



HEATING THE BAUHAUS

UNDERSTANDING THE HISTORY OF
ARCHITECTURE IN THE CONTEXT OF
ENERGY POLICY AND ENERGY TRANSITION

October 2019

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for Energy Policy**

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INTRODUCTION

The design of the built environment is an essential aspect of any energy transition. Design plays a role in the technological intensification of energy efficiency; design is also crucial to fostering a culture of low-carbon living and encouraging discussion about policy, lifestyles, and urban transformation. The history of the Bauhaus Dessau provides a concise case study on these terms.



The Bauhaus Dessau building,

Photo: Flickr/Christian Stock

ENERGY AND CULTURE

Discussions of the relationship between energy and culture have proliferated in the past decade. Scholars have sought to emphasize how energy has played a role in cultural, economic, and political developments over the centuries. This has especially been the case relative to the processes of industrialization. To be modern, many scholars have argued, is to depend on the capacities and abilities generated by fossil fuel (Boyer and Szeman 2017).

Processes of industrialization, modernization, and colonization have all been productively reframed as historical periods where energy transitions were essential to new ways of life, for better or worse (Engelke and McNeill 2016, Bonnieul and Fressoz 2017, Malm 2016). The capacity for increased energy use has been essential to the expansion of democracy and freedom around the globe in the 20th century; the dynamics of energy, economic growth, and democratic governance are of significant concern in the face of increasing environmental pressures and the rapid global increase in economic inequities of the past few decades (Chakrabarty 2009, Moore 2013).

Cultural relations to energy are foundational both to the patterns and contours of social life, and also to understanding how to adjust these patterns as new contingencies emerge in relationship to energy systems. *Architecture* sits in the center of this dynamic relationship, as both a material force for energy transitions and as a cultural reflection of energy systems.

The intentions of designers—and policy makers, economists, developers, and others engaged in the design process—reveal the contours of cultural interaction with energy systems. Architecture is a kind of *medium*—a means through which cultural actors communicate to others and articulate a milieu for specific kinds of activity (Martin 2016). Architecture

is both a screen on which to watch environmental change, and a medium from which to produce it.

Given the tight connection between energy and modernity, it is striking that so little attention has been paid to the history of architecture and energy. Histories of the environment more generally have, until recently, been in the background of architectural discussions (Borasi and Zardini 2007, Leslie 2018); with energy this gap in the scholarship becomes more pronounced.

However, energy was essential to the development of modern architecture on both cultural and technological terms (Barber 2016, Barber 2017). This policy digest succinctly addresses this glaring gap in the historiography, articulating how the narrative of one prominent building in the history of architecture, the Bauhaus Dessau, clarifies the mutual interdependence of architectural innovation and energy transition.

An epochal energy transition is upon us (Podobnik 2006, Petit 2017). Scholars, architects, and policy makers may differ as to the nature of the transition and its possible outcomes, though most will agree that the current regime of unbridled fossil fuel use will soon come to an end. Given that buildings are widely understood to produce between 40 to 60% of carbon emissions, architecture is a crucial site for the discussion and the application of new ideas about energy efficiency, energy use, social patterns that relate to it, and the prospects for new ways of life (Laird 2001).

This study examines architecture not only as an analytic lens through which to understand these dynamics in detail, but also as a generator of new ideas and conditions for energy use, energy policy, and architectural methods as part of this transition.

THE BAUHAUS DESSAU

The Bauhaus Dessau building, designed by Walter Gropius and built outside Berlin from 1925 to 1927, relied on increased access to heating energy from coal. It was built for the experimental Arts and Crafts school, the Bauhaus, that Gropius led until 1934.

The premise of the school was to form open workshops where master and student could interact, and with which industry could readily engage. Numerous design collaborations emerged—Marcel Breuer, for example, worked closely with the furniture manufacturer Thonet, for example, to mass produce bent aluminum chairs; other collaborations led to innovations in textile design, typeface, and photography (James-Chakrabarty 2006).

The school's ambitions depended on the open spaces of these workshops for their pedagogical innovations—and heat from coal to make the long, open, uninsulated spans bearable (at best) in the winter. The building had one of the first “curtain walls,” a thin, uninsulated single pane of glass in iron spandrels that surrounded three sides of the building. While effective in producing a sense of openness and engagement, this design and construction approach was remarkably poor as a thermal system, effectively drawing heat out of the space and into the lower atmosphere.

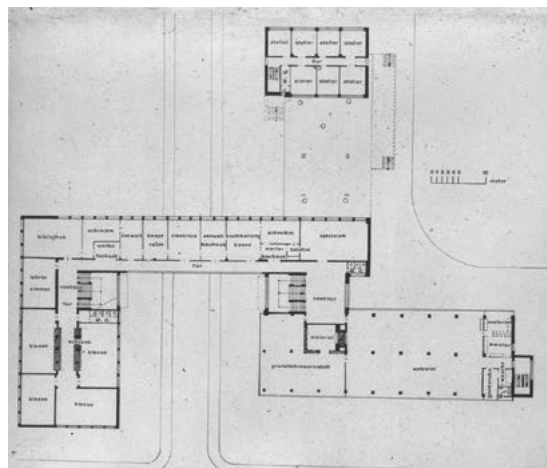
The building's energy demands were significant, and underwent a number of heating plant renovations: even just seven years after it was completed, the system was rebuilt—taking advantage of the opportunity to draw more energy from the coal burning heater and district steam plant (Uekotter 2009). Documents of the last 80 years of the building's energy transformations help to frame concerns that are re-emerging relative to the

FIGURE 1A: WALTER GROPIUS, MODEL OF THE BAUHAUS DESSAU BUILDING, 1925



The Dormitory wing is in the white, taller element, the Workshop wing is at the top of the photograph.

FIGURE 1B: WALTER GROPIUS, TYPICAL PLAN OF THE BAUHAUS DESSAU BUILDING, 1925



The workshop wing (*weber*) is on the bottom right.

FIGURE 1C: FACADE OF THE BAUHAUS DESSAU WORKSHOP WING, SHOWING THE CURTAIN WALL



larger history of architecture, and the building's material impact on the present.

The building's organization, while innovative, was quite simple (see Figure 1). It consisted of four major components: the three levels of open workshop spaces, the housing/dormitory block, a third volume to the north that housed an unrelated school, and the connecting bridge, which included the oft-photographed office of the director.

While the building has been extensively written about, documented, and criticized, almost no mention has been made of the heating system, or the importance of innovations in heating technology and coal availability to the programmatic ambitions of the site.

In what follows I will describe the heating system and its changes over the decades, in the context of more general transformations to the energy conditions of Germany (also East Germany), both in terms of resource availability and energy policy. I will conclude with a discussion of the latest energy upgrade of the building, and some more general conclusions regarding the changing understanding of architecture, energy, and climate.

HEATING THE BAUHAUS DESSAU

The programmatic and design components of the Bauhaus Dessau required an aggressive heating system. One piece of evidence of the strain of the thermal conditions on the design of the system is the large and sometimes awkward placement of radiators. In the workshop wing there is a row of radiators next to the thin glass membrane (see Figure 2); one celebrated radiator placement is in the central stairway, where a radiator is hung high on the wall (see Figure 3). Concern over thermal conditions is also evident in the relative operability of window openings for summer ventilation. The perimeter wall of the auditorium provides a clear example, with extensive radiators lining the wall, and a wheel to adjust the window openings (see Figure 4).

When the building opened in 1927, it used a low-pressure steam system, consisting of five pulverized coal (PC) boilers that used coal dust as fuel. The coal was stored under the connecting bridge. At the time, this was an innovative approach; PC boilers have since become commonplace, especially in large-scale power generation where the conditions of feeding the boiler have been mechanized (Yeh and Rubin 2005). Pulverized coal has significant health risks for those exposed directly to it, especially the single boilerman employed to manage and maintain the system.

By the end of 1927, alterations were already being made, including a more precise control system and an early iteration of a watering system to help reduce free particulates. Two boilers were replaced in 1931: the insulation conditions were so poor that they cracked due to over-firing. The Bauhaus building was shut down by the Nazis in October of 1932 (aspects of the school continued in Berlin for another year).

FIGURE 2A: A TYPICAL WINDOW WALL OF THE WORKSHOP WING OF THE BAUHAUS DESSAU BUILDING



Note the extensive radiators exposed to the glazing.

FIGURE 2B: A TYPICAL FACADE, SEEN FROM THE OUTSIDE WITH CURTAINS BEHIND THE WINDOW



FIGURE 3: THE STAIRCASE AND HALLWAY TO THE OFFICES AND NORTH WING



Note the extensive radiators exposed to the glazing.

FIGURE 4: TOUR GUIDE PRESENTING THE WINDOW OPENING MECHANISM IN THE AUDITORIUM



Note also the radiators and blackout curtains.

The building was damaged during the war, but had been roughly repaired by 1946. Only two the PC boilers still worked; pulverized coal and coal dust was now harder to come by as it was being used in larger scale power plants rather than small, building-scale systems.

The boilers were converted to raw coal, able to use numerous kinds of coal briquettes or high-temperature coke. These systems were considerably less efficient and more polluting. A ramp was installed between the coal storage bunkers (still under the bridge) and the boiler room, breaking through exterior and partition walls, in order to provide more convenient access. By the early

1960s coal was also stored outside, next to the coal bunker, to have enough fuel on hand for colder periods.

By this time, however, the boilers were dated and inefficient. A sixth boiler was added around 1967; there were now two full-time boiler operators, keeping all of them firing in the winter from 4 a.m. to 8 p.m., and 24 hours when frost conditions existed. The building could not be left unheated in the winter, even for a short period, for fear of negative impacts on furnishings, electrical wires, and other interior systems.

In 1970, records indicate that the boilermen were not able to keep enough coal on hand, due to a combination of supply inconsistencies and rising demand by virtue of the boiler's inefficiency. In 1972, the six boilers were repaired and updated, a third boilerman was hired, and a larger space behind the dormitory wing was used to store the fuel, at this point mostly brown coal.

Smoke from the boilers became an issue, discoloring the walls on the interior and exterior of the building. And yet, the increased capacity still proved inadequate. In March 1973 the six furnaces were replaced by five new boilers, which were both more efficient and had a higher capacity; this led to increased demand and increased use of coal despite the more efficient system.

The Bauhaus Dessau building underwent significant renovation in 1976, in preparation for 50th anniversary celebrations in 1977 (see Figure 5). The main concern, relative to the heating system, was to obviate the need for the unsightly hill of coal behind the building. An initial plan to build an underground storage area was dismissed as too costly. Instead, largely out of concerns for the discoloration of the furnace exhaust, it was decided to switch to a gas-fired system. A system was purchased, but was not installed as there was not a system in place that could provide an adequate supply of gas.

Attempts were made to connect the building to the district heating system of Dessau. In part because of some technical concerns, and in part because the city of Dessau had consistently distanced itself from the school and its building during the communist years, the district heating plan fell apart in 1977. The relatively inefficient coal burning system remained.

FIGURE 5: IMAGES FROM 1966, BEFORE THE MID-70S RENOVATION (IMAGE FROM KENTGENS-CRAIG 1998)



Brenne Architekten schematic approach.

The 1976 renovation also led to the replacement of many windows, especially in the dormitory and the north wing. Many operable windows were now sealed, in order to marginally increase insulation—the window system still involved single-paned, rather than more insulative double-paned, glass panels.

On New Year's Eve of 1978, a sudden temperature drop froze parts of the heating system. During the holidays, the system was run at a minimum, which proved inadequate to the temperature. A number of pipes and radiators cracked, and again the heating system was subjected to an overhaul. A warm water system was set up to supply the radiators in the workshop building, while the bridge and dormitory wing were still heated by steam from the boilers. By the end of the year, the entire system was converted to warm water that heated the radiators.

FIGURE 6: A PHOTOGRAPH OF THE DISTRICT HEATING CONTROL AND MAINTENANCE ELEMENTS, BAUHAUS DESSAU, 2019



A few years later attempts were made again to connect the building to a district heating system. Pipes had been laid on site in 1976, but 1982 negotiations to make the connection stalled again, due to changes in the city's management.

Up until the dissolution of East Germany in the early 1990s, the building relied on the pile of coal in the back, feeding an inefficient, inadequate system. Finally, in 1998, the building was connected to a district heating system (see Figure 6). The boilers, and the coal pile, were removed; the space that contained the boilers is now the coat room and bathrooms for visitors to the building.

GERMANY'S ENERGY SYSTEM

Germany's political consolidation towards the end of World War I involved the restructuring of a number of disparate approaches to regulating energy systems. For the most part, before WWI, energy policy was a local affair, involving the regulation of labor, systems of distribution, and often shared methods of energy generation and consumption (Warde 2013).

The outbreak of WWI led to the rapid mechanization of the coal extraction process, buttressed by low credit costs that encouraged investment in regional infrastructure, especially in the Ruhr Valley and Silesia in northwestern Germany. By the end of the 1920s, almost 100% of Germany's coal was extracted through the complex industrial and labor heavy processes, constantly growing to respond to the demands of the Weimar Republic, and its support, through direct investment and credit availability, of the energy industry (Jopp 2016).

Explicit energy policy in Germany was organized around managing and encouraging rapid growth while mitigating negative factors in labor and especially pollution. Parts of what is now Germany had regulatory mechanisms for smoke going back to the mid-19th century, but with varying levels of intensity and enforcement.

After World War I, however, ambivalence set in. The strong desire on the part of industrialists and the public for regulatory mechanisms was tempered by concern over bureaucratic overreach. A further barrier to regulation involved the technical nature of possible solutions to efficiency and smoke abatement, which many business leaders and politicians were unwilling to address (Uekotter 2013).

In general this led to resistance to mechanical upgrades and furnace replacement, as evidenced in the specific case of the Bauhaus Dessau. These issues were exacerbated by a staunchly independent culture of German engineering which resisted regulation, seeing it as an impediment to technical innovation.

In sum, German energy policy was unfocused over the period of the Bauhaus Dessau's design, construction, and the short period (1928 to 1934) when the building was used for the celebrated school. There was little incentive to reduce smoke or waste, and while there were substantive efforts across the German industrial economy to render coal furnaces more efficient, this was not done systematically. During the Cold War, buildings like the Bauhaus were seen as evidence of Western cultural excess, which further exacerbated the situation and isolated the building from related technological and policy improvements.

By contrast, in more recent years, both the engineering community and the policy community in Germany have, by and large, gotten behind the prospect of an energy transition off of fossil fuels. Much of the effort towards energy transition began with local, grassroots efforts but has since been supported through industry practice and government policy (Hager 2015).

The German *energiewende* is both celebrated and excoriated as a model for a broader global energy transition, and the specific issue of moving buildings off of coal and increasing energy efficiency is widely praised (Sturm 2017). The Bauhaus Dessau represents a high-profile example of extensive retrofit activities occurring much more broadly, and with support through

government policies; as taught in prominent schools and encouraged through internships and other professional development mechanisms.

The series of renewable energy acts known collectively as the *Erneuerbare Energien Gesetz* have increased in specificity and intensity of the transition policy every couple of years for the past two decades (Jänicke 2012). After the decision to not rely on nuclear energy, the role of buildings in increasing energy efficiency has accelerated dramatically, with regulations and recommendations relative to renewable energy generation, upgrades to insulation, and changes in use and program so as to minimize excessive waste (Hedberg 2018).

RENOVATION AND RETROFIT

In 1996 the Bauhaus Dessau was included on the UNESCO World Heritage List; a process that aimed to restore the building to its original condition while also respecting the need for substantive mechanical upgrades (Kentgens-Craig 1998).

In 2011 Brenne Architekten, a Berlin-based firm that focuses on the energy retrofit of modernist buildings, was hired to renovate the building according to changing thermal standards, without compromising the heritage value of the structure.

One central decision was made by the architects and the foundation that controlled the building, the significance of which cannot be overemphasized: *the workshop wing was abandoned*. Due to the poor insulative conditions of the single-paned windows, and the scale and position of the radiators that could not be altered, it was determined that no ongoing public activities could persist in the workshops—the architects could not guarantee that the space could be consistently maintained above 16 degrees Celsius (60 degrees Fahrenheit) (see Figure 7).

The offices and remaining student activities were moved to the north wing. The workshop area still contains the gift shop on the first floor and a café on the ground floor; the upper floors are occasionally open for tours. However, in order to preserve the character of the workshop wing, it was determined that only minimal interventions would be made.

A number of other interventions were made to increase the energy efficiency of the dormitory wing, the bridge, and the north wing:

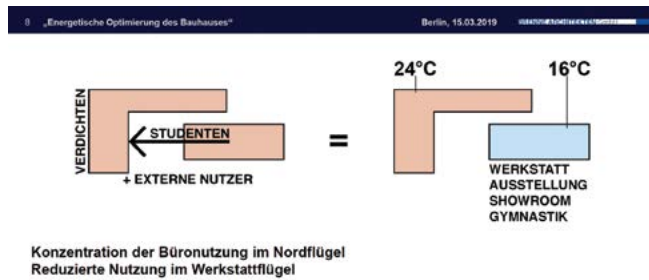
- **Photovoltaic panels** were added to the roof of the north wing to provide energy for the electrical system. While there was resistance from preservationists, this was argued for on the basis of the continued thermal drain of the workshop: i.e., in order to preserve the workshop as is, energy loss needed to be compensated for by adding a new input source.
- **New black-out curtains** were installed in the auditorium. These have significant insulative qualities and are intended to remain down aside from the few times when the space benefits from daylighting (the room is usually used for film viewings or conferences where slides are projected, so darkening the room is generally preferred).
- **Insulative curtains** were also installed in the office wing, in two rows in order to provide further insulation with an air-space between.
- **New windows** were installed in the dormitory wing. They are visually identical to the original versions but with new materials and an innovative, custom sealing profile. Existing windows were stripped of paint, repainted and resealed with caulk. Numerous window openings that had begun to let rainwater in were aggressively resealed, especially on the ground floor of the workshop wing and the north wing.
- **Outer doors** were replaced and/or resealed.

The most significant change was to the window profiles of the north and dormitory wings. On the north wing, as noted above, a number of windows had been replaced

in 1976 with un-openable, sealed panels (see Figure 8). These were removed and replaced with windows that could be opened for ventilation in the summer.

In the dormitory wing, a number of the windows were replaced. As this is the only part of the building inhabited overnight, it had more extensive demands relative to heating and cooling. Brenne Architekten did substantive

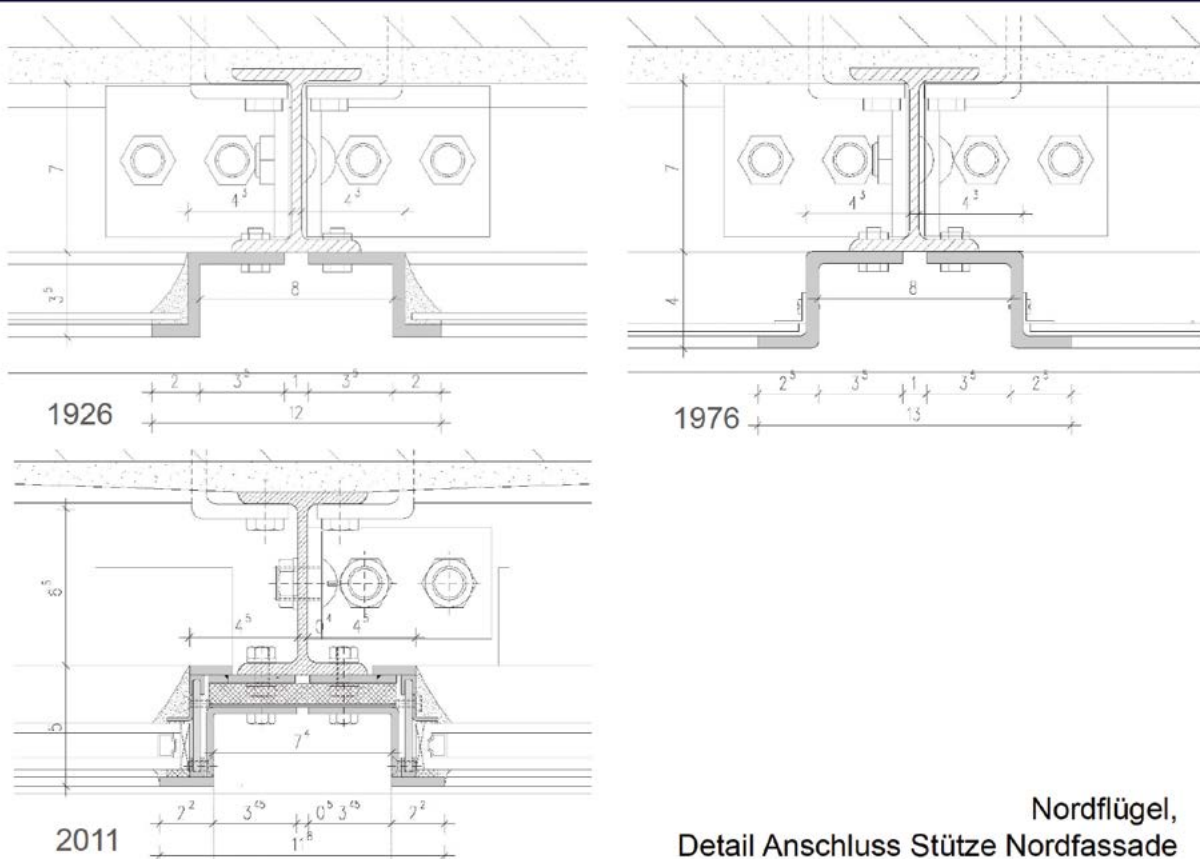
FIGURE 7: BRENNE ARCHITEKTEN SCHEMATIC DRAWING OF THE NEED TO MOVE PROGRAM OUT OF THE WORKSHOP WING DUE TO DIFFICULTIES IN THERMAL MANAGEMENT



archival research to determine the changing window profiles from 1926 to 1976, and worked with a fabricator to produce a custom unit that joined the rolled steel of the original window with a carbon fiber reinforced plastic insertion that acted as an effective thermal barrier (see Figure 8).

A thin copper band was also installed to provide heating right at the sealing mechanism, thereby reducing both cold air and water from entering. The windows had a small outlet for condensed water, tucked under the steel frame, to reduce wear. The team also installed humidity sensors to better assess the potential wear on the units over time. The windows look the same from the outside, but their thermal capacities improved dramatically. According to the architecture firm’s subsequent monitoring, the dormitory wing saw a 72% reduction in energy use.

FIGURE 8: COMPARISON OF THE WINDOW MECHANISMS—ORIGINAL (1926), FIRST RENOVATION (1976), AND 2011



CONCLUSION

The history of the heating system of the Bauhaus Dessau suggests a number of interesting inflections to familiar narratives of architectural history. As an initial, large-scale reframing, it provides evidence that many of the formal and programmatic innovations associated with German modernism were reliant on the changing conditions of energy policy and energy provision. Put simply: the Bauhaus Dessau relied on coal.

In recent attempts to reduce the carbon output of the building, the workshop wing—the jewel in this particular crown—has been functionally abandoned. Other buildings could be examined to support this thesis of a tight inter-relationship between energy systems and architectural expressions: the AEG Turbine Factory in Berlin, designed by Peter Behrens in 1918; the Arbeitsamt in Dessau, designed by Walter Gropius in 1928, which provides an interesting parallel to his nearby Bauhaus; and the ADGB School north of Berlin, designed by Hannes Meyer in 1928 and recently retrofit by Brenne Architekten.

Also put simply: many prominent modern buildings perform horribly. It is ridiculous, on some level, to even consider the energy efficiency of a pre-World War II building according to contemporary standards. Many prominent modern structures, such as the Bauhaus, were built with little regard for energy conservation, since people of that era saw energy use as a positive contribution to economic activity.

Buildings that required a lot of energy were, until quite recently, welcome. And today many are still being built. Architecture and building culture has developed an industrial infrastructure rooted in energy profligacy, such

that most performance metrics continue to assume least production of energy, rather than carbon-neutral or carbon-sink construction.

The Bauhaus Dessau is exemplary for the planimetric arrangement of its energy collapse; it is not atypical. Other icons in the history survey are similarly environmentally misapprehended, from the sealed, conditioned interiors of mid-century skyscrapers, to any number of museums, cultural centers, archives, and urban developments.

Energy has not been a concern for architects in the way it has suddenly become the issue: towers, malls and suburbs demand intensive energy throughput, even when using efficient sources. Too many modern buildings and projects stand as monuments to the inevitability of growth. They are stranded assets, objects in the urban landscape—and object lessons in how not to live and build.

Other implications follow, relative to the relationship between energy efficiency, energy policy, and cultural heritage. How much do societies want to change a building, if making it more energy efficient, in some cases, is seen as compromising its historical legacy?

Also of interest, in the case of the Bauhaus: if the workshop space was so thermally inadequate, what were the conditions of its occupation during the short period in which the school was active? It must have often been quite cold. The current thermal conditions do not meet German standards for occupation.

How much have social standards changed relative to thermal comfort, and what is the impact on energy use and energy policy? Can we begin to, collectively, imagine and produce standards that measure comfort on different terms, so as to reduce carbon emissions without compromising health and productivity? These and similar questions get at the heart of debates in energy culture, and in broader issues relative to the role of architecture in imagining, designing, and building a low-carbon future.

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Note on sources: The narrative of the Bauhaus' heating system was drawn from material in the city archives of Dessau, thanks to the archivist Monika Markgraf for her assistance. The material from Brenne Architekten was based on in-person interviews and unpublished presentation material provided by the firm, and summarized with permission; thanks to both Winfried Brenne and Fabian Brenne for their time, hospitality, and interest. I am grateful to Ulrike Beck who assisted me at the archive, in the interview, and in translating relevant material.

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This article is published in collaboration with the forthcoming issue of *Perspecta: the Yale Architectural Journal*. A version first appears here, and will later appear in *Perspecta 53: Onus*.

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