, 2018): 121–30, https://doi.org/10.1016/j.enbuild.2018.07.028.

¹⁰ Daniel A. Barber, *Modern Architecture and Climate: Design before Air Conditioning* (Princeton: Princeton University Press, 2020).

changed drastically throughout the course of the 20th century, so that today, it is hardly fair to evaluate modern architecture using contemporary values. Thus, it is critical to understand the mindset of modernists and to examine each project within its individual environmental context and programming. Only possible after such an objective evaluation it is possible to plan and execute interventions to upgrade modern heritage.

Thus, it is essential to discuss historic evidence of how architects considered climate conditions and the impact of the environment, precisely the sun, before proceeding with the details of the case study that constitutes the main subject of this thesis. Concept drawings as well as light and air diagrams by prominent designers of Modernism such as Le Corbusier and Walter Gropius prove their recognition of environmental conditions, as can be seen in Figures 1, 2 and 3, respectively.

Figure 1 shows Le Corbusier's sketch for the Barcelona *Lotissements*. His inclusions of the sun room and the roof vegetation are noteworthy, especially considering that he indicated the location of the sun with respect to the building in his drawing.¹¹ In his sketch in Figure 2 for *Immeuble Clarté* in Geneva, his considerations of climate conditions are clearer: He demonstrates the function of the brise-soleil by using a seasonal sun path diagram, including drawings for the different sun angles in winter and summer at the top right corner of the sketch.¹²

Figure 3, the "light and air diagram" by Walter Gropius shows the architect's analysis of buildings of various heights from a climate perspective: He writes on the

¹¹ Barber, Modern Architecture and Climate: Design before Air Conditioning

¹² Barber, Modern Architecture and Climate: Design before Air Conditioning

diagram that "the higher the number of floors [gets], the smaller the angle of incidence of the light [becomes]" and "sun exposure conditions become more advantageous".¹³

¹³ Author's own translation of the inscription on the diagrams.

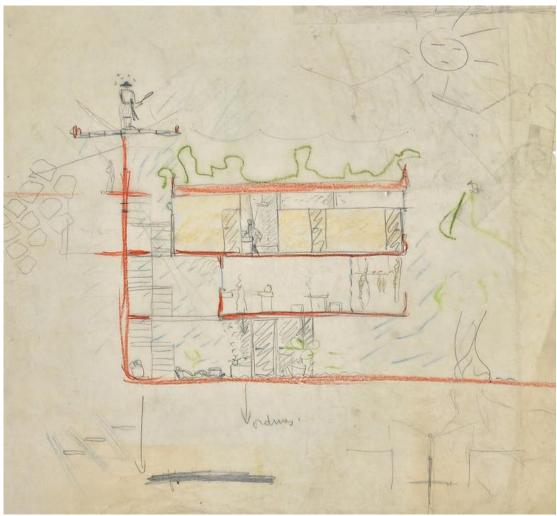


Figure 1. Le Corbusier, Lotissement concept drawing

Barber, Daniel A. Le Corbusier's Lotissement concept drawing, 1931, in Modern Architecture & Climate (Princeton: Princeton University Press, 2020) page 15

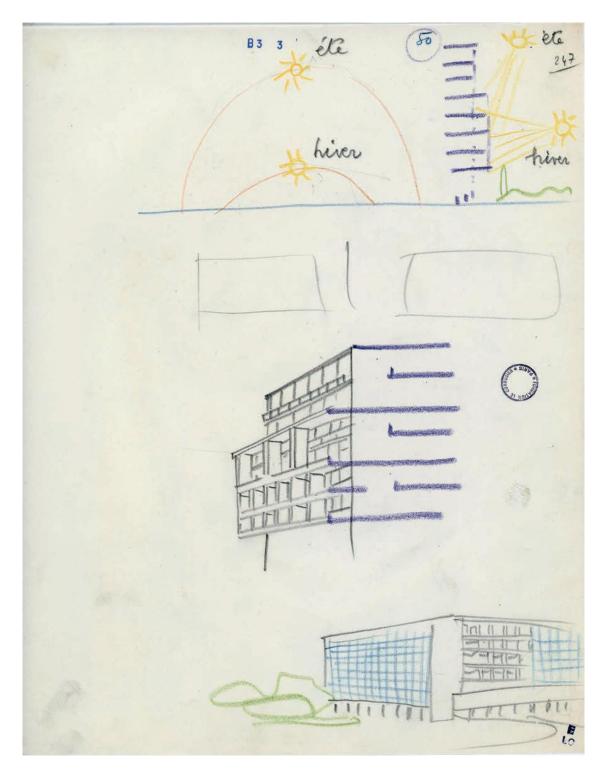
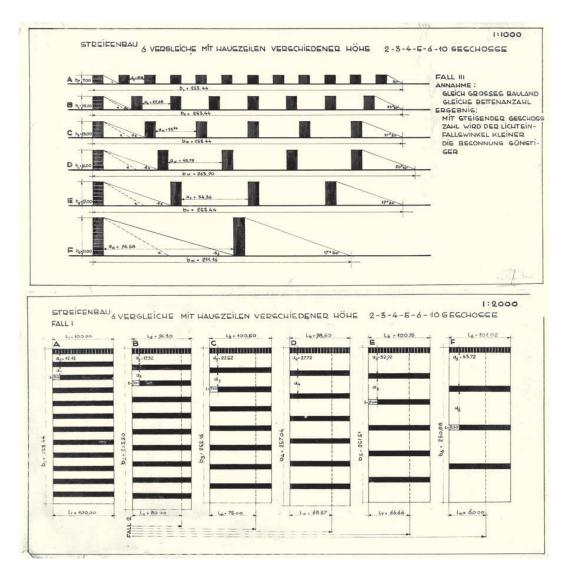
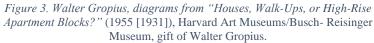


Figure 2. Le Corbusier, Immeuble Clarté sketch indicating the principles of relationship between the façade shading system (brise-soleil) and the seasonal path of the sun

Barber, Daniel A. Le Corbusier's, Immeuble Clarté sketch, in Modern Architecture & Climate (Princeton: Princeton University Press, 2020) page 53





Barber, Daniel A. Walter Gropius, diagrams, 1931, in Modern Architecture & Climate (Princeton: Princeton University Press, 2020) page 37

C. MODERNISM, WINDOWS & ENERGY

The extensive use of glass, both in terms of quantity and size of openings and spans, is a distinctive element in Modernism. This was the result of a new, simplistic and, in some cases, industrial aesthetic in design, following the adoption of a new functionalism in architecture. Also significant was the desire to create spatial continuity by connecting the interior of a building to exterior space, led to the use of glass in unprecedented scales. The new opportunities proposed by innovative industrial materials enabled the design and construction of glass façades. As Walter Gropius wrote in the New Architecture and the *Bauhaus*, the "new synthetic substances – steel, concrete, glass" replaced more traditional construction materials within a short period of time.¹⁴ Moreover, these materials possessed sufficient rigidity and molecular density such that they "made [it] possible to erect widespanned all but transparent structures for which the skill of previous ages was manifestly inadequate."15 Gropius was also concerned with achieving an "altered perception of architecture", meaning that he wished to enable a building to be understood in different ways depending on physical perspective, through the use of glass in large scales in his designs, and this concern was particularly significant in his design of the Bauhaus school building in Dessau.¹⁶

The insertion of glass in such large quantities had the goal of optimizing daylight. At the same time, though, it caused a number of problems related to energy performance. Thermal insulation was typically not considered in window design during the period as the

¹⁴ Walter Gropius and P. Morton Shand, *The New Architecture and the Bauhaus* (Cambridge, MA: M.I.T. Press, 1998).

¹⁵ Walter Gropius and P. Morton Shand, *The New Architecture and the Bauhaus* (Cambridge, MA: M.I.T. Press, 1998).

¹⁶ Walter Gropius, "Glasbau", *Die Bauzeitung* 20 (1926)

main concern, especially in all-glass façades; instead, transparency and the uninterrupted flow of natural light was the primary concern. In areas with extremely cold winters, the lack of insulation caused increased heating and cooling loads. Problems caused by the extensive use of glass throughout façades or roofs were not limited to energy loss in winter time. In Peter Behrens' AEG Factory, for instance, the amount of sunlight transmitted through the glass roof made it "impossible [for factory employees] to work" during the warm summertime of Berlin. Therefore, the roof had to be covered only after a short time after opening.¹⁷

Another significant aspect of windows related to the energy demand of a building is operability. Because most early modern architecture was designed before air conditioning, operable building openings, especially the windows, were the main source of air circulation. Design choices such as the orientation of a building and its windows, in addition to the use of window treatments also have significant impact on the energy performance of a building as well as the daily experience of its habitants.

Problems inevitably arose, given the "poor performance and limited longevity" of modern architecture and its materials.¹⁸ Challenges related to windows in modern architecture have been addressed in numerous case studies as well as academic research, including recommendations for the glass and steel industries.¹⁹ Strategies to address the poor performance of windows include alteration of glazing, repairing and/or replacing

¹⁸ Ayón Angel, Uta Pottgiesser, and Nathaniel Richards, "Introduction," in *Reglazing Modernism Intervention Strategies for 20th-Century Icons* (Basel: Birkhäuser, 2019), p. 6

¹⁷ Julius Posener, "A visit to the Bauhaus Dessau", in *The Dessau Bauhaus Building*, 1926 – 1999, ed. Margret Kentgens-Craig (Birkhäuser, 1998) 134-142

¹⁹ Ayón Angel, Uta Pottgiesser, and Nathaniel Richards, *Reglazing Modernism Intervention Strategies for 20th-Century Icons* (Basel: Birkhäuser, 2019), 232 - 246

existing steel frames; and window panes, adding thermal breaks and installing insulation in various forms.²⁰ In *Reglazing Modernism Intervention Strategies for 20th-Century Icons*, Angel, Pottgiesser and Richards have identified 20 such case studies, categorizing them based on the nature of the interventions. Their research identified an array of common intervention strategies and considered the motivation for renovations as well as the techniques used.

Their analysis demonstrates that decay in materials was the motivation for a majority of the projects. Of 20 cases, 9 renovation projects had the additional motivation of energy conservation. 6 of these interventions occurred at sites in Northern Europe with 1 site in Russia and 2 sites on the East Coast of the United States.²¹ These numbers suggest an increased interest in energy upgrades in areas that have cold winters, given the expectation of winter temperature drops as a result of climate change.

D. SUSTAINABLE PRESERVATION AND ITS CHALLENGES

Collaboration between the fields of historic preservation and environmental design has significantly increased in the past decade. As the literature review performed by Lidelöw, Örn, Riciani and Rizzo in 2018 shows, there is a growing interest to bring preservation practices up to date with standards of sustainability, with a considerable part of the exiting literature taking on an "energy analysis" point of view, evaluating the energy uses of individual buildings.²²

 ²⁰ Ayón Angel, Uta Pottgiesser, and Nathaniel Richards, "Case Studies – Introductory Notes," in *Reglazing Modernism Intervention Strategies for 20th-Century Icons* (Basel: Birkhäuser, 2019), 26 - 31
 ²¹ Angel, Pottgiesser, Richards, *Reglazing Modernism*, 32-33

²² Sofia Lidelöw et al., "Energy-Efficiency Measures for Heritage Buildings: A Literature Review," *Sustainable Cities and Society* 45 (February 1, 2019): 231–42, <u>https://doi.org/10.1016/j.scs.2018.09.029</u>.

Safeguarding the historic built environment by adopting strategies and principles of environmental sustainability is essential, as it contributes to the well-being of existing as well as future generations. According to Young and Elefante in *Stewardship of the Built Environment: Sustainability, Preservation, and Reuse*, these contributions include, but are not limited to: "decreasing the long-term extraction and depletion of natural resources;" "reduc[ing] the consumption of energy used in demolition and the compounded effects of the embodied energy needed to create new or replacement buildings;" and "reducing the creation of green sprawl."²³

Despite the extensive amount of research currently being done on the environmental sustainability of all cultural heritage assets, the discussion of sustainability in preservation here is limited to modern heritage. Sustainable preservation efforts generally include maximizing energy efficiency to satisfy current energy standards while preserving the authenticity and integrity of the buildings. Obtaining both goals, however, usually cannot be achieved without compromise. As Carl Elefante wrote in 2008, there are a number of major problems in the sustainable preservation of modern architecture: The first of these is the reality that a large part of modern built environment was designed during a time when energy was available at low prices, mostly from fossil fuels. The second most common issue is related to the exterior envelope of modern buildings. The nature of materials used, energy requirements and thermal comfort standards "might require

²³ Robert A. Young and Carl Elefante, *Stewardship of the Built Environment: Sustainability, Preservation, and Reuse* (Washington: Island Press, 2015).

replacement instead of enhancement" of the original building fabric, especially in windows.²⁴

The Bauhaus school building in Dessau, Germany, provides an opportunity to study these problems in a comprehensive way. The issues identified in this section, common to a majority of modern buildings, were addressed at the site through a range of preservation strategies, with the most recent interventions specifically directed towards improved energy performance.

²⁴ Elefante, Carl. "Renewing Modernism." *Places: Forum of Design for the Public Realm* 20, no. 1 (2008): 44–51.

PART 3: WALTER GROPIUS & THE BAUHAUS DESSAU

A. THE LEGACY OF WALTER GROPIUS & THE BAUHAUS

Considered one of the inventors of the International Style, Walter Gropius and the Bauhaus had an undeniable impact on the development of modern art and architecture.²⁵ Although the Bauhaus operated actively for only fourteen years, from 1919 to 1933, the institution had a large influence on the world of art and architecture. Not only did it lay the stylistic foundations for what became the International Style, it also inspired countless other areas of modern design and design education, from furniture to typography. Students of the Bauhaus later became influential names in the world of design, some of whom even taught at the Bauhaus towards the institution's later years, such as Josef Albers, Marcel Breuer and Herbert Bayer.²⁶

The influence of the Bauhaus was not limited to Germany or Europe. As Bauhaus architects fled Germany to countries outside continental Europe due to the increasingly oppressive Nazi regime, the language of modern architecture became common in other countries, including the United States, Brazil and Israel. Especially in the US, the arrival of European architects, specifically Walter Gropius and Mies van der Rohe, changed the course of design education through institutions such as the Harvard University Graduate School of Design and the Illinois Institute of Technology.

²⁵ Alfred J. Barr, "Modern Architecture- International Exhibition," in *Modern Architecture- International Exhibition* (New York, NY: Museum of Modern Art, 1932), pp. 12-18.

²⁶Maristella Casciato, Gary Fox, and Katherine Rochester, "Masters and Apprentices," Bauhaus: Building the New Artist (The Getty Research Institute, Los Angeles, June 10, 2019), <u>https://www.getty.edu/research/exhibitions_events/exhibitions/bauhaus/new_artist/history/masters_apprenti</u>

<u>ces/</u>.

B. THE BAUHAUS DESSAU

i. Site Introduction & Context

The Bauhaus school is located at Gropiusallee 38 in the urban district of Dessau – Roßlau in the state of Saxony-Anhalt, in Germany. The building lies along the axes NW-SE and NE-SW on a flat terrain and it is accompanied by the Masters' Houses (Meisterhæuser) situated further north on the corner of Gropiusallee & Ebertallee. The dominant materials of construction at the Bauhaus Dessau are concrete, steel, glass and brick masonry. In Gropius' own words, the building "covers an area of about 2630 sqm and has a cubic capacity of about 32450 cbm."²⁷

²⁷ Walter Gropius and Hans Maria Wingler, Bauhausbauten Dessau (Berlin: Gebr. Mann, 1997).

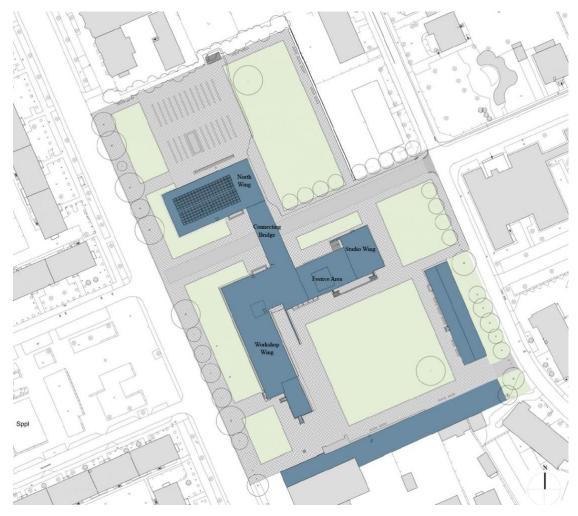


Figure 4. Bauhaus Dessau Site Plan

Brenne Architekten. Lageplan Bauhausensemble. 2012. Brenne Architekten, Berlin. Accessed 22 May 2021. https://www.brenne-architekten.de/bauhaus-dessau/

Composed of five main sections- namely the Workshop Wing, the North Wing, the Studio Wing, the Festive Area ²⁸ and the connecting bridge between the North Wing and the Workshop Wing- the building complex was designed by Walter Gropius and it was built between 1925-26. The asymmetrical positioning of the five main parts was a deliberate attempt by Gropius to avoid having a central view, so that it is only possible for the observer to comprehend the form of the building by moving around and through building.²⁹ Each part of the complex was designed to express its functions to the observer. Moreover, Gropius aimed to "create a balance between individual spaces" and thus made sure to create continuity in the interior space.³⁰

Workshop Wing:

The Workshop Wing is located at the southwest end of the building complex and has three stories. The three main façades, namely the Southwest, North and the Northeast façade, consist of glass curtain walls. According to original floor plans by Gropius (Figures 5 through 7), the first floor (conventionally named as the "ground floor" in Germany) consisted of a display room, the cabinet making workshop, the machine shop, a room for veneer work, a room for foremen and a washroom. The second floor included the workshop space for the preliminary course of the Bauhaus and the weaving workshop. The third floor

²⁸ Monika Markgraf, "The Glass Façades of the Bauhaus Dessau Building", in *Glass in the 20th Century Architecture: Preservation and Restoration*, eds. Franz Graf, Francesca Albani (Mendrisio: Mendrisio Academy Press, 2011), 28

²⁹ "Bauhaus Building by Walter Gropius (1925-26)," Bauhaus Building by Walter Gropius (1925-26) : Bauhaus Building : Stiftung Bauhaus Dessau / Bauhaus Dessau Foundation (Bauhaus Dessau Foundation), accessed November 19, 2020, <u>https://www.bauhaus-dessau.de/en/architecture/bauhaus-building/bauhausbuilding.html</u>.

³⁰ Magdalena Droste, Karen Williams, and Jane Michael, *Bauhaus: 1919-1933* (Köln: Taschen, 2019).

accommodated separate workshop spaces for galvanizing, soldering, metalwork, wall painting and varnishing as well as wardrobes and washrooms for students.

The individual spaces throughout the Workshop Wing were used for administrative purposes until the most recent rehabilitation project took place on site. For reasons that will be given in the remainder of this thesis, the Workshop Wing is now used only for temporary events such as exhibitions and/or large gatherings.

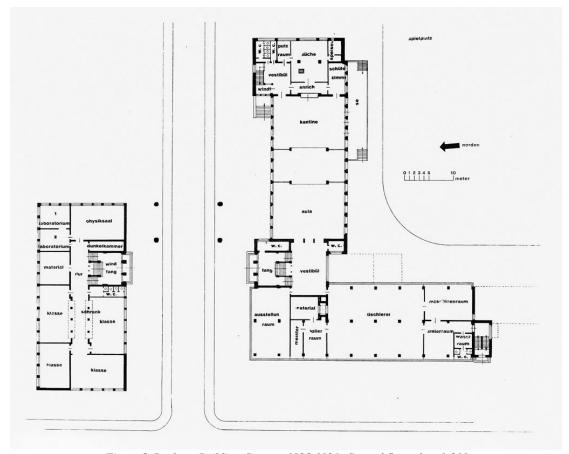


Figure 5. Bauhaus Building, Dessau, 1925-1926: Ground floor plan. 1:200.



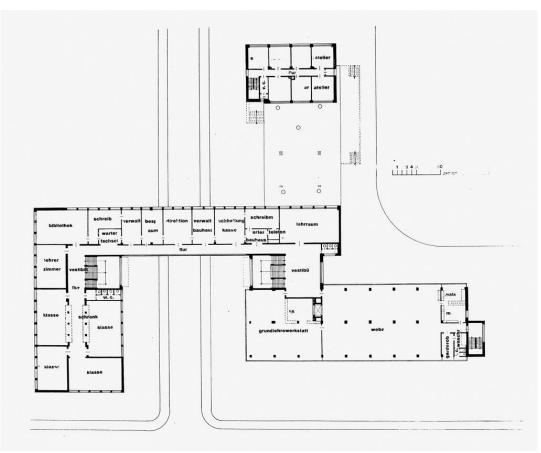


Figure 6. Bauhaus Building, Dessau, 1925-1926: First floor plan. 1:200.

BRGA.20.5. Harvard Art Museums/Busch-Reisinger Museum, Gift of Walter Gropius https://harvardartmuseums.org/collections/object/222104?position=85

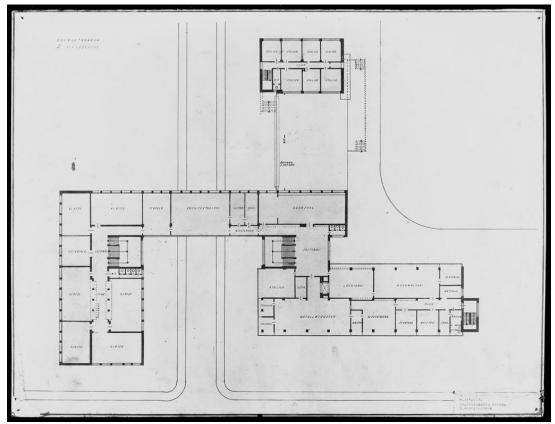


Figure 7. Bauhaus Building, Dessau, 1925-1926: Second floor plan.

BRGA.20.4. Harvard Art Museums/Busch-Reisinger Museum, Gift of Walter Gropius. https://harvardartmuseums.org/collections/object/197711?position=84

North Wing:

Also named as the "Administrative Wing", "Technical School" or "Vocational School", the North Wing is three stories high. The original floor plans show that the first floor had classrooms, laboratories, a physics room, a storage space for materials and lockers for students. The second floor consisted of the library, a staff room, classrooms, a waiting room, the typing workshop and additional lockers. Access to the Workshop Wing via the connecting bridge is enabled on the second floor. The third floor had six classrooms and a materials storage room. Today, the North Wing is used for administrative purposes and most classrooms have been converted to offices.

Studio Wing:

This part of the building complex had the sole function of a dormitory for the students and the junior masters of the Bauhaus. The Studio Wing is five-stories high with a total of twenty-eight individual studio units. Each unit has the floor area of 20 m² and a small balcony facing the east.³¹ The function of the spaces has not changed throughout the use of the Bauhaus Dessau; the Studio Wing is still used for accommodation purposes today, allowing visitors as well as resident artists to stay on site.

Festive Area:

The one-story Festive Area connects the Studio Wing to the Workshop Wing and it consists of the cafeteria, the auditorium and the stage.

³¹ "Bauhaus Building by Walter Gropius (1925-26)," Bauhaus Building by Walter Gropius (1925-26) : Bauhaus Building : Stiftung Bauhaus Dessau / Bauhaus Dessau Foundation (Bauhaus Dessau Foundation), accessed November 19, 2020, <u>https://www.bauhaus-dessau.de/en/architecture/bauhaus-building/bauhausbuilding.html</u>.

Connecting Bridge:

The bridge connecting the North Wing to the Workshop Wing has two stories and it provides additional office space. Originally, the bridge had a mostly administrative function with defined offices, including the office of Bauhaus founder Walter Gropius at the center of the first floor. After the creation of the architecture department within the Bauhaus school in 1927, a separate office was dedicated to the department on the second floor.

ii. Climate Conditions in Dessau & Climate Change Predictions:

Current Conditions of Climate

The city of Dessau-Roßlau in Saxony-Anhalt has a similar climate with the rest of Germany, which can be described as temperate and marine with cold, cloudy winters and warm summers. The dominant winds come from the West and they are of humid nature. The overall climate in the area has a continental character³² with immensely cold, lengthy winters and summers that are increasingly warm.³³

According to Meteoblue, a meteorology service based in the University of Basel, the warmest months in Dessau-Roßlau are July and August with daily average temperatures sometimes exceeding 86 °F. However, the mean daily temperature during the summer months is as low as 76 °F.³⁴ This suggests that although the average daily temperature

 ³² Refers to "continental climate" observed in areas with very cold winters and warm, dry summers.
 ³³ Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021,

https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau germany 2937959. ³⁴ Please see Appendix B for graphs related to the climate of the region.

throughout the entire summer season is not very high; on some days, especially in the month of July, temperatures rise to a level that is outside the range of human comfort, which is defined as "between approximately 67 and 82 °F" according to the ASHRAE Standard 55-2017.³⁵ The same meteorology data shows that during the winter months of December, January and February, the mean daily minimum temperature drops below 32 °F with most snowfall also occurring in these months.³⁶

Another essential aspect of the climate conditions is the number of sunny days in the area. The number of sunny days is highest during July and August, with an average of 6.8 sunny days in July and 7.7 sunny days in August, corresponding with the highest daily average temperature data.

The yearly precipitation amount in the area has an average distribution with 210.9 dry days per year. On average, the number of days with more than 10 mm of precipitation is 8.4 mm.

As mentioned above, the dominant winds in the area come from the West, the West-Southwest and the Southwest. The humid winds are of larger force scale in these directions.³⁷ Noting the wind patterns of the area is important, considering the positioning of the glass curtain wall of the Studio Wing, which has operable windows facing the Southwest direction.

³⁵ ANSI/ASHRAE (2017) Standard 55: 2017, Thermal Environmental Conditions for Human Occupancy. ASHRAE, Atlanta

³⁶ Please see Appendix B for graphs related to the climate of the region.

³⁷ Please see Appendix B for wind rose.

Climate Change and Predictions for the Future

The climate in Germany has shown changes in the 20th century as it has in the rest of the planet. A 2005 study by the German Federal Environmental Agency explains that the change of climate patterns has not been linear over time, noting that the period around 1940s was "exceptionally warm" and a "cooling trend followed until the 1970s". Since the 1970s, there has been a continuous and rapid increase in the average annual temperature throughout the country. The study also emphasized changes in precipitation levels, which varied between regions. However, it is notable that precipitation levels increased by 34% in winter and 13% in spring between 1971 and 2000.³⁸

A more recent study conducted by the German Federal Environmental Agency, whose headquarters are located in Dessau-Roßlau, predicts that the annual average temperature in northern Germany will increase of up to 2 °C in the period between 2021 and 2050. In the more distant future the predicted increase in temperature could be as much as 3.5 °C. The number of hot days during the summer is expected to have an increase of up to 10 days annually, with increased impact on indoor climate and cooling systems is predicted for the near future. The same study foresees increased precipitation during winter and a decreased amount of rainfall during the summer months, causing extended dry summer periods. In the long term, winds are also expected to grow stronger. ³⁹

https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate change 24 2015 s ummary vulnerabilitaet deutschlands gegenueber dem klimawandel 2.pdf

³⁸ German Federal Environmental Agency (Umweltbundesamt), *Germany's Vulnerability to Climate Change*, (Dessau-Roßlau: Umweltbundesamt, 2015),

³⁹ German Federal Environmental Agency (Umweltbundesamt), *Climate Change in Germany:Vulnerability and Adaptation of Climate Sensitive Sectors,*, (Dessau: Umweltbundesamt, 2005), <u>https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2974.pdf</u>

iii. History & Significance

The Bauhaus building was commissioned by the city of Dessau and Gropius developed the designs between 1925 and 1926. Construction of the building complex was completed in 1926. Gropius was involved in every aspect of the building, from construction management to the interior decoration and design of the furniture used throughout.

The initial inspiration for the industrial appearance of the Dessau building came from the Faguswerk, which Gropius and Adolf Meyer had designed before WWI in Alfeld on the Leine in Lower Saxony, Germany. The building includes numerous features that would later become the key characteristics of the International Style, namely the flat roof, the enormous glass curtain wall and the sleek steel window frames. The Dessau school was "a crystal clear, wonderful, monumental building that is a classic example of constructivism in architecture" according to Kurt Kranz, a former student of the Bauhaus.⁴⁰ The exceedingly modern techniques of construction allowed for drapes of glass and steel, which could also be used for air circulation as the individual window elements were operable. These individually operable windows were combined in such an impressive way that they created a large curtain wall of steel and glass.

Importance was also given to the communicative nature of the building, which expressed the collaborative function of the school that was so important to Gropius. The use of clear glass along with the distinctively spacious staircase enabled the visibility of different workshops and common recreational areas, therefore the collaborative nature of the school was realized. Even in the individual rooms of students in the dormitory wing,

⁴⁰ "The Face of the Twentieth Century Bauhaus (1994) Frank Whitford," YouTube (Classifilm, February 3, 2020), <u>https://www.youtube.com/watch?v=yuaGN45mLu0</u>.

Gropius inserted balconies that facilitated direct and close communication from one balcony to another, on the grounds of providing a continuous sense of synergy and connection among students.

Inside, modern décor was noteworthy. Gropius was fascinated by two things; honesty and innovation, and he wanted transparency in both the literal and the figurative sense. Combining his admiration of innovation in industrial design with his search for transparent expressivity, he placed radiators right at the edge of the workshops, so that they were visible through the glass façade. He was fascinated with the radiators as they were the latest industrial design. The radiators were the latest industrial design and also used as decorative elements on the walls accompanying the main staircase--visible expressions of Gropius' manifesto of the "unity of art and technology".⁴¹ He was interested in making visible "what ordinarily was hidden / tucked away," and for him this was a matter of "moral honesty", a principle that had impact throughout the building.⁴² All parts, no matter how large or small, showed how they were made - walls, lighting, and even the smallest of bolts.

The students and masters of the Bauhaus carried out education in Dessau starting in 1926 until 1932 when the National Socialist Party decided to dissolve the school. For a brief time period afterwards, the school was used by the NSDP for the education of their members.⁴³ Allied bombings of the city of Dessau in 1945 damaged the building

⁴¹ The Bauhaus Manifesto - Articles," bauhaus imaginista, accessed November 23, 2020, <u>http://www.bauhaus-imaginista.org/articles/1771/bauhaus-manifesto-re-cap</u>.

⁴² absolutMEDIENBerlin, "Bauhaus – Modell Und Mythos / DVD-Trailer," December 13, 2013, <u>https://www.youtube.com/watch?v=FKF4TvQljDI</u>.

⁴³"Das Bauhaus in Dessau," Das Bauhaus in Dessau (Bauhaus Dessau Foundation), accessed December 3, 2020, <u>https://www.bauhaus-dessau.de/en/history/bauhaus-dessau/the-bauhaus-dessau.html</u>.

significantly, especially the windows of the glass curtain wall of the Workshop Wing. In some parts of the wing "complete detachment from the concrete slab structure" occurred.⁴⁴

After the German Democratic Republic rediscovered the Bauhaus heritage, the building complex was listed as a national East German landmark in 1974. This led to an extensive restoration project in 1976, the scope of which will be discussed in detail in a following section of this thesis.

Four years following the 1990 reunification of Germany, the German Federal Government started a foundation that aimed to study and preserve the heritage of the Bauhaus. The Bauhaus Foundation still operates as a non-profit organization today. After the building's designation as a World Heritage Site by UNESCO in 1996, the Foundation took the initiative to organize a large restoration project between 1996 and 2006.

Currently, the Bauhaus Dessau serves as the headquarters of the Bauhaus Foundation and accommodates artist residency programs, academic conferences and education programs on a regular basis. The building complex is also open as an attraction for visitors throughout the year.

The building complex in Dessau, along with the Bauhaus school buildings in Weimar, were added to the World Heritage List by UNESCO in December 1996 for the reasons that the Bauhaus "revolutionized architectural and aesthetic concepts and practices between 1919 and 1933" and that the institution "represents the desire to develop a modern architecture using the new materials of the time (reinforced concrete, glass, steel) and

⁴⁴ Ayón Angel, Uta Pottgiesser, and Nathaniel Richards, "Bauhaus Dessau," in *Reglazing Modernism Intervention Strategies for 20th-Century Icons* (Basel: Birkhäuser, 2019), 196-209.

construction methods (skeleton construction, glass facades)."⁴⁵ The statement of significance created by UNESCO identifies the Bauhaus Dessau, along with the other buildings in the city designed by Bauhaus architects ⁴⁶, as "fundamental representatives of Classical Modernism", emphasizing the iconic role of the Bauhaus in shaping the architecture of the 20th century.⁴⁷ Additionally, the report noted that "that this type of inscription testifies a better recognition of the 20th century heritage", signalizing to the increased importance of preserving modern architecture.⁴⁸

iv. Character-Defining Elements

Although the detailed analysis of all the character-defining elements of the large building complex Bauhaus Dessau is not in the scope of this thesis, a brief summary of the CDEs is given here, following the guidelines given by the National Parks Service in *Preservation Brief 17 - Architectural Character—Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving their Character.*⁴⁹

⁴⁵ UNESCO World Heritage Centre, "Bauhaus and Its Sites in Weimar, Dessau and Bernau," UNESCO World Heritage Centre, accessed April 15, 2021, <u>https://whc.unesco.org/en/list/729/</u>.

⁴⁶ The World Heritage Site status of the Bauhaus was expanded in 2017 such that it includes the Masters' Houses, the ADGB Trade Union and the Houses with Balcony Access all located in Dessau. A map showcasing the expansion can be found in Appendix A.

⁴⁷ UNESCO World Heritage Centre, "Bauhaus and Its Sites in Weimar, Dessau and Bernau," UNESCO World Heritage Centre, accessed April 15, 2021, <u>https://whc.unesco.org/en/list/729/</u>.

⁴⁸ UNESCO World Heritage Committee. *Convention Concerning the World Cultural and Natural Heritage Report*. Merida, Mexico: UNESCO, 1997.

⁴⁹ Lee H. Nelson, Preservation Brief 17: Architectural Character—Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving their Character, (Washington, DC: National Parks Service, 1982), <u>https://www.nps.gov/tps/how-to-preserve/preservedocs/preservation-briefs/17Preserve-Brief-VisualAspects.pdf</u>

Overall Visual Aspects:

- Asymmetric design of the interconnected cubic blocks
- Individual blocks reflecting their separate functions
- Industrial appearance enabled by the steel skeleton and reinforced concrete structure
- Flat roofs (some of which are fully accessible) covered with asphalt
- Open façades
- Extensive use of glass throughout the building
- Transparency and reflective character of glass throughout the building
- The glass curtain wall of the Workshop Wing
- Balconies of the Studio Wing

Visual Character at Close Range:

- Sleek steel window frames used throughout the building
- White stucco used on the exterior of walls
- The iconic Bauhaus sign
- The visibility of interior building materials, most importantly the steel columns from the exterior of the building. This is especially significant for the Workshop Wing with the presence of the glass curtain wall.
- Deliberate lack of ornaments on the exterior
 - Interior Spaces, Features and Finishes:
- Color schemes of individual spaces
- Spacious staircase of the North Wing

- Furniture and décor made of industrial materials, mostly at the Bauhaus workshops by students
- Radiators made of industrial materials used as décor
- Deliberate lack of ornamentation on the interior
- Innovative opening mechanisms and various directions of operability of windows throughout the building.

C. CHRONOLOGY OF CHANGE AT THE BAUHAUS DESSAU

During its ninety-five-year history, the Bauhaus Dessau witnessed many changes, both in the building itself and of the stakeholders involved. As mentioned in previous sections of this text, the Bauhaus operated in the building between 1926 and 1932. Although the institution had changed directors twice - from Walter Gropius to Hannes Meyer in 1928 and from Meyer to Mies van der Rohe in 1930 - the building itself did not experience any major changes in this period, except for alterations in the heating system. As Daniel Barber wrote, the building initially used a low-steam heating system "consisting of five pulverized coal (PC) boilers that used coal dust as fuel." The heating system was only slightly modified with the replacement of two boilers in 1931. ⁵⁰

After the departure of the Bauhaus students and masters from Dessau to Berlin in 1932, the National Socialist Party briefly used the building for their activities. Again, there is no documentation of significant changes to the building during this time. Perhaps the most significant change to the building happened with the Dessau bombings of 1945, which

⁵⁰ Daniel A. Barber, "Heating the Bauhaus: Understanding the History of Architecture in the Context of Energy Policy and Energy Transition", *Perspecta: the Yale Architectural Journal* 53, (2020)

almost destroyed the curtain wall of the Workshop Wing, causing significant loss of character defining original fabric. A partial restoration process occurred between 1946 and 1947. The heating systems also were altered during this time; the boilers were converted to burn raw coal, which decreased their efficiency significantly and increased pollution. As coal was stored in bunkers under the connecting bridge, a ramp was installed between the storage area and the boilers, which caused an alteration in the exterior and partition walls.⁵¹

After the partial destruction of the glass curtain wall in 1945, a large part of it was repaired by inserting "brick masonry infill walls and wood frame windows," which remained in place until 1961.⁵² A brief façade renovation went on in 1965, following the building's designation as a landmark for the District of Halle in 1964.

By 1967, the heating systems of the building were considered to be outdated and new boilers were installed. The heating schedule was also rearranged, such that during frost conditions, all boilers remained in operation twenty-four hours a day to protect the building's internal systems and furniture from frost damage. Due to the coal shortage of the early 1970s, the boilers were upgraded once again, with coal storage relocated to an area behind the Studio Wing, also known as the Dormitory. Over a short period of time, this change caused significant discoloration in the exterior as well as the interior walls of the building, interfering with the appearance of the characteristic, perfectly white stucco.⁵³

The designation of the Bauhaus Dessau in 1974 as a national landmark by the German Democratic Republic (GDR), also known as East Germany, followed the GDR's rediscovery of German heritage. This designation inspired an extensive restoration project

⁵¹ Barber, "Heating the Bauhaus"

⁵² Angel, Potgiesser, Richards. *Reglazing Modernism*.

⁵³ Barber, "Heating the Bauhaus"

in 1976, to mark the 50th anniversary of the building. The project included the reconstruction of the glass curtain wall as well as the windows on other parts of the building.⁵⁴ In addition, there was a plan to alter the heating systems. A gas-fired system was considered, but the existing building infrastructure was not strong enough to support this system. Therefore, after failed attempts to connect the building to the district heating network, the relatively inefficient heating system based on coal remained. In 1978, some pipes and radiators were damaged by an instant decrease in temperature. This led to installation of a new heating system throughout the building based on radiators heated by warm water.⁵⁵

The World Heritage designation stimulated a second restoration project between 1996 and 2006, involving the reconstruction of some windows to match the originals as well as the reinstallation of several original windows that were rediscovered on site.⁵⁶ The heating systems were also altered following the building's successful connection to the district heating system in 1998. This allowed for the reuse of the boiler room as a space for visitors.⁵⁷

A third phase of interventions took place between 2009 and 2012 at the Bauhaus Dessau, focusing on improving the overall energy performance of the building. The interventions were performed on the windows of the North wing and the Studio wing. Additionally, there were changes in the programming of the Bauhaus Dessau in response to problems of condensation and energy performance issues, including relocation of offices

⁵⁴ The next section of this text will look at this restoration period in detail.

⁵⁵ Barber, "Heating the Bauhaus"

⁵⁶ The next section of this text will look at this restoration period in detail.

⁵⁷ Barber, "Heating the Bauhaus"

and restricting the use of the Workshop wing. The Bauhaus Foundation's reasons to pursue this most recent phase of interventions include increased visitor numbers as well as the desire to increase thermal comfort for occupants throughout the building.

Change of Stakeholders

The stakeholders involved with the Bauhaus Dessau changed multiple times over the course of the building's history.⁵⁸ The involvement of multiple stakeholders, some of whom were international organizations such as UNESCO and ICOMOS, is critical to understanding the complexity of the three distinct phases of renovations that took place in 1976, 1996 - 2006 and 2009 – 2012, respectively. In the 1970s, upon the GDR's efforts to re-explore German heritage, early 20th century German art and architecture gained importance with heritage conservation endeavors focusing more on "modern monuments".⁵⁹ The designation of the Bauhaus Dessau as a national landmark was part of this movement to conserve early German modernism, leading to the decision to restore the heavily-damaged curtain glass wall of the Workshop Wing to regain its aesthetic and functional significance. Until 1994, the building served as an education center for the German Office for Industrial Design led by Martin Kelm, who was also involved in the historic preservation efforts at the Bauhaus Dessau.

Perhaps one of the most important changes in stakeholders took place when the Bauhaus Foundation came in possession of the building in 1994. The foundation is a nonprofit organization that is "funded by the State of Saxony-Anhalt, the Federal

⁵⁸ For the detailed history of building use and ownership between 1932 - 1999, please refer to "Uses of the Bauhaus Building 1932 - 1999" by Ralf Kölner in *the Bauhaus Dessau Building* 1926 - 1999

⁵⁹ Monika Markgraf, "Einblicke in Die Dessauer Bauhausbauten Als Materielles Erbe," *Architectura*48, no. 1-2 (January 2018): pp. 134-153, <u>https://doi.org/10.1515/atc-2018-1008</u>.

Commissioner for Culture and the Media and the City of Dessau-Roßlau."⁶⁰ The Foundation's mission as both an artistic and a scientific organization contributed to research on the Bauhaus Dessau itself, with specific work done to understand, document and repair building materials.

The second main restoration process included multiple stakeholders engaged in it, namely the Bauhaus Foundation, UNESCO, ICOMOS and the city of Dessau. The ten-year period of restoration was undertaken by Brambach & Ebert Architekten, a firm based in the District of Halle. Three years after the second general restoration ended, a new phase of renovations that targeted improved energy performance began. The project was supervised by ICOMOS as well as the Bauhaus Foundation, with Brenne Architekten, a Berlin-based architecture firm, and TransSolar, a multinational "climate engineering" firm, performing the rehabilitation and reprogramming at the building.

ICOMOS Germany remained involved with the building throughout the execution of the project as well as a number of years after its completion by performing preventive monitoring between 2010 and 2015. Dr. Thomas Will of the Technical University of Dresden and Dr. Andreas Schwarting of the University of Applied Sciences Konstanz provide an overview of this monitoring process in their presentation for the World Heritage Committee's 39th Session, held in Bonn in 2015, which shows that the involvement of

⁶⁰"Bauhaus Dessau Foundation," Foundation: Stiftung Bauhaus Dessau / Bauhaus Dessau Foundation (Bauhaus Dessau Foundation), accessed May 2, 2021, <u>https://www.bauhaus-dessau.de/foundation.html</u>.

academics in addition to international organizations played a decisive role during the upgrading of the Bauhaus Dessau.⁶¹

⁶¹ "Preventive Monitoring of World Cultural Heritage Sites" (Bonn: ICOMOS Germany, 2015), pp. 43-61.

PART 4: ANALYZING STRATEGIES OF PRESERVATION AT THE BAUHAUS

A. DISCUSSION & CRITIQUE OF STRATEGIES

i. Strategies of Preservation

The first comprehensive restoration of 1976 followed the building's designation as a national landmark by the GDR in 1974. Although a chronological survey of Germany's preservation policies is beyond the scope of this thesis, it is worth mentioning here that the decisions and strategies followed in this first restoration influenced the later interventions. For instance, in 1976, the iconic curtain glass wall of the Workshop Wing was reconstructed using aluminum frames instead of steel, as in the original designs. In lieu of restoring the original steel frames during the most recent phase of renovations, the aluminum sashes were preserved as an homage to the East German preservation philosophy of the 1970s, which in itself has become part of the building's history. The reconstruction was considered "a completely new kind of monument preservation process for all concerned", due to the limited previous experience in the GDR with modern heritage.⁶² In fact, it was the Foundation's as well as the architects' opinion that the reconstruction "demonstrates the GDR's excellent achievement in monument conservation." ⁶³

Based on existing literature, documentation and data supplied to the author by a number of stakeholders, the preservation strategies used in the three phases of intervention can be summarized as shown in Tables 1 - 3 below. The strategies are assigned for the

⁶² Wolfgang Paul, "Renovation 1976" in *The Dessau Bauhaus Building*, 1926 – 1999, ed. Margret Kentgens-Craig (Birkhäuser, 1998) 160-173

 ⁶³ Winfried Brenne and Ulrich Nickman, "Neue Fenster fürs Bauhaus, DE-Dessau," Architektur
 + Technik (August 2012), p. 97, accessed 11 May 2019, <u>http://www.architektur-</u>

 $[\]label{eq:constraint} \underline{technik.ch/Web/internetAxT.nsf/0/5845EF24E2DDBD5EC1257A83004EC0CC/\$file/096-100\%20Bauhaus-Fenster.pdf?OpenElement.}$

three main parts of the building, namely the Workshop Wing, the Studio Wing and the North Wing. It should be noted that later on in this text, the discussion will center mostly around the strategies followed during the most recent phase of interventions, in accordance with the focus of this thesis. The categorization of strategies used in the Bauhaus Foundation's interventions to the windows is based on the classification of interventions adopted by authors Potgiesser, Ayon and Richards in their 2019 book, *Reglazing Modernism: Intervention Strategies for 20th Century Icons*. Other strategies related to reprogramming and a number of miscellaneous action items specific to the Bauhaus have also been noted.⁶⁴

For contextual clarification, the categories Restoration, Rehabilitation, Replacement, Reinstallation and Reprogramming are defined below by the author: ⁶⁵

- Restoration; refers to all acts of modification that have the goal of converting existing building parts and/or individual elements back to their original appearance. Includes acts of recreating missing / detached building parts.
- Rehabilitation; refers to all acts of changes, repair and upgrade without detaching any building parts. Includes minor repairs of existing original fabric.
- Replacement; refers to the physical act of changing existing building elements with different, in most cases new/upgraded ones.
- Reinstallation; refers to the act of attaching original building materials and/or elements found on site back in the building.

⁶⁴ Angel, Potgiesser, Richards. *Reglazing Modernism*.

⁶⁵ These definitions do not precisely match those included the Secretary of the Interior's Standards and were created by the author to help the reader comprehend the strategies followed at the Bauhaus Dessau over the years.

• Reprogramming; refers to changes of use and/or relocation of some spaces within the building.

Before the detailed analysis of each of the categories, it should be noted that the Bauhaus Foundation's contributions to the planning of interventions were invaluable. The Foundation categorized the windows of the building into three groups, namely as "to be preserved, investigated or changed." ⁶⁶ The establishing of these groups helped the preservation architects and the climate engineering team in their decisions about alterations. The windows that were designated to be preserved were mainly on the Workshop Wing, and this category included the entirety of the glass façade.

⁶⁶ Brenne, Nickman, "Neue Fenster fürs Bauhaus, DE-Dessau"

WORKSHOP WING			
YEAR	STRATEGY	CATEGORY	
1976	Curtain glass wall reconstructed using aluminum frames instead of steel as in original design. Aluminum was anodized to match original appearance.	Restoration	
1976	Plate glass with single glazing used as in original design.	Restoration	
1976	Operabillity features and mechanisms reconstructed with respect to original designs.	Restoration	
1976	Exterior walls rendered and sprayed with paint to regain original appearance.	Restoration	
1999	Technical survey executed on the curtain wall to determine the level of structural integrity and service life.	Miscellaneous	
2006	Walls and ceiling covered with thin layer of plaster to enhance protection of original finishes without compromising original appearance.	Rehabilitation	
2009	Glass surfaces were assessed and categorized as to be "preserved, investigated or changed"	Miscellaneous	
2009	An initial energy performance analysis was performed to comprehend the largest possible improvement degree of energy efficiency.	Miscellaneous	
2011	Energy management concepts were developed.	Miscellaneous	
2011	All office spaces were relocated to the North Wing to limit the use of the Workshop Wing to special events only.	Reprogramming	
2011	The temperature of the Workshop Wing is kept at 16° C to reduce costs of heating and to solve condensation problems.	Miscellaneous	

Table 1. A chronology of preservation strategies at the Workshop Wing

STUDIO WING			
YEAR	STRATEGY	CATEGORY	
1976	Glazing of windows modified, reducing transparency.	Rehabilitation	
1976	Operability of windows reduced with a number of windows being sealed.	Rehabilitation	
1976	Original window frames replaced with simpler versions.	Replacement	
2006	Walls and ceiling covered with thin layer of plaster to enhance protection of original finishes without compromising original appearance.	Rehabilitation	
2006	Window frames were painted the same color as original designs in 1926.	Restoration	
2009	Glass surfaces were assessed and categorized as to be "preserved, investigated or changed"	Miscellaneous	
2009	An initial energy performance analysis was performed to comprehend the largest possible improvement degree of energy efficiency.	Miscellaneous	
2011	Energy management concepts were developed.	Miscellaneous	
2011	Window frames from 1976 were replaced with thermally insulated hot rolled flat steel sections and thermal breaks, their appearance respecting the original designs from 1926.	Replacement	
2011	Trial and error process was executed by testing the appearance of windows using different levels of insulation and glazing.	Miscellaneous	

Table 2. A chronology of preservation strategies at the Studio Wing

NORTH WING				
YEAR	STRATEGY	CATEGORY		
1976	Operability of windows reduced with a number of windows being sealed.	Rehabilitation		
1976	Original window frames replaced with simpler versions.	Replacement		
2006	Walls and ceiling covered with thin layer of plaster to enhance protection of original finishes without compromising original appearance.	Rehabilitation		
2006	Original windows already present were preserved with minor maintenance work.	Rehabilitation		
2006	Window frames were painted the same color as original designs in 1926.	Restoration		
2006	Damaged windows reconstructed with respect to original appearance in 1926.	Restoration		
2006	Irrepairably damaged windows replaced with reconstructed versions.	Replacement		
2006	Original windows rediscovered at a greenhouse on site, reinstalled into the building after treatment.	Reinstallation		
2009	An initial energy performance analysis was performed to comprehend the largest possible improvement degree of energy efficiency.	Miscellaneous		
2009	Glass surfaces were assessed and categorized as to be "preserved, investigated or changed"	Miscellaneous		
2011	Energy management concepts were developed.	Miscellaneous		
2011	All office spaces were relocated to the North Wing to limit the use of the Workshop Wing to special events only.	Reprogramming		
2011	Photovoltaic pannels were installed on the roof to compensate for energy losses caused by the single glazing of the curtain glass wall.	Miscellaneous		
2011	Innovative insulation curtains were installed for increased thermal comfort of habitants.	Miscellaneous		
2011	Trial and error process was executed by testing the appearance of windows using different levels of insulation and glazing.	Miscellaneous		

Table 3. A chronology of preservation strategies at the North Wing

a. Restoration

Most of the strategies categorized in this thesis under restoration were carried out at the Workshop Wing, specifically the curtain glass façade, during the interventions of 1976, as can be seen from Table 1. Existing literature states that the decision-making process at the time was driven by two main considerations. The first of these was the uniqueness of the site, as the conservation of modern heritage was mostly unprecedented in the GDR. The second was regaining the original appearance of the curtain glass façade to the highest degree possible. ⁶⁷ The damage on the Workshop Wing caused by the War was substantial and the original fabric was mostly destroyed with little to no original drawings of the windows. Thus, the reconstruction of the curtain glass wall relied heavily on historic photographs.⁶⁸

One of the major points of discussion related to the 1976 renovations was the reconstruction of the curtain glass façades in aluminum. The decision was based on the need to "reduce maintenance costs." Anodizing enabled the aluminum frames and sash to achieve a similar color to the original steel frames without having to be painted regularly. Structural analysis was performed to eliminate the possibility of structural failure.

Another aspect of the 1976 interventions was the decision to use plate glass with single glazing in the reconstruction of the glass façade, rather than using coated glass. At the time, it was acknowledged that the latter would be a better choice. However, the significance of the transparency and reflective character of the glass façade was important, in compliance with the preservation philosophy based on maintaining the innovative

⁶⁷ Wolfgang Paul, "Renovation 1976"

⁶⁸ Monika Markgraf, "Einblicke in Die Dessauer Bauhausbauten Als Materielles Erbe"

character and architectonic features of the Bauhaus, single glazed plate glass was selected.⁶⁹ The 1976 interventions were thus the starting point of the discussions of compromises between energy efficiency -or thermal performance- and preserving the architectural character at the Bauhaus Dessau.

For existing windows in other parts of the building, the appearance of windows was the main concern. Considering the building's designation in the World Heritage List, achieving an overall appearance that matched the original was very important, taking the expected increase in visitor numbers into account as well, given the appeal of the building as a site of tourism.

Interventions in the 1999-2006 period did not consider any upgrades to the building's energy performance. As Monika Markgraf wrote in an article that elaborates on the priorities of this intervention period, the main concern then was to retain as much original fabric as possible, in addition to the detailed technical, structural and material surveys conducted on the building. Although it is expected and understandable that the priorities were determined in accordance with the World Heritage nomination criteria with emphasis on material integrity, the total lack of consideration of the building's energy properties during this period is peculiar from a preservation technology and energy performance point of view.

b. Rehabilitation

Referring to changes made on existing building parts, rehabilitation strategies were used during all three main phases of interventions. It is important to note here, that, in the

⁶⁹ Wolfgang Paul, "Renovation 1976"

case of the Bauhaus Dessau, not all strategies of rehabilitation improved the energy conservation of the building. During the work done in 1976, for instance, changes made to the Studio Wing windows that compromised their authentic functionality as well as their original appearance. Most of the windows of the Studio Wing were sealed and their direction of operability changed. Sealing window openings, thus reducing the number of operable windows, was expected to decrease air infiltration and therefore reduce heating costs. However, the mechanical opening mechanisms of the windows were part of the innovative character of the Bauhaus Dessau, so this decision represented a compromise. Another compromise occurred when the glazing of Studio Wing windows was modified, intervening with the transparency of the glass. This decision was specific to the Studio Wing windows as improved energy conservation was prioritized over the characterdefining transparency, as opposed to the decision of using single-plate glass in the reconstruction of the glass façades of the Workshop Wing. The rehabilitation strategies of the second renovation project in the 2000s mostly had a reparative nature with minor maintenance work.

c. Replacement

Replacement of existing fabric started in 1976 and continued in all three phases of intervention. The first example was when a number of the original steel window frames and sashes were replaced with simplified versions in the reconstruction process of 1976. This affected the windows of the Studio Wing, the Festive Area and the North Wing. In the following phase, windows that were damaged beyond repair in the connecting bridge and the North Wing were replaced with reconstructed versions based on original window designs. The largest number of replacements were executed during the latest phase of interventions. First, the 1976 window frames in the Studio Wing were displaced. These reconstructed frames did not have thermal breaks or thermal insulation. After energy p analysis performed prior to the start of interventions showed that air infiltration constituted the major cause of energy loss throughout the building, insulated window frames were a priority.⁷⁰ The energy cost analyses showed that heating the Bauhaus Dessau required a larger budget every year, with the total cost of district heat increasing 25% between 2009 and 2010 alone.⁷¹ Such a dramatic change, with the desire to enhance user comfort to meet contemporary thermal standards, required improved energy performance.

The replacement of window frames was challenging, as all stakeholders agreed that respecting original designs and materiality was essential, yet thermal performance had to be upgraded. Following a thorough market search for manufacturers of thermallyinsulated, hot rolled steel frames, new flat steel sections incorporating thermal breaks were installed in the Studio Wing. The sashed of sealed windows were modified and elements of the opening mechanism replaced with reconstructed ones.

For the Studio Wing windows, after careful consideration of energy loss and the compromised transparency caused by the 1976 renovations, multiple glazing options were tested. In the end, low-iron float glass with uncoated double glazing replaced the glass from 1976. The choice of uncoated glazing was finalized after evaluations of the character defining transparency and reflection of light in the building: Using uncoated glass enabled

⁷⁰ Christian Matt, Matthias Schuler, *Gesamtenergiekonzept für das Bauhaus Dessau* (Transsolar Energietechnik GmbH, Dessau: March 2013)

⁷¹ Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau

improvement in energy performance, though to a lesser degree than other choices, such as glass with low-reflective coating. A certain amount of compromise from was tolerable, and in fact, necessary, as respecting Walter Gropius' original vision for the building was considered as crucial as reducing energy costs. This replacement, along with the insertion of "mineral-based insulating plaster and thermal insulation made of fiberglass-strengthened plastic" on the frames, enabled a 66% reduction in the energy costs of the east façade of the Studio Wing.⁷²

d. Reinstallation

Original windows from 1926 that were detached from the building were discovered stored in a greenhouse on site.⁷³ Reinstalling them into the building during the second interventions phase was critical strategy. Thus, original historic fabric coexisted with reconstructed windows from 1976 and those which were restored and/or repaired in 2006. This strategy is particularly important when Article 11 of the Venice Charter is taken into consideration, as the historic changes in the building exert themselves in the form of this coexistence.

e. Reprogramming

Historically, there were programmatic changes in the building that resulted in new spaces for the use of visitors, but these were not executed with energy concerns. Here, the reprogramming strategy refers to the relocation of all offices to the North Wing and the limited use of the Workshop Wing. This is again related to compromise: the listed status

⁷² Brenne, Nickman, "Neue Fenster fürs Bauhaus, DE-Dessau"

⁷³ Monika Markgraf, "Conservation and Preservation of the Bauhaus Building in Dessau"

of the glass façade prohibited any alterations to the windows of the Workshop Wing.⁷⁴ The uninsulated aluminum frames of the glass façade, in addition to the single-glazed windows at such large quantities, creates significant heat loss. Therefore, keeping offices in this section would mean increased energy costs as well as a substantial waste of resources. An additional aspect of the reprogramming strategy included limiting the use of the Workshop Wing to special events for temporary time periods.

This represents two aspects of compromise. The first in energy performance. Although reprogramming the Workshop Wing minimizes energy loss through limited use, it does not it entirely. The second compromise relates to the original intention of use at the Workshop Wing. Walter Gropius designed the glass façade to optimize daylight for the students of the Bauhaus. The Bauhaus Dessau still hosts artist residency programs, as well as programs related to art and architecture education, so the inability of the students to use this space as it was originally intended represents a compromise of spatial use.

f. Miscellaneous

This last category of preservation strategies includes management strategies, energy analyses, technical surveys, temperature management and the installation of photovoltaic panels.

One of the key targets of the interventions made after the World Heritage designation was understanding the building so that the existing historic fabric could be salvaged to the greatest degree possible. a detailed survey of the building was executed with specific focus on the glass curtain wall of the Workshop Wing. This survey showed that the glass façade was in good condition and it did not possess any structural risks. In

⁷⁴ Brenne, Nickman, "Neue Fenster fürs Bauhaus, DE-Dessau"

combination with its listing as a character defining feature, the glass façade was thus able to be kept outside of any renovations. This also provided the opportunity to include the reconstruction period of 1976 in the historic character of the building, treating the preservation strategies of the period as cultural heritage assets.

Before the most recent interventions, an energy performance analysis was carried out to identify building parts that were most problematic in terms of energy loss and thus, able to the largest possible improvements in energy efficiency. The analysis also served the stakeholders to comprehend that, the Workshop Wing required the largest amount of heating and cooling energy.⁷⁵ Following the energy analysis, energy management strategies? were developed. These concepts included a number of action items such as comparing operating and comfortable temperature levels, creation of operating optimization plans and calculations of targeted CO2 emissions.⁷⁶

Another strategy related to the reprogramming of the Workshop Wing was the temperature management in this section. There had been severe problems from condensation on the curtain wall due to the lack of thermal breaks in the aluminum frames and the single-glazing. The climate engineering team and the architects agreed to maintain the interior temperature of the space at $16 \degree C.^{77}$ This strategy also reduced heating and cooling costs.⁷⁸ At this point, however, the question of thermal comfort during the use of the space arises – as the use of the Workshop Wing has not been eliminated altogether but instead limited use was planned for events such as conferences and workshops.

⁷⁵ Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau

⁷⁶ Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau

⁷⁷ 16 ° C = 60.8 ° F

⁷⁸ Brenne, Nickman, "Neue Fenster fürs Bauhaus, DE-Dessau"

The insertion of photovoltaic panels on the roof of the North Wing as well as the use of insulation curtains on some of the office windows in this section of the building are also noteworthy. The architects explain that installing photovoltaic panels compensated for energy losses occurring at the Workshop Wing due to the unrehabilitated glass façade.⁷⁹ This could be considered as a disruptive addition to the flat roof of the building, which is a character-defining feature of the Bauhaus Dessau; however, the consensus among stakeholders was that visitors could not see the roof or the photovoltaic panels on top of it and thus did not compromise in the building's monumental appearance.

A final strategy an essential one that summarizes the main challenge of energy efficiency upgrades in modern heritage buildings. During the process of considering possible alterations of glazing, especially in the windows of the Studio Wing where previous interventions had caused a loss of character-defining transparency, a trial-and-error method was used. Multiple types of glazing with different coatings were inserted in different locations of the building and evaluated visually to see if the changes were tolerable. The materials were also evaluated in terms of energy performance, taking their Ug values into consideration.⁸⁰ The architecture firm reported that, although uncoated glazing has a higher Ug value than coated glass, indicating that it is less efficient, it was the final choice, since the coatings caused a significant compromise on the reflective property of the windows.⁸¹

Preservation Strategies & Climate Change

⁷⁹ Brenne, Nickman, "Neue Fenster fürs Bauhaus, DE-Dessau"

⁸⁰ Ug value refers to the thermal performance of glass panels.

⁸¹ Jan Cremers and Winfried Brenne, "Renovation of the Bauhaus Dessau," in *Building Openings*

Construction Manual: Windows, Vents, Exterior Doors (Munich: Edition Detail, 2016), pp. 230-233.

All of the strategies should be evaluated from the perspective of climate change. As explained in Part 3, annual average temperature in Dessau has shown a continuous increase over time and this pattern is not expected to change, bringing longer and warmer summers. Winters are expected to be colder, with more severe frost conditions. These changes may produce certain challenges for the Bauhaus Dessau and its occupants, especially in the Workshop Wing where no material changes were made due to the restrictions mentioned earlier in this text. Despite the reprogramming, the curtain wall still remains as single glazed with uninsulated aluminum window frames. These conditions propose the threat of even higher solar heat gains on the building due to the highly transmissive nature of the existing glass.

As Stephenson wrote as early as 1963, the orientation of "transparent walls" is also essential when considering solar heat gains, with the east and west façades having the most insolation during the period between April and October.⁸² Although a detailed analysis of solar angles and building orientation of the Bauhaus Dessau is outside the scope of this study, site plans and architectural drawings indicate that a large part of the glass curtain wall faces the west. None of the information provided by the climate engineering team, the preservation architects or the Bauhaus Foundation indicates consideration of building orientation in the planning of preservation strategies. Moreover, the strategies of the latest intervention phase focus mostly on reducing energy costs and energy performance in comparison with the building's past condition. There are no projections related to future

⁸² D. G. Stephenson, "Solar Heat Gain Through Glass Walls," *Canadian Building Digests* 39 (March 1, 1963), <u>http://web.mit.edu/parmstr/Public/NRCan/CanBldgDigests/cbd039_e.html</u>.

energy use or cost. Considering the thorough planning and analysis process followed at the Bauhaus Dessau, neglecting to include the impacts of projected changes in climate is indeed surprising. This gap provides a major opportunity for future studies on the energy use and the preservation of the Bauhaus Dessau.

B. EVOLUTION OF STRATEGIES AND PRESERVATION PHILOSOPHY

The Bauhaus school in Dessau is considered a monument of modernism and it is one of the pioneer examples of educational architecture in which an industrial aesthetic was adopted. Considering the numerous changes that have occurred at the building throughout the years, it would be appropriate to further acknowledge the Bauhaus Dessau as a monument of change. Political and historical events as well as economic developments have impacted the building. Thus, the significance of the Bauhaus school also lies in having witnessed multiple historical milestones throughout its life, such as World War II and the fall of the Iron Curtain. These events, along with political and financial changes in Germany and in Europe overall, had their impact on the building and were reflected in strategies of preservation followed by various stakeholders. An essential point to consider here is how these circumstances affected the standards of preservation, as the preservation is not isolated. It is concerned with social, economic and political issues just as much as with the historic built environment. The priorities in historic preservation practice, as well as preservation standards themselves, evolve over time and this evolution also leaves its marks on buildings that have experienced multiple phases of change. The Bauhaus Dessau constitutes a perfect example.

In the case of the Bauhaus Dessau, interventions occurred during periods when the political structures were different. The first main intervention phase happened in 1976, while the Iron Curtain was still present. The 50th anniversary of the Bauhaus Dessau was perceived as a precious opportunity to promote the GDR's image; thus, the priority was to fix the Workshop Wing's glass façades and return the building to its original exterior appearance. Material integrity and salvaging existing historic fabric were not seen as absolute necessities, as can be understood from the use of aluminum frames to reconstruct the glass façade and replacements of window parts in the Studio Wing. This focus on exterior appearance and lack of emphasis on material integrity in the German standards might be interpreted as a disregard of the Venice Charter, which clearly expresses the necessity in preserving original fabric.⁸³

The building's designation as an East German landmark in 1974 did not prevent the changes in historic fabric either. The renovations of 1976 were critical, since they were influential on the decision-making processes in later phases of interventions. This first phase of interventions indicate that reconstruction was an important step towards preserving the modernist icon. However, lack of awareness and/or involvement from international stakeholders as well as lack of knowledge about the challenges of preserving modern architecture meant that some of the changes would be frowned upon today.

The second phase of interventions occurred in the decade following Germany's unification and the international recognition of the Bauhaus as cultural heritage. The World

⁸³ IInd International Congress of Architects and Technicians of Historic Monuments, Venice, 1964. <u>https://www.icomos.org/en/participer/179-articles-en-francais/ressources/charters-and-standards/157-thevenice-charter/</u>

Heritage designation brought international stakeholders such as ICOMOS to the table, with regular supervision on all future preservation efforts at the Bauhaus Dessau. The adoption of internationally standardized norms in preservation, along with the formation of the Bauhaus Foundation, led to a new perspective on the building's conservation, one that is focused on retaining original building fabric. The foundation's focus on material authenticity was inspired by Walter Gropius' *Gesamtkunstwerk* concept, since the materials were seen to reflect the architect's vision. The foundation's preservation management explains that "...the (original) material is proof of the building technology and construction that must be preserved and protected... The exact knowledge of building material – its composition, its aging properties, its physical and static coactions with other building materials – is most important for concepts for the future preservation of old buildings."⁸⁴

The third and most recent phase of interventions were more complex, due to the added goal of energy efficiency improvements. Here, upgrading the building was as important as regaining significant original features. Replacing the Studio Wing's reconstructed aluminum window frames with steel and adding thermal insulation, for instance, directly responds to both goals. The consideration of thermal comfort, in addition to the maintained supervision of ICOMOS throughout the renovation process constituted a multifaceted renovation project. A final point to note is the high regard shown for the 1976 interventions, which were seen as an essential milestone in the building's history and as "a general turn in the appreciation of the modern architecture whose properties as cultural monument were increasingly recognized", thus leading the stakeholders to keep the

⁸⁴ Markgraf, "Conservation and Preservation of the Bauhaus Building in Dessau"

reconstructed curtain glass wall and compensate for energy losses by means of reprogramming and renewable energy solutions where applicable.⁸⁵

C. EXAMINATION OF WINDOW RENOVATIONS

The previously mentioned renovation projects have affected numerous elements of the Bauhaus Dessau. However, this thesis focused on changes on the windows. The most important changes to the windows are summarized in Tables 1 to 3. The most critical changes occurred at the windows of the Workshop Wing, the Studio Wing and the North Wing, so changes are summarized for these types in Tables 4 to 6.⁸⁶

⁸⁵ Markgraf, "The Glass Façades of the Bauhaus Dessau Building

⁸⁶ Please see Appendix C for elevation drawings indicating the locations of the windows.

WORKSHOP WING (GLASS CURTAIN WALL)						
	1926	1976	2006	2009-2012		
Window Components	1					
Frames	Double-rebated hot rolled steel frames.	Reconstruction with non- thermally broken aluminum frames, thicker mullions than original.	Retained as they were found to be in good condition.	Retained exactly as they are due to listed status of the curtain wall.		
Sashes & Operability	Individual elements of the curtain wall are operable.	Operability features also reconstructed according to original state.		Operability features were retained due to listed status.		
Operating Mechanism	Innovative opening mechanism.					
Glass	Crystal plate glass, single glazing.	Reconstructed with single glazing, with respect to original appearance	Retained as reconstructed in 1976.	Single glazing, insulation could not be applied due to the character defining nature.		
Window Treatments						
Curtains	none					
Other Measures				Condensation was causin structural problems, so reprogramming was executed by relocating some offices from the workshop wing to the north wing. The workshop wing is expected to be used only for short-term events in a temporary manner with indoor temperature fixed at 16° C.		

Table 4. Summary of changes in window elements (Workshop Wing)

The 1976 reconstruction of the glass façade remains unchanged. Initially, the preservation architects considered the option of applying double glazing on the façade, but this was dismissed because the change in appearance and the loss of light reflectivity were intolerable for a listed character-defining element.



Figure 8. Part of the glass façade at the Workshop Wing photographed in 2006 (Bauhaus Dessau Foundation, Martin Brück 2006)

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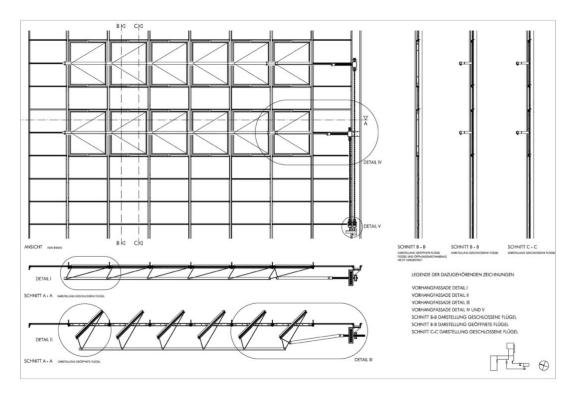


Figure 10. Reconstructed glass curtain wall

(Bauhaus Dessau Foundation, Petra Welhöner, 2003)



Figure 9. Reconstructed glass façade photographed in 2016

The renovations of the Studio Wing constitute a major part of the latest phase of interventions, which aimed to improve energy performance. As explained in the analysis of strategies, they were converted to their original operable state, allowing for natural ventilation, which decreased cooling loads. The most severe problem related to the energy performance of the Bauhaus Dessau was the excessive energy spent for heating the building, which is not surprising, considering the 24-hour usage of the dormitory.⁸⁷ The new double-glazing and the thermally-insulated hot-rolled steel frames were a significant solution that resulted in a reduction of 64% in the energy needed for heating.

The double glazing and insulation as well as the conversion to the original operating mechanism can be seen in the details below in Figure 11. Figures 12 and 13 show the direction of opening in the windows and the balcony door of a single unit at the dormitory facing the east, in 1976 and in 2011, respectively.

⁸⁷ Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau

	1926	WING (DORMITORY V 1976	2006	2009-2012
Window Components	1740	17/0	2000	2007-2012
Frames	Double-rebated hot rolled steel frames.	A number of frames were replaced with aluminum with larger, simplified profiles. Insulation was not applied.		Back to original appearance. Thermally insulated hot rolled flat steel sections with insertion of thermal breaks.
Sashes & Operability	Windows fully operable with various kins of sashes depending on direction of operation.	Most windows were sealed with a reduced number of operable windows.		Windows were converted back to original operable state with only slight modifications.
Operating Mechanism	Innovative opening mechanism.	Modified opening mechanism with changes in direction of operation.		Visible bascule locks and top-hung window fitting reconstructed with original finishes replicated. Opening direction converted to original state.
Glass	Crystal plate glass with single glazing.	Glazing was modified causing compromise in appearance.		Low-iron float glass was used with uncoated doubl glazing.
Window Treatments	•		•	1
Curtains	White curtains were used for privacy and shading purposes.			
Other Measures				Mineral-based insulating plaster and thermal insulation made of fiberglass-strengthened plastic used.**
Notes			Maintenance purposes mostly. The fifth floor windows on the west façade were reconstructed according to the 1926 model.***	
			***: See attached elevation drawings with color codes in the appendix.	**: See detail drawings included below for furthe information.

 Table 5. Summary of changes in window elements (Studio Wing)

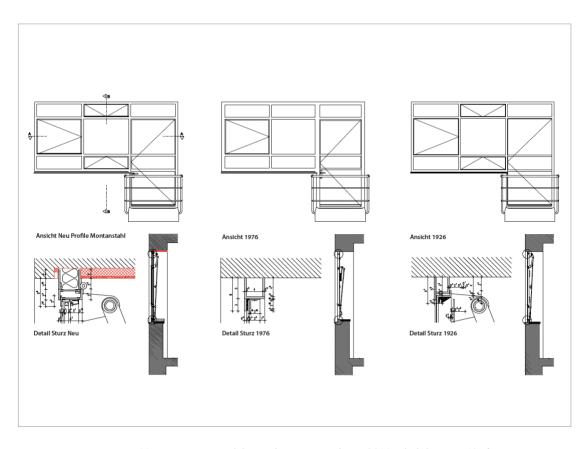
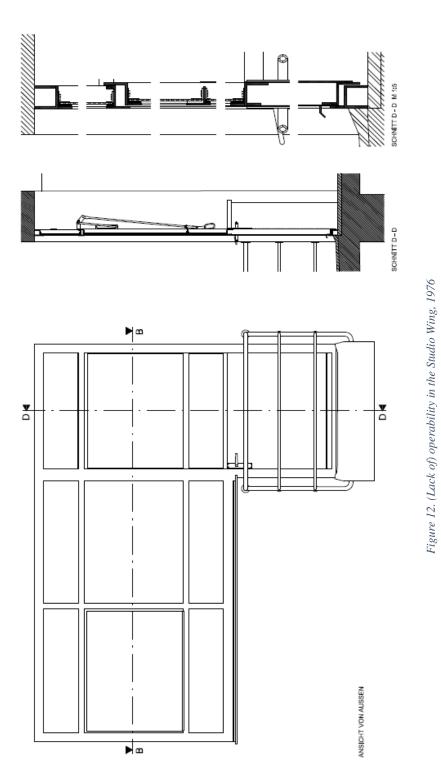


Figure 11. A comparison of the Studio Wing windows: 2011 rehabilitation, 1976 reconstruction and original construction in 1926

Monika Markgraf, "The Glass Façades of the Bauhaus Dessau Building", in Glass in the 20th Century Architecture: Preservation and Restoration, eds. Franz Graf, Francesca Albani (Mendrisio: Mendrisio Academy Press, 2011)





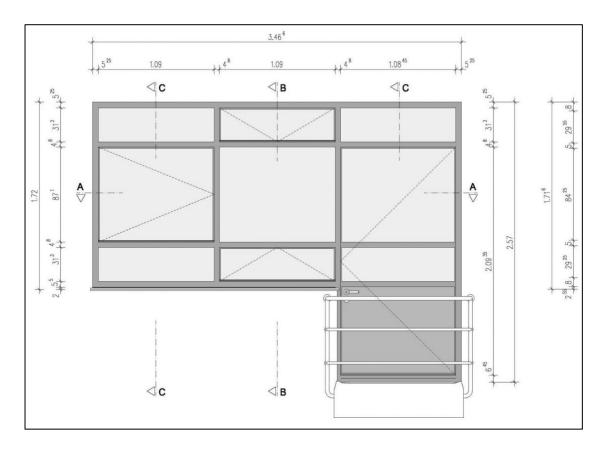


Figure 13. Operability of windows in the Studio Wing after 2011 renovations

(Brenne Architekten. 2012. Brenne Architekten, Berlin. Accessed 22 May 2021.) https://www.brenne-architekten.de/bauhaus-dessau/



Figure 14. Studio Wing windows and balcony doors facing the east after the renovations in 2011

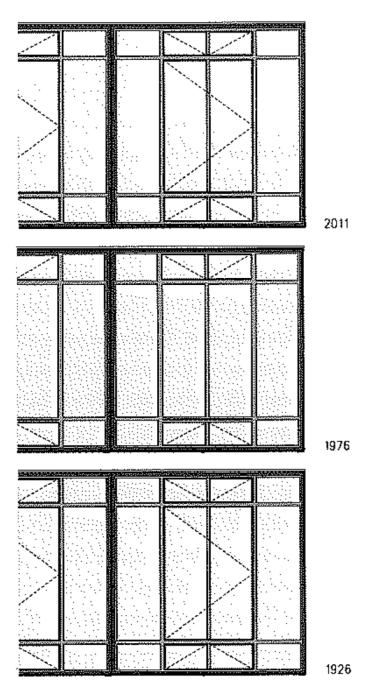
(Brenne Architekten. 2012. Brenne Architekten, Berlin. Accessed 22 May 2021.) <u>https://www.brenne-architekten.de/bauhaus-dessau/</u> The North Wing window changes were the result of innovative thinking and a thorough market research process. The energy analyses showed a serious air infiltration issue throughout the North Wing façades. Therefore, after detailed calculations and modelling of thermal bridges, the preservation architects decided to use an insulating plaster on the steel frames as well as "electrical protection heating" on the exterior that consists of a copper strip.⁸⁸ The copper strips are not visible from the exterior and, along with the thermal breaks of the hot-rolled steel frames and double glazing, they generated a 58% reduction in the heating energy of the North Wing. Additionally, this provides an "optimized level of comfort in winter."⁸⁹ A summary of changes on the North Wing windows is given below in Table 6. Detail drawings of the North Wing windows and their modifications can be found in Figures 15 through 17 below.

⁸⁸ Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau

⁸⁹ Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau

	1926	(ADMINISTRATIVE W 1976	2006	2009-2012
Window Components	1/20	1770	2000	2007 2012
Frames	Double-rebated hot rolled steel frames.	Reconstruction with non- thermally broken aluminum frames, thicker mullions than original.		Original uninsulated frames, fitted with auxiliary heating in the form of self-limiting heating bands.
Sashes & Operability	Windows fully operable with various kins of sashes depending on direction of operation.	A number of windows were sealed with some windows left operable. Direction of operability modified.		Windows were brought back to original operable state.
Operating Mechanism	Innovative opening mechanism consisting of small awning, hopper and casement.	Fixed units with large awning.		Operability and configuration were converted back to their original state.
Glass	Crystal plate glass with single glazing.			Low-iron float glass was used with uncoated doubl glazing.
Window Treatments				
Curtains				Innovative insulation curtains were installed fo increased thermal comfor of habitants.
Other Measures				
Notes			The north façade of the north wing has windows restorated according to the original from 1926, reconstucted windows from 1976 and original windows from 1926 on all three floors. The same is true for the third floor on the west façade. ***	
			***: See attached elevation drawings with color codes in the appendix.	

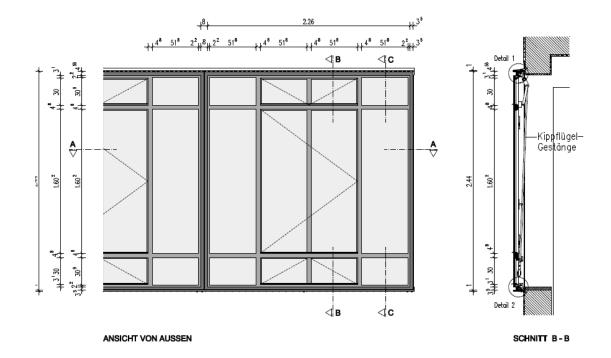
Table 6. A summary of changes in window elements (North Wing)

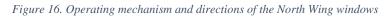


©2012 Winfried Brenne Architekten

Figure 15. Changes in direction of operability of the North Wing windows. Note the fixed center windows in 1976, back in operable state in 2011.

(Winfried Brenne Architekten, 2012)





(Matt, Schuler, Gesamtenergiekonzept für das Bauhaus Dessau)

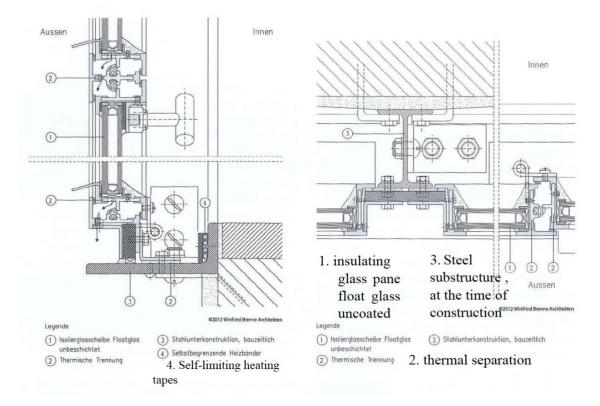


Figure 17. North Wing windows on the north façade, vertical and horizontal sections, respectively

(Winfried Brenne Architekten, 2012)

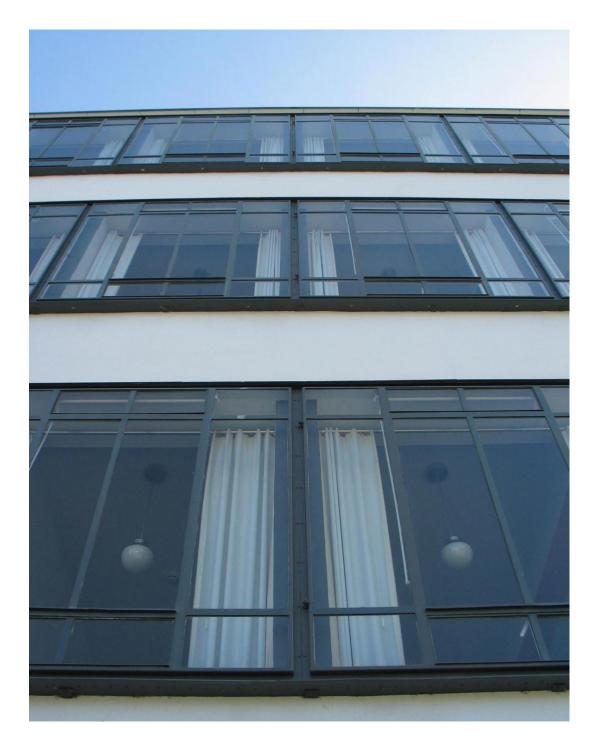


Figure 18. Window profiles of the North Wing

(Brenne Architekten. 2012. Brenne Architekten, Berlin. Accessed 22 May 2021.) <u>https://www.brenne-architekten.de/bauhaus-dessau/</u>

PART 5: CONCLUSION

The Bauhaus Dessau is a monumental work of modern architecture that has been preserved, rehabilitated and changed in numerous ways. Representative of the technical, material and stylistic innovations of early modernism as well as the unmatched architectonic vision of Walter Gropius, the building's preservation history is as noteworthy and rich as the building itself. This thesis has categorized the three main phases of interventions that have taken place in the building according to five preservation strategies: Restoration, Rehabilitation, Replacement, Reinstallation, Reprogramming. Numerous other actions were grouped as Miscellaneous. Following the examination of renovation periods (1976, 1999-2006 and 2009-2012), details have been analyzed in terms of their chronological evolution and impact on energy performance.

The analysis of preservation strategies identified a number of key points that are significant not only for the Bauhaus Dessau but for the preservation of modern heritage as a whole. First, the inevitability of compromise revealed itself in multiple forms, especially during the most recent phase and choices regarding options for glazing and coating. The reasoning was that the significance of glass transparency and light reflections should be prioritized over the largest possible reduction in energy use, thus using double glazed uncoated glass for most openings was the final decision. This raises the question of whether similar compromises would be made in non-designated buildings with similar issues.

Much of the existing built environment, especially in large cities, contains buildings that were designed with the principles of modernism and they pose similar challenges of energy efficiency as those found at the Bauhaus Dessau. On the one hand, all rehabilitation projects should show sensitivity in terms of respecting the authenticity in design and materials. On the other hand, thermal comfort standards and the availability of energy resources have changed over time and this continues to affect the existing building stock as well as building occupants. Therefore, preserving modernism without regarding for environmental sustainability can at best be considered as an incomplete form of preservation, if not inadequate. such compromise may be inevitable and strategies to address character- defining elements may be too site-specific to produce a set of recommendations. In fact, they might differ within a single building, as demonstrated by the Bauhaus Dessau, where different strategies were adopted for the Workshop Wing's curtain glass wall and the Studio Wing windows.

The second important conclusion relates to the treatment of accumulated change on buildings as a character-defining feature. The decision to preserve the 1976 reconstruction of the Workshop curtain wall, respecting the GDR's pioneering preservation modern architecture, reflects the possibility of change becoming part of heritage itself. It should also be emphasized that this decision was based on the preservation standards that relate to listed building features, i.e. the glass façade. Keeping the glass façade exactly as it was led to the adoption of other measures, such as restricting the use of the Workshop Wing and inserting photovoltaic panels on the building's roof to counterbalance the energy losses caused by the glass façade.

The third and final key point is related to preservation measures against future climate change, which were missing at the Bauhaus Dessau. Multiple strategies were applied to improve the energy performance of the building. However, there is no evidence that these considered future changes in climate patterns or extreme weather events. Instead, energy management plans and the preservation strategies that followed compared the building's proposed energy performance to that of prior periods in the near past, without predictive modelling and climate change scenarios. These strategies solved existing problems instead of accounting for future issues that may be created by climate change. This offers a tremendous opportunity for future studies on the building, as well as on other modern heritage sites. Understanding of possible impacts of climate change is not limited to how buildings have responded to environmental changes up to the present, but also requires anticipating possible problems, especially considering potential advancements in the field of environmental sciences.

BIBLIOGRAPHY

- Anderton, Frances. "Celebrating Modernism, Promoting Conservation." New York Times, June 26, 2003, F3. Gale In Context: Opposing Viewpoints (accessed May 12, 2021). <u>https://link.gale.com/apps/doc/A104307828/OVIC?u=upenn_main&sid=OVIC&x</u> <u>id=11ee37bc</u>.
- Barber, Daniel A. Modern Architecture and Climate: Design Before Air Conditioning. Princeton: Princeton University Press, 2020.
- Barber, Daniel A. "Heating the Bauhaus". Perspecta: the Yale Architectural Journal 53, (2020)
- Barr, Alfred J. Introduction. In Modern Architecture- International Exhibition, 12–18. New York, NY: Museum of Modern Art, 1932.
- "Bauhaus Manifesto Articles." bauhaus imaginista. Accessed November 23, 2020. http://www.bauhaus-imaginista.org/articles/1771/bauhaus-manifesto-re-cap.
- Calero, Mónica, Enrique Alameda-Hernandez, Mercedes Fernández-Serrano, Alicia Ronda, and M. Ángeles Martín-Lara. "Energy Consumption Reduction Proposals for Thermal Systems in Residential Buildings." Energy and Buildings 175 (September 15, 2018): 121–30. <u>https://doi.org/10.1016/j.enbuild.2018.07.028</u>.
- Campos, Inês D.D.; Bernardo, Luís F.A. 2020. "Architecture and Steel. Reflection and Analysis on the Use of Steel Structures (in Sight) as a Concept in the History of Architecture" Designs 4, no. 3: 30. <u>https://doi.org/10.3390/designs4030030</u>
- Casciato, Maristella, Gary Fox, and Katherine Rochester. "Masters and Apprentices." Bauhaus: Building the New Artist. The Getty Research Institute, Los Angeles, June 10, 2019. <u>https://www.getty.edu/research/exhibitions_events/exhibitions/bauhaus/new_artist</u> /history/masters_apprentices/.
- Cremers, Jan, and Winfried Brenne. "Renovation of the Bauhaus Dessau." Essay. In Building Openings Construction Manual: Windows, Vents, Exterior Doors, 230– 33. Munich: Edition Detail, 2016.
- Elefante, Carl. 2008. "Renewing Modernism." Places: Forum of Design for the Public Realm 20 (1): 44–51. <u>https://search-ebscohost-</u> <u>com.proxy.library.upenn.edu/login.aspx?direct=true&db=asu&AN=505299576&s</u> <u>ite=ehost-live</u>.

- Fixler, David N. "Appropriate Means to an Appropriate End: Industry, Modernism, and Preservation." APT Bulletin: The Journal of Preservation Technology 39, no. 4 (2008): 31-36. Accessed May 12, 2021. http://www.jstor.org/stable/25433963.
- Fixler, David N. "Repair of Modern Structures: Stepping Back and Looking Forward." Change Over Time 1 (2011): 80–108.
- Gropius, Walter. "Glasbau." Die Bauzeitung 20, (1926)
- Gropius, Walter, and P. Morton Shand. The New Architecture and the Bauhaus. Cambridge, MA: M.I.T. Press, 1998.
- "Ind International Congress of Architects and Technicians of Historic Monuments." Venice, 1964.
- Kohlberg, Edmund. "Balancing Modernism with Preservation." The Military Engineer 103, no. 674 (2011): 67-68. Accessed May 12, 2021. http://www.jstor.org/stable/44532508.

Lidelöw, Sofia, Tomas Örn, Andrea Luciani, and Agatino Rizzo. "Energy-Efficiency Measures for Heritage Buildings: A Literature Review." Sustainable Cities and Society 45 (February 1, 2019): 231–42. <u>https://doi.org/10.1016/j.scs.2018.09.029</u>.

- Markgraf, Monika. "Einblicke in Die Dessauer Bauhausbauten Als Materielles Erbe." Architectura 48, no. 1-2 (2018): 134–53. <u>https://doi.org/10.1515/atc-2018-1008</u>.
- Markgraf, Monika. "The Glass Façades of the Bauhaus Dessau Building", Glass in the 20th Century Architecture: Preservation and Restoration, eds. Franz Graf, Francesca Albani (Mendrisio: Mendrisio Academy Press, 2011), 28
- Markgraf, Monika. "Conservation and Preservation of the Bauhaus Building in Dessau," Heritage at Risk – Special Edition 2006: The Soviet Heritage and Europe Modernism, Chapter IV. World Heritage Sites of the 20th Century – German Case Studies, eds. J.rg Haspel, et al. (Berlin: Hendrik B..ler Verlag, 2007), p. 110.
- Matless, David. "Ages of English Design: Preservation, Modernism and Tales of Their History, 1926-1939." Journal of Design History 3, no. 4 (1990): 203-12. Accessed May 12, 2021. <u>http://www.jstor.org/stable/1315761</u>.
- Matt, Christian & Schuler, Matthias. Gesamtenergiekonzept für das Bauhaus Dessau (Transsolar Energietechnik GmbH, Dessau: March 2013)

- Mitchell, Stephen M. "Modernism on Trial: An Analysis of Historic Preservation Debates in Chicago." Order No. 1562602, Illinois State University, 2014. <u>https://proxy.library.upenn.edu/login?url=https://www-proquestcom.proxy.library.upenn.edu/dissertations-theses/Modernism-on-trial-analysishistoric-preservation/docview/1566192611/se-2?accountid=14707.</u>
- Morgenthaler, Hans Rudolf. The Meaning of Modern Architecture: Its Inner Necessity and an Empathetic Reading. United Kingdom: Ashgate, 2015.
- Paul, Wolfgang. "Renovation 1976", The Dessau Bauhaus Building, 1926 1999, ed. Margret Kentgens-Craig (Birkhäuser, 1998) 160-173
- Preventive Monitoring of World Cultural Heritage Sites. Bonn: ICOMOS Germany, 2015.
- Powell, Kenneth. "Modern Matters: Modern Masters: Hans Döllgast: Conservation and Modernism." The Architects' Journal (Archive: 1929-2005) 194, no. 18 (Oct 30, 1991): 84. <u>https://www.proquestcom.proxy.library.upenn.edu/docview/1427119827?pqorigsite=summon&accountid=14707</u>
- Posener, Julius. "A visit to the Bauhaus Dessau", The Dessau Bauhaus Building, 1926 1999, ed. Margret Kentgens-Craig (Birkhäuser, 1998) 134-142
- Publication. Leitbild Denkmalpflege Zur Standortbestimmung Der Denkmalpflege Heute. Vereinigung der Landesdenkmalpfleger. Accessed May 21, 2021. <u>https://www.vdl-</u> <u>denkmalpflege.de/fileadmin/dateien/Broschüren/VdL_Leitbild_Final_160527_1</u> _.pdf.
- Prudon, Theodore. "Preservation, Design and Modern Architecture: the Challenges Ahead." Journal of Architectural Conservation 23, no. 1-2 (2017): 27–35. <u>https://doi.org/10.1080/13556207.2017.1327193</u>.
- Rich, Geoff. "Renewing Modernism: Emerging Principles for Practice." Journal of Architectural Conservation 23, no. 1–2 (May 4, 2017): 116–40. <u>https://doi.org/10.1080/13556207.2017.1326552</u>.
- Stephenson, D. G. "Solar Heat Gain Through Glass Walls." Canadian Building Digests39 (March 1, 1963). http://web.mit.edu/parmstr/Public/NRCan/CanBldgDigests/cbd039_e.html.
- Young, Robert A., Stewardship of the Built Environment: Sustainability, Preservation, and Reuse. Washington, DC: Island Press, 2012.



APPENDIX A: Site Context and Historic Photographs



UNESCO World Heritage Committee. Convention Concerning the World Cultural and Natural Heritage Report. Merida, Mexico: UNESCO, 1997.

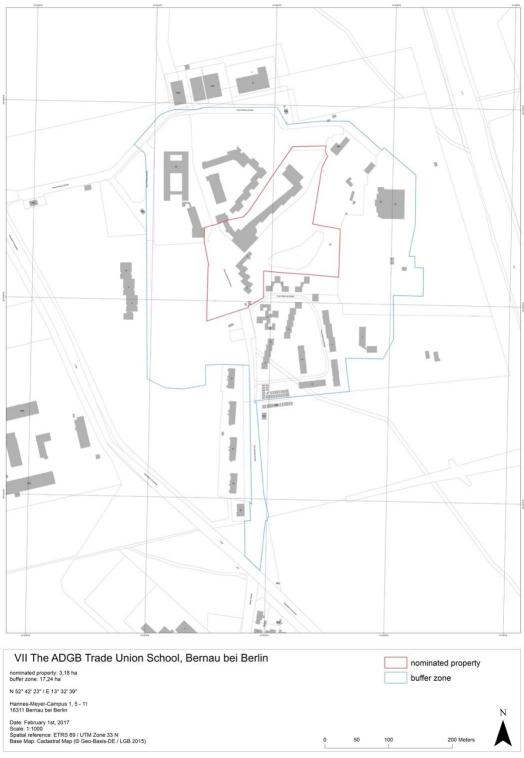


Figure 20. UNESCO World Heritage Inscription map – additional designation of Bauhaus sites

UNESCO World Heritage Committee. Convention Concerning the World Cultural and Natural Heritage Report. Merida, Mexico: UNESCO, 1997.



Figure 21. Bauhaus Building, Dessau, 1925-1926: Main entrance on opening day, 4 December 1926

BRGA.20.57.2. Harvard Art Museums/Busch-Reisinger Museum, Gift of Ise Gropius. https://harvardartmuseums.org/collections/object/176647?position=107



Figure 22. Bauhaus Building, Dessau, 1925-1926: Studio wing from the southeast

BRGA.20.15.2. © Estate of Erich Consemüller. Harvard Art Museums/Busch-Reisinger Museum, Gift of Walter Gropius. https://harvardartmuseums.org/collections/object/172609?position=72



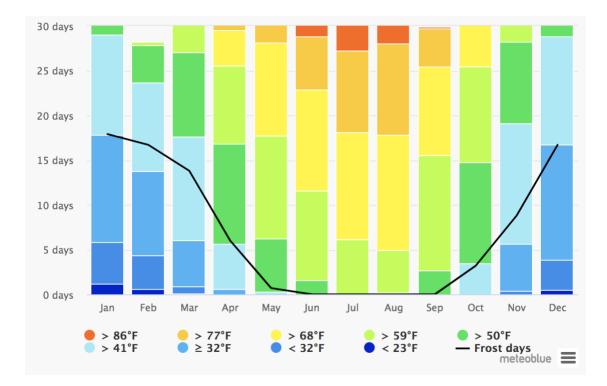
Figure 23. Bauhaus Building, Dessau, 1925-1926: Workshop building from the west

BRGA.20.37.1. © Artists Rights Society (ARS), New York/VG Bild-Kunst, Bonn. Harvard Art Museums/Busch-Reisinger Museum, Gift of Ise Gropius



Figure 24. Bauhaus Building, Dessau, 1925-1926: Technical school stairwell landing

BRGA.20.149. Harvard Art Museums/Busch-Reisinger Museum, Gift of Ise Gropius. https://harvardartmuseums.org/collections/object/52286?position=181



APPENDIX B: Dessau Climate Data

Figure 25. Maximum temperatures in Dessau – Roßlau

Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021, https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau_germany_2 937959.

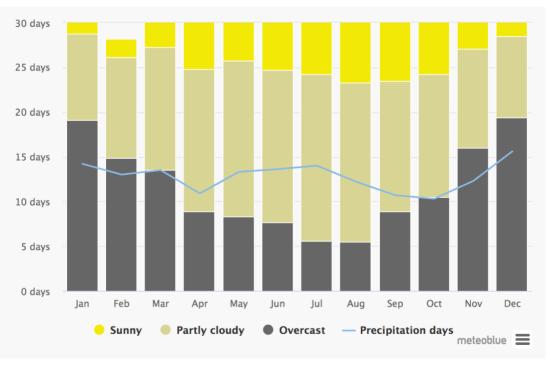


Figure 26. Cold, sunny and precipitation days in Dessau – Roßlau

Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021, <u>https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau_germany_2</u> <u>937959</u>.

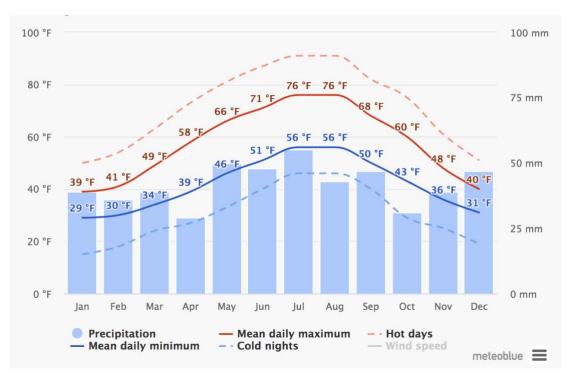


Figure 27. Average temperatures and precipitation in Dessau – Roßlau

Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021, <u>https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau_germany_2937_959</u>.

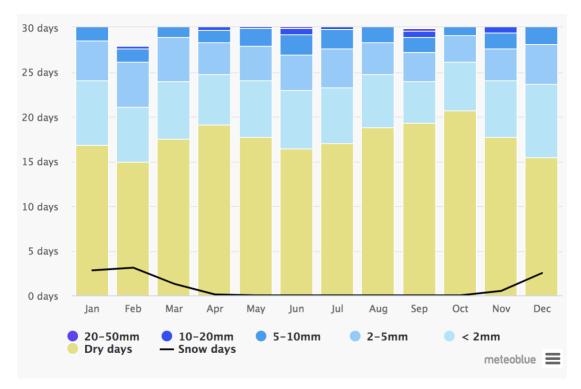


Figure 28. Monthly precipitation amounts in Dessau – Roßlau

Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021, <u>https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau_germany_2937</u> <u>959</u>.

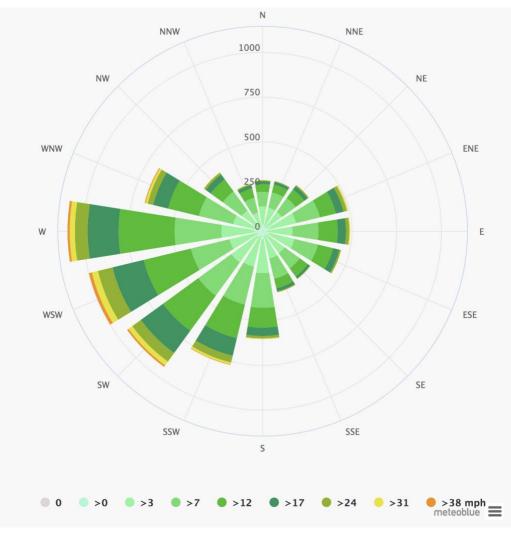


Figure 29. Wind rose for Dessau – Roßlau

Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021, <u>https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau_ger</u> <u>many_2937959</u>.

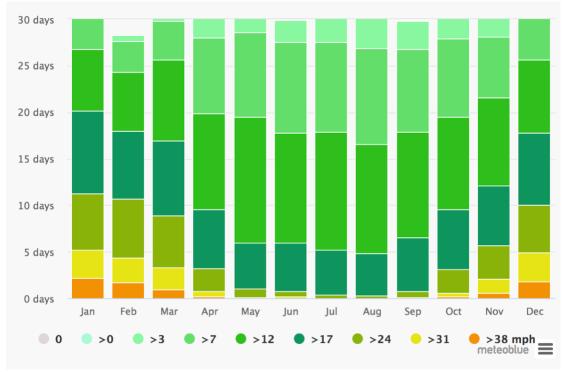


Figure 30. Monthly wind speed in Dessau – Roßlau

Milotlamicha, "Climate Dessau," meteoblue, April 19, 2021, https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/dessau_germany_293795

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APPENDIX C: Supplementary Documents Related to Preservation Strategies

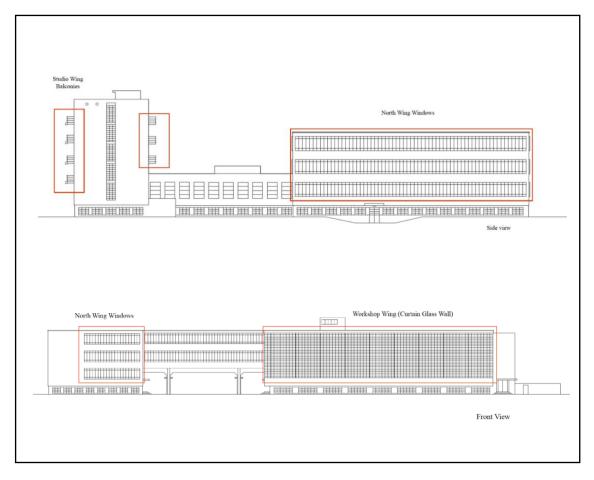
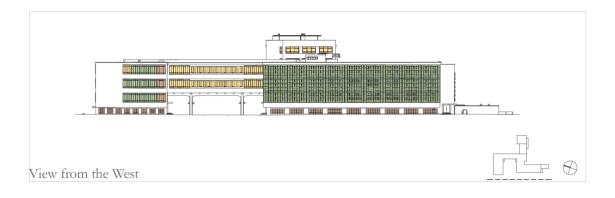


Figure 31. Side and front view elevations indicating locations of Studio Wing balconies and North Wing windows



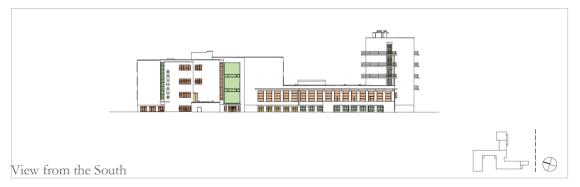
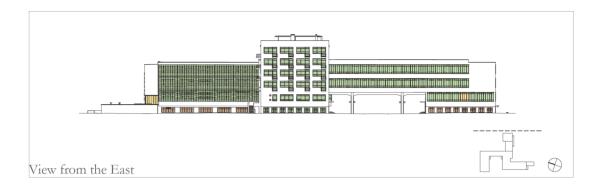


Figure 32. West and South views showing the coexistence of original windows from 1926 (red) with 1976 reconstructions (green) and 2006 reconstructions (yellow)

Monika Markgraf, "The Glass Façades of the Bauhaus Dessau Building", in Glass in the 20th Century Architecture: Preservation and Restoration, eds. Franz Graf, Francesca Albani (Mendrisio: Mendrisio Academy Press, 2011



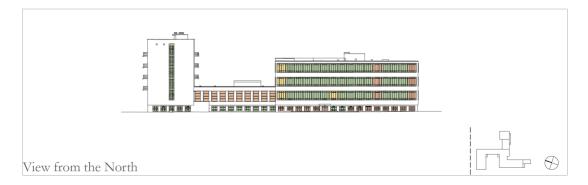


Figure 33. East and North views showing the coexistence of original windows from 1926 (red), 1976 reconstructions (green) and 2006 reconstructions (yellow)

Monika Markgraf, "The Glass Façades of the Bauhaus Dessau Building", in Glass in the 20th Century Architecture: Preservation and Restoration, eds. Franz Graf, Francesca Albani (Mendrisio: Mendrisio Academy Press, 2011

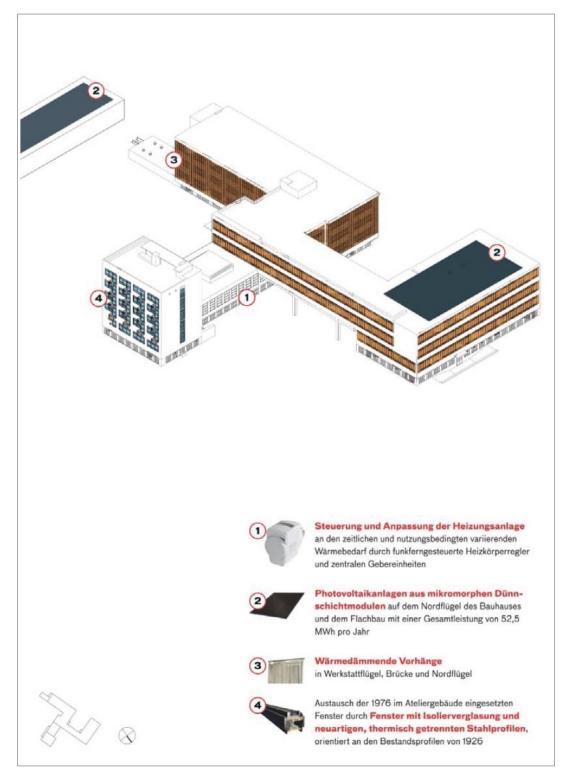


Figure 34. Energy efficiency improvement measures throughout the building Bauhaus Dessau Foundation, Petra Natho 2006, Yvonne Tenschert 2011

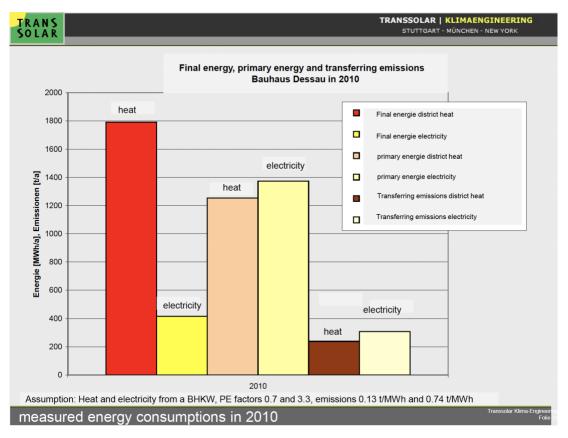


Figure 35. Energy consumption measurements at the Bauhaus Dessau, 2010

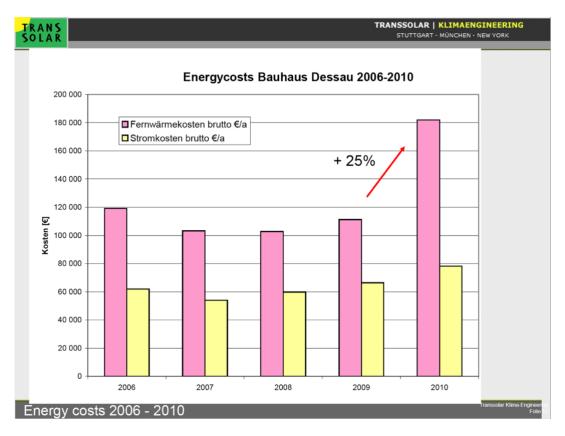


Figure 36. Energy costs of the building between 2006 – 2010

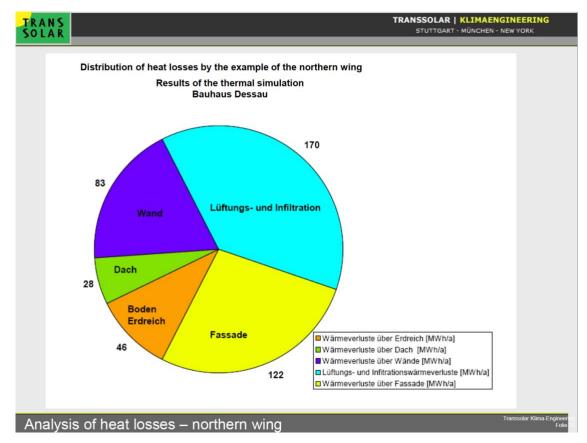


Figure 37. Results of heat loss analyses at the North Wing

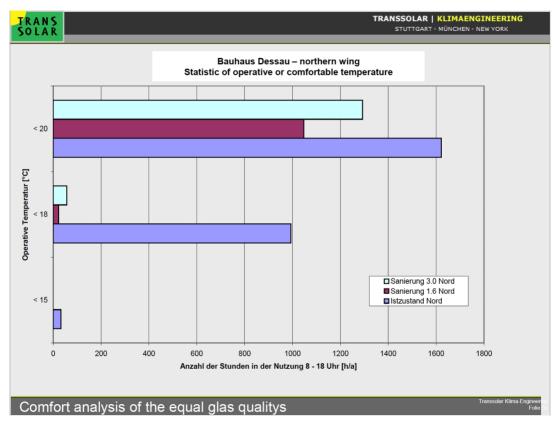
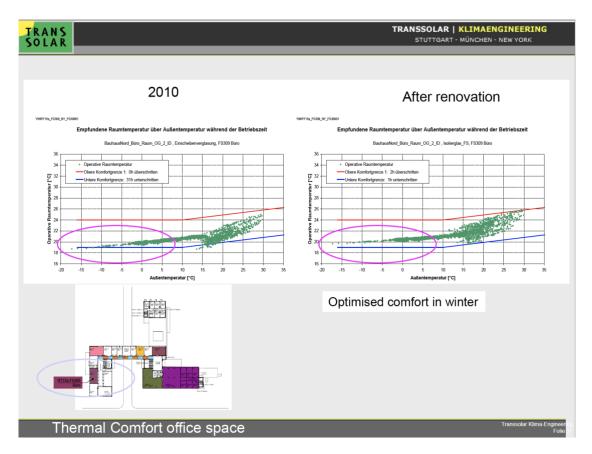


Figure 38. Thermal comfort analysis at the North Wing





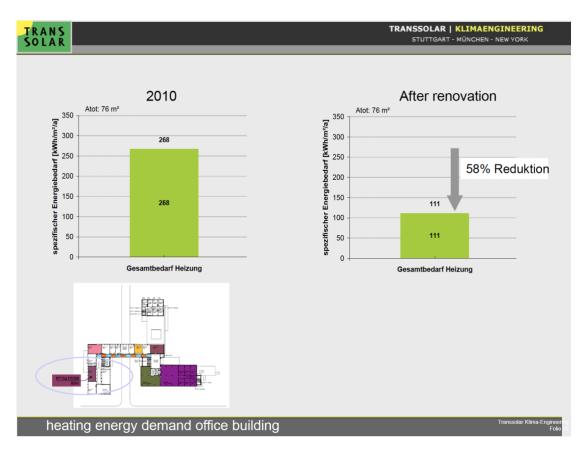


Figure 40. The demand for heating energy at the North Wing before and after the renovations

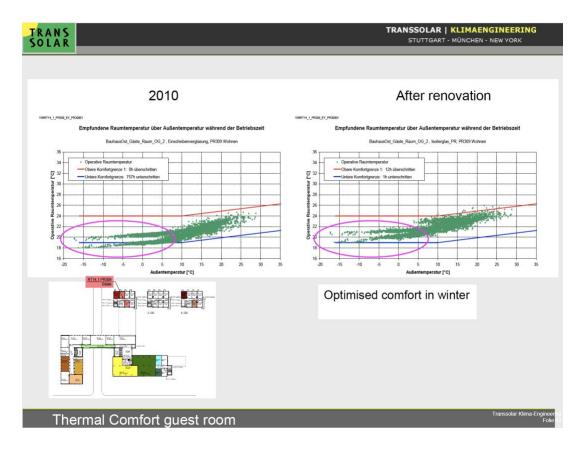


Figure 41. Thermal comfort analysis of the Studio Wing dorm rooms before and after the renovations

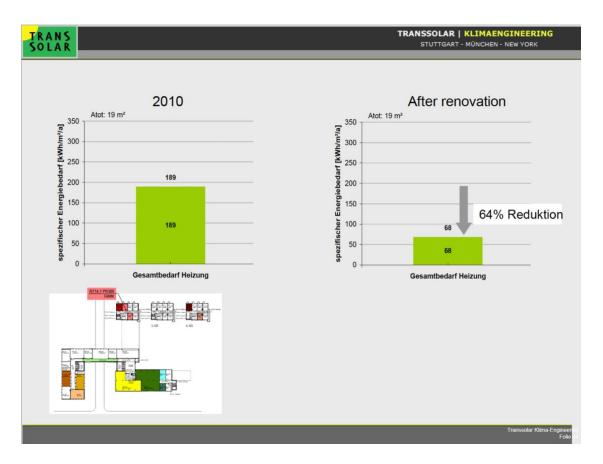


Figure 42. The demand for heating energy at the Studio Wing before and after the renovations

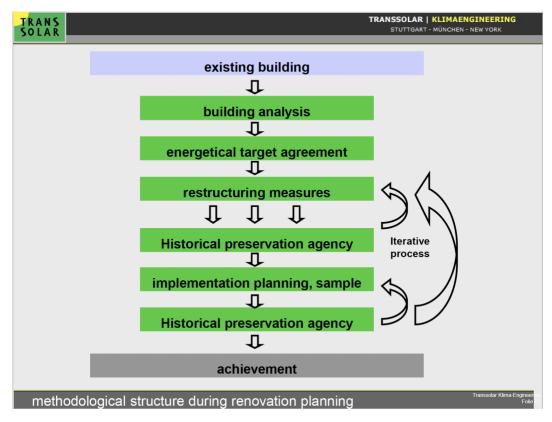


Figure 43. Methodology of preservation planning

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