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Sustainability in Scandinavia: Architectural Design and Planning

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The challenges of the global climate crisis are heightened in large part by a pervasive uncertainty regarding how architects and designers can address this challenge most effectively. In a situation where action is needed, but the correct strategies remain unknown, it is essential for architects to share their experiences and knowledge as broadly as possible. They must seek out perspectives that can help them overcome these impasses. When climate change was put at the top of the international environmental agenda more than a decade ago, Scandinavian countries were ready and able to respond quickly and methodically. Today, Scandinavia is still on the forefront of sustainable development, reorienting cultural engagement and economic growth to face climate change. The experience and knowledge accumulated by architects from Denmark, Norway and Sweden have the potential to enrich the exchange of ideas that is vital to a shift towards holistic thinking and sustainable architectural practice.

In this book, essential aspects of sustainability in architecture and planning are approached from many diverse perspectives. They exemplify the breadth and depth of explorations underway. The collection of writings is based on six years of visits made to the three Scandinavian countries, and sustained engagements with the schools of architecture in the capital cities of Copenhagen, Oslo and Stockholm. The book aims to illuminate lessons being learned by architects in Scandinavia, that are also relevant in a global perspective.

The main drivers of sustainability are highlighted through case studies that cover all scales from planning and infrastructure to buildings and components. The cases illustrate central themes such as energy, lifecycles, industrialization, durability, transformation, and history. More acutely architectural topics such as adaptability, integrated design, and architectural education/tradition further permeate the cases. At the same time, the projects exemplify the best practices of sustainable architecture in Scandinavia including housing, offices, cultural buildings, and urban development.

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Scandinavian countries responded quickly and methodically when climate change became highlighted as the main international environmental agenda decades ago. Today, Scandinavia is on the forefront of sustainable development, with cultural involvement, economic growth, and climate change in mind. The experience and knowledge accumulated over the years by architects from Denmark, Norway and Sweden have the potential to enrich the international architectural community as it transitions its practice towards a more holistic and sustainability future.

In this book, essential aspects of sustainability in architecture and planning are approached from many diverse perspectives that exemplify the breadth and depth of explorations underway in Scandinavia today. The collection of writings is based on six years of visits made to these three Scandinavian countries, and sustained engagements with the schools of architecture in the capital cities. The presentation of these perspectives is intended to illuminate lessons being learned by architects in Scandinavia, and to share these ideas with a global audience.

The main drivers of sustainability are highlighted through case studies that cover all scales from planning and infrastructure to buildings and components. They treat global, regional, political, and cultural themes, and give each their specifically architectural significance. More acutely architectural topics such as adaptability, holistic thinking, and architectural education/tradition further permeate the cases. At the same time, the cases exemplify the best architectural practices of sustainability in Scandinavia.

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Scandinavia is on the forefront of sustainable development, with cultural involvement, economic growth, and climate change in mind. The roots of this book began in a summer program conceived by Professor Ali Malkawi in 2010 while at the University of Pennsylvania School of Design. It is based upon many years of engagement with schools of architecture, leading practitioners, and stakeholders at the municipal level in the capital cities of Denmark, Norway, and Sweden.

The intention of that program was to educate students about the advancements that these Scandinavian countries have made in architectural design and sustainability, and to illustrate their specific commonalities and subtle differences. It was evident that little interaction has been established among the three nations in professional practice or academic approaches. The program was held in collaboration with partnering professors and their associated universities: Professor Marius Nygaard at the Oslo School of Architecture and Design (AHO) in Norway; Associate Professor Erik Stenberg at the Royal Institute of Technology (KTH) in Stockholm, Sweden; and Professor Anne Beim at the Royal Danish Academy of Fine Arts (KADK) School of Architecture in Copenhagen, Denmark.

In the fall of 2015, the symposium "Sustainability in Scandinavia" was held at the Harvard Center for Green Buildings and Cities at the Harvard University Graduate School of Design. A workshop with the main participants in the program followed, initiating the writing of this book. During two subsequent other meetings at KTH in Stockholm and AHO in Oslo, the contributors continued to work on the structure and content of the book and began to define its chapters.

This book discusses the essential aspects of sustainability in architecture and planning, with the intention to bring lessons learned in Scandinavia to the forefront. The main drivers of sustainability are highlighted through case studies that cover all scales, from planning and infrastructure to buildings and components. At the same time, the cases exemplify the best practices of sustainable architecture in Scandinavia, including housing, offices, and cultural buildings. Both historical and contemporary projects illustrate the strengths of their respective practices. They illustrate the diversity and enhancements of Scandinavian architecture and urban work.

The main themes of this book were developed on the basis of extensive dialogues between the authors. The discussions explored several dimensions of sustainability, including global, regional, political, and cultural topics that range in scale from the city to the building to a structural component. Global versus regional themes included climate, geographies, natural resources, and demography; political topics included economies, governmental, and societal structures; and, finally, cultural discussions included building culture, traditions and history, social culture, and aesthetics.

The commitment to sustainability in the built environment is prominent throughout Scandinavia. Although the three countries discussed here have much in common, their developments and differences in terms of sustainability are very much rooted in their varying geopolitical and cultural developments, natural resources, and climates.

In contrast to the US, and even Europe, Scandinavia developed a form of minimalism in combination with a strong concern for developing the "welfare state" after WWII. Scarcity of resources, extreme weather, and their respective sociopolitical movements impelled these three nations to conserve and sustain resources.

When climate change became highlighted as the main environmental international agenda more than a decade ago, these three countries self-imposed stricter emissions regulations. Among many other factors, their resource differences influenced and differentiated their building codes. For example, the use of biofuel and waste source energy is prominent in Sweden and Denmark, as opposed to Norway, which relies more on hydropower.

These three countries present sophisticated examples of infrastructure systems that allow energy to be exchanged, in some cases among buildings; in others, between buildings and transport systems. They also allow waste heat to be collected from incinerators, for example, and combined with other energy-generating systems. This provides planners and architects with the means to design systems and buildings that are integrative, durable, and highly efficient as regards energy exchange and balance.

Denmark

Denmark is a small country, with a total area of only 42,931 square kilometers. Natural energy sources and material resources have historically been limited and are still so today. Danish building culture has therefore grown out of material scarcity, necessity, and ingenuity—and today, these aspects form an architectural tradition of simplified, efficient, and creative design. These aspects are also at the root of how Danish architects are defining sustainable architecture today. A holistic idea of well-designed architecture that cares for its social and cultural context and composed of natural, sound materials is a core concern in most sustainable architectural solutions. However, this understanding has been seriously challenged ever since the energy crises of the 1970s, which led to a strong political focus on energy consumption and technologies for alternative energy resources in Denmark. Buildings began to be considered from the perspective of energy performance, and building legislation changed accordingly to address questions of engineering.

For decades Denmark has, among many efficiency-enhancing initiatives, prompted the use of district heating systems that reduce waste and improve efficiency. Denmark hosted the United Nations Framework Convention on Climate Change in 2009; in the same year, the city council adopted the Copenhagen Climate Plan, and formulated a vision for Copenhagen to become carbon-neutral by 2025. The first of these sets the ambition of reducing emissions by twenty percent by 2015. The second, the CPH 2025 Climate Plan, is a holistic plan as well as a collection of specific goals and initiatives covering four areas: energy consumption, energy production, green mobility, and city administration.

Since the oil crises of the 1970s, Denmark's policies have striven for self-sufficiency in terms of energy supplies; initially by means of oil and gas from the North Sea, and later by use of wind energy and waste incineration. Today, Denmark is almost self-sufficient.

Denmark implemented the EU Building Energy Performance Directive early on, and ambitiously. Denmark follows the general EU regulations that aim for a thirty percent reduction of CO^2 emissions in 2020 (as compared to 1990), and over time strict energy codes have been incorporated into Danish architecture at all levels. In 2008, voluntary "Low Energy Classes" were introduced by the government, providing incentives for the entire Danish construction industry to improve competencies and products.[1] The strictest, Building Class 2020, reduces energy consumption by about fifty percent as compared to today (2017), which is comparable with passive house standards. Even better, Building Class 2020 also asks for such qualities as a healthy and comfortable indoor climate, good architecture, and daylight.

While optimizing energy performance has been a central part of Danish building legislation for almost half a century, a relatively new driver of sustainable building is the high-level use of building components and advanced building technologies. Pioneering architects are making exceptional strides toward reducing the energy consumption of buildings, proposing design strategies that make creative use of both new and reused materials, alternative technologies, and construction designs.

The focus of sustainability in Denmark is expanding from a sole focus on energy consumption in the building's operational phase to include considerations of the durability of building materials and their environmental impact.

Due to political demands for energy renovations of existing buildings, this market is estimated to grow. This tendency has sparked an interest in reclaiming and reusing building materials and components from the perspectives of efficient waste handling, the circular economy, and environmental protection. Parallel to these concerns there is an increased emphasis on the cultural aspects of energy renovation among Danish architects. How one can improve energy performance without losing or harming cultural heritage of both cities and buildings has thus become a vital question. This has also provoked discussions not only about how architecture creates value for society and individuals across economic, social, and environmental spheres, but also, quite importantly, how cultural and aesthetic qualities are now, little by little, being taken into consideration.

Sweden

Beginning in the early 20th century, the possibility of constructing a new society through the built environment became apparent. It was also a way to counter the negative side effects of industrialization and urbanization, such as poverty, sickness, and pollution. Politicians, planners, and architects joined forces to work on building the welfare state in an unprecedented way. In this effort, architects such as Gunnar Asplund, Sven Markelius, Backström & Reinius, Oswald Almquist, and Hakon Ahlberg were instrumental. From the Woodland Cemetery to the Stockholm Public Library, Asplund was able to transform ideas into form to construct and serve the People's Home (*Folkhemmet*) as outlined by Prime Minister Per Albin Hansson in 1928. The duo Backström & Reinius not only master-planned Vällingby Centrum as an "ABC city" wherein A stands for "work," B for "housing," and C for "center" or "commercial," in the 1950s, but also developed the residential typology "Stjärnhus," which provided all apartments with light from three sides. The ABC city of Vällingby became a model for how to build sustainably outside the overcrowded city centers, pairing the goal of mixed use with major infrastructure systems such as public transportation and district heating. However, the real impact was that the Stockholm Public Library and Vällingby did not remain isolated examples; the whole of Sweden's urban fabric was transformed in this progressive manner. For example, ninety percent of Sweden's total housing stock has been built since 1930. Sustainability in 20th-century Sweden has been primarily driven by a political and social ambition that has employed technological advances, with both economic and environmental implications.

The rapid urbanization that Sweden is currently experiencing is, in some ways, reminiscent of the last turn of the century, but which brings about a whole new set of challenges. Of these, the global environmental condition is the greatest driver for change. The environmental, social, and economic sustainability as described by the Brundtland Commission[2] (formerly the World Commission on Environment and Development) in 1987 has been translated into new patterns of urban growth. The renaissance of the concentrated city center and the "walkable city" are making an incredible impact on the Swedish urban fabric. Examples such as Hammarby Sjöstad and Norra Djurgårdsstaden in Stockholm, Älvstranden in Göteborg, and Vallastaden in Linköping are the contemporary equivalents of Vällingby. Just as every small municipality in the postwar era was building modernist housing areas, compact urban grid planning is now being utilized throughout the country; even where surrounding urban density is lacking. As in Denmark, the European Union goal of reducing energy consumption by twenty percent by 2020 and fifty percent by 2050 has also resulted in a great effort to recalibrate and renovate the existing building stock and increased energy standards for new construction. On the social and building scale, new solutions for living and working with less space (and therefore with a smaller environmental impact) are actively being investigated by a new generation of planners and architects. For example, the use of wood as a sustainable building material has become a major trend within a greater awareness of architecture's carbon footprint.

The recent National Strategy for Sustainable Development and its climate change goals have targeted local and national aspects of economic and population growth, and how that growth can be sustainably managed. Today many eco-municipalities are flourishing in Sweden, and the trend has spread to Norway and Denmark. These municipalities are using renewable energy, mass transit, green building strategies, zero waste, and open space preservation.

The seventeen goals of the UN's 2030 Agenda for Sustainable Development adopted in 2015 are now starting to impact Sweden's regulations for a sustainable built environment.[3] A renewed interest in social sustainability (following years of increased urban socio-economic segregation) is being coupled with ambitious environmental goals. For instance, Stockholm's ambition of becoming carbon neutral by 2040 has translated into regulations for maximum energy usage in new construction. At the same time, the national building sector is searching for new ways to reduce their environmental impact while increasing production to meet demands for up to seven hundred thousand new units of housing (and accompanying urban fabric) by 2025.

Norway

Norway's geographical location and dramatic topography create a multitude of climatic zones. The humid and temperate landscapes along the ocean coast and deep fjords are only a few kilometers away from polar mountain areas. The northern boreal forest belt has supplied materials for diverse building cultures adapted to the local climate. Inland farms were typically located on warmer hillsides, above the cold valley bottoms and below the chilly, windy hilltops. Local resources were utilized for log construction and slate or turf cladding on roofs. The coastal towns contain buildings used for shipping and fishing, timber structures protected from wind and rain by wooden cladding. Both the structure and details of old, traditional buildings lend themselves to easy maintenance, expansion, and the possibilities of reuse that are vital to sustainability.

Warmed by the Gulf Stream, the coastal zones allow for small-scale farming, which, together with fishing, formed a stable economic basis for settlements. Industries based on natural resources, oil, and hydroelectric power sustained decentralized growth in Norway. Supported by a strong tradition of municipal government and investments, this regional development has modified the transfer of people, wealth, and power to the cities. Today, sustainable urbanism and architecture is adapting to the variety of urban patterns in Norway.

The rebuilding of Norwegian towns and settlements after WWII was influenced both by social programs and a scarcity of resources. Together with international impulses, it inspired a modern architecture wherein rationality and simplicity were modified and adapted to the site and the local culture. Architects and teachers such as Knut Knutsen, Arne Korsmo, and Sverre Fehn influenced architectural education.

Between the mid-sixties and the mid-eighties, the speed and size of urban expansion increased while the quality of large-scale social housing developments decreased. This coincided with the environmental threat of pollution and severe conflicts over hydropower plans for Norway's remaining waterfalls. While searching for alternatives, many architects took part in the development of autonomous houses and communities based on natural building materials, solar energy, small-scale farming, and local systems for water and sewage. Other architects initiated projects that demonstrated new technologies for utilizing renewable energy and controlling heating and ventilation.

In the late nineties, the focus shifted from singular solutions to the performance of whole buildings and urban developments. Environmental programs were formulated that defined quantified aims ranging from energy demand via use of materials to landscaping and facilitation of bicycling and public transport. The political aims of near-zero energy and emissions have initiated government and industry funded research efforts that have defined and exemplified this category of buildings.[4] It shows that the choice of materials is vital when aiming for zero emissions. Another conclusion is that the systems for energy supply and indoor climate control must be simplified to be reliable and to allow future changes in building use. Today, the diverse trends of techno-criticism and rigorous scientific exploration unite in searching for sustainability in urban patterns, and in the materiality, spatial structure, and natural flows of light and air in architecture.

A series of ambitious Norwegian innovation programs has led to the rapid implementation of strategies for building with energy and emissions near zero in a life-cycle perspective.[5] The abundance of renewable hydroelectric power has enabled a ban in the use of fossil fuel for heating. Increased energy efficiency in buildings frees up capacity for the electrification of road transport, which is subsidized by the lenient taxation of electric cars.

The Planning and Building Act[6] regulates municipal authority and public information and influence on planning and building. This is vital to the social sustainability of urban development, but has been weakened in the last decades by a gradual transfer of property ownership and planning initiatives to the private sector.

After ratifying the UN Paris agreement in 2016, the Norwegian government proposed a climate act that binds future administrations to a forty percent reduction of greenhouse gas emissions by 2030 and a reduction of more than eighty percent by 2050.[7] This introduces another push toward new regulations for the building industry, where further innovations in sustainable architecture and urbanism need to be developed and implemented.

1 In 2008, the Danish "low energy class" was defined as a building that uses 70 kWh per square meter per year. Passive house standards (ca. 20KWh per square meter per year) will almost be reached in 2020.
2 See http://www.un-documents.net/our-common-future.pdf
3 See http://www.globalamalen.se/om-globala-malen/
4 The Research Centre on Zero Emission Buildings (ZEB) at the Norwegian University of Science and Technology in Trondheim: See http://www.zeb.no/index.php/en/final-report
5 The FutureBuilt program (2010-2020) for sustainable architecture and urban development.
6 The Planning and Building Act originally commenced in 1965. Successive revisions have strengthened environmental regulations, both as regards planning and building processes and building performance.
7 Emission reductions compared to 1990 levels.

Yesterday and Tomorrow Today

Sustainability in Woodland Cemetery, Stockholm, 1915–1940, by Gunnar Asplund and Sigurd Lewerentz

___David Leatherbarrow

Think globally, act locally

This well-known and often-repeated truism couples responsible action within a closely circumscribed vicinity with wide-eyed awareness of broadly encompassing frameworks—those of the natural world, of course, but also those of history and culture. Architects who adopt this axiom are thus enjoined to develop projects that acknowledge conditions that are more extensively ambient than the building's immediate site—regional and social topographies, understood spatially. On principle, this would seem to be a normal and attractive task, as nothing is more natural for architects than concern for spatial conditions. Among the arts, architecture's special competency is the arrangement and construction of inhabitable spaces. Though this is a valid assumption, the focus here will be on another dimension of architecture (and architectural sustainability): the built work's temporal dimensions.[1] The basic premise is the uncontroversial definition: architecture gives durable dimension to the spaces of our lives.

While there is no agreement about who originated the truism cited above, it is frequently credited to Patrick Geddes, whose *Cities in Evolution* has inspired many generations of sustainability-minded architects and planners. An entirely credible alternative source is the philosopher René Dubos, who was one of the driving intellectual forces behind the Declaration of the United Nations Conference on the Human Environment of 1972, an international meeting that was held in Stockholm.

The city was a generous host, opening a number of its splendid buildings, among them the Royal Palace, to the attendees.[2] Inside the residence, participants repeatedly reinforced the "think globally, act locally" principle when addressing matters of population, pollution, resource use, habitat pre-servation, and economic, educational, and urban development. Coincidentally, just before the conference, Sigurd Lewerentz had developed designs for expanding that very Palace, designs that demonstrated architecture's contributions to a city's spatial order very clearly. Lewerentz envisaged a new ensemble of public and private settings, proposing changes that would have creatively transformed, indeed improved, pre-existing circumstances. Sadly, his project came to an end only months before the statesmen, scientists, and philosophers held their deliberations.

Thinking beyond a project's boundary while acting within its proper limits was hardly new to Lewerentz in 1972. This approach can be seen very clearly in his well-known project for a cemetery in the same city, the Woodland Cemetery, designed in collaboration with Gunnar Asplund.[3] That project's contribution to our understanding of sustainable architecture, however, is not only as a spatial arrangement. Even more important—more challenging and decisive—is what the project teaches us about sustainability's temporal dimensions.

Building Time

Given our typical concern for a building's palpable concreteness, its readiness for direct and immediate use and experience, a work's extended temporality will probably seem largely

Base of the Granite Cross sculpture, designed by Asplund in 1939, Woodland Crematorium in background. All photos: David Leatherbarrow.

Next spread: Portico of the Woodland Crematorium.

insignificant, if considered at all. We tend to think that a construction is as it should be when its materials, construction, layout and "look" exist in the way that was specified in design. Unfinished and under-maintained buildings are unfit for life. Inhabitation begins when construction and reconstruction end.

Uncontroversial as these commonplaces may seem, they are contradicted by the equally plain fact that a building's "move-in" and "photo-ready" condition never lasts very long, hardly more than a season, certainly not through the years and decades of its use, well after the builders have left the site. "Houses rise and fall," T. S. Elliot observed in *Four Quartets*, and they:

> . . . crumble, are extended,
> Are removed, destroyed, restored, or in their place
> Is an open field, or a factory, or a by-pass.[4]

Succession, it would seem, is the result of environmental and cultural change. It is not, however, their governing principle, at least according to the poet. The poem's solemn invocation suggests another sense of time, one that is nonlinear, not exactly cyclical, but intelligible and familiar just the same:

> Time present and time past
> Are both perhaps present in time future,
> And time future contained in time past.[5]

The basic question is, can we discover the same mingling of chronological phases in built works that present themselves as sustainable—an "interlapsing" of past, present, and future? Considering the decades-long construction of the Stockholm Woodland Cemetery, as well as its extension beyond a few buildings into the wider landscape, one should ask whether the achronological—neither linear nor fully cyclical—life span of buildings and landscapes is not decisive in projects that seek to sustain themselves. The question can be refined more by considering what might be called the artificial and natural time of buildings, their schedules of construction, inhabitation, and renewal, as they unfold in concert with the passing of days, seasons, years, and ages.

Despite the appreciation of intelligent design and skilled craft, it seems there is no good reason to privilege a work's first over its later appearances. Our tendency to concentrate on the qualities of a building that display the designer's intentions is a disciplinary prejudice that limits one's grasp of its pre- and post-professional life. This conclusion runs against the grain of most planning and restoration campaigns, no matter whether they are undertaken by specialists in programming or preservation or by the designers themselves. Many buildings improve over time.[6] Sometimes this occurs through intentional modifications (additions and alterations) that compensate for inadequate foresight.

Other improvements result from the work's "natural" tendency to settle into its location, absorbing into its physical body qualifications that render it more congenial to ambient conditions—and by this, weathering in all its forms: sedimentation, saturation, staining, erosion, coloration, and so on.

Unforeseen improvements qualify the work, sometimes making it more livable than what had been intended—although, admittedly, these types of changes sometimes make the building worse. Even if we postpone judgments about the merit of unforeseen alterations, they are inevitable in works that last and therefore should be taken into consideration in any account of a building's concrete reality. Surely sustainability has a temporal register, along the indices of which its successes and failures can be measured.

The question becomes more specific: how might a designer's understanding of likely change—the past understood as a former present and the future as a present yet to come—be made legible on the surfaces or in the spaces of a built work? If architecture's basic task is to convey knowledge of the ways that an individual exists in the world, how might an orientation such as this be both spatial and temporal, topographical and historical?

Buildings live, and they die

Contemporary architectural theory, at both the center and margins of sustainability discussions, frequently returns to considerations of life cycle.[7] Duration/durability/endurance is the basic issue. Subtopics include recycling (materials), replacement (of elements), and life span (long- and short-term). The currency of these considerations should not lead one to assume they are recent discoveries. The understandings that excite designers and thinkers today were already topical in the 1970s, as we have seen in the principles of the Stockholm Conference, but they were no less relevant in the first decades of the 20th century, when the competition for the Woodland Cemetery was held, and well before that too.

Nor is it surprising that ideas of temporality in architecture, especially of deterioration and finality, entered into the design processes of the Woodland Cemetery, inasmuch as endings (also beginnings, thus cycles) could not be avoided. In fact, they had to be thematized, for the funeral settings and graveyards were dedicated to remembrance, which is to say keeping present what had passed. Lewerentz observed that a single upright stone can make time's passing vividly apparent. Duration willbe plainly evident, he said, when upright elements stand against the forces that range across the earth's horizons.[8] This is because every work that is raised out of the ground suffers the effects of those forces, varying in direction, cycle, and intensity, through diurnal, seasonal, and annual changes.

The built work's suffering begins on day one. The end of construction starts the clock of decay. Changes multiply as hours, days, and seasons pass: more marks on the surfaces, more erosion of carefully cut edges, and less regularity in designed geometries. The overall tendency, of course, is downward; eventually all the way down through 90 degrees. No building stands forever. Admittedly, it is a little premature to speak of ruins at the time of construction. Well-designed cemeteries can also, Lewerentz said, convey a "feeling of peace, emanat-

The Way of Seven Wells, toward the Chapel of Resurrection.

Approach to Woodland Chapel, designed by Gunnar Asplund and inaugurated in 1920; porch places a distinct accent on verticality.

Departure from Woodland Chapel; the same porch now emphasizes horizontality.

ing from eternity. . .[allowing] new generations to rediscover the harmonious, serene forms of the large burial grounds, keeping them alive . . ."[9] The question is how built works can achieve and maintain this manner of tranquility and poise. Surely the equanimity Lewerentz described is the real promise of a sustainable architecture and, more plausibly, a sustainable landscape.[10]

Context as Pretext

Before there was a project for the Woodland Cemetery, there was a given site, one with particular environmental conditions and cultural meanings. Speaking generally, it was a forest location—hardly something strange in Sweden. More particularly, it was a landscape in which groves of trees had been selectively cleared for the digging of quarries (gravel pits). The site was edged by farmlands on one side and a railway on the other. These existing conditions, variously primitive and practical, suggested to Lewerentz and Asplund the development of a range of landscape elements: mounds, dells, valleys, knolls, paths, and enclosures. This is to say that anterior circumstances served as pretexts for the design's narratives, in both their spatial and temporal configurations.

To treat context as pretext means not only taking it as an excuse for one element or another, but rather adopting it as a set of first premises or initial prompts—parts of a text, one can say, set out before the project begins. Many of the Cemetery's paths, for example, were designed to follow the contours of the given terrain, edging its depressions where a meandering through-route was required, or turning against the slope when a ritualized entry or exit was intended. Both cultivation and construction occurred in this way, working with and against existing conditions. And each approach had precedents. The forest had developed on the site over centuries, albeit for the purposes of gravel extraction and agricultural yield, thus construction of the site's enclosures and contours was well underway before the architects arrived. The design of the Woodland Cemetery was thus not an instance of "fitting into the natural context," because the context was as much an artifact as an outgrowth of environmental forces.

The Memorial Gardens laid out in the 1920 plan, much like the contour-defining paths, also took advantage of anterior conditions, by largely transforming, though not wholly eradicating them. In this case especially, what the architects found on the site was far from "natural." The location for these gardens was one of the places where trees had been cleared and gravel pits cut. Although the old depression was retained in the design, the gardens did not precisely follow the existing sectional geometry of the cut. Instead, the new levels were to be set at equal intervals along the line of descent, and regularly patterned in rows of long, equally spaced walks, terminated by diagonal stairways. These lines were drawn parallel to the main axes of the entire ensemble, so that this part would be coordinated with the geometry of the whole. One line was the long axis that linked the entrance to the main chapel, the other was the Way of Seven Wells, located between the plateau garden (Hill of Remembrance) and site of the future Resurrection Chapel. This second axis, the "Way of Seven Wells," followed the line of a path that had been previously cut through the preexisting forest.

To describe this manner of developing the site as incremental would seem correct, except for the fact that some steps forward were accompanied by some steps backward—interpretations, transformations, and restorations of what was there before the project began. Yet, to say this work was retrospective is also incorrect, since forward-looking enhancements and amplifications of preexisting conditions went hand in hand with large-scale alterations and reformations. Individual places within this site—and within all sites that have the capacity to sustain themselves—refuse the step-by-step continuation of what had been in favor of modifications that bring the location into greater conformity with current expectations.

What was true for landscape transformations can also be seen in the design of the individual buildings, their overall form, spaces, and individual elements. New forms were never wholly new (can forms ever be wholly new?). Consider, for example, the well-known and often-praised entry porch for Asplund's Chapel.

The arboreal shelter provided by the ancient forest is both recalled and transformed in the timber uprights and ceiling that define the outdoor vestibule. The connection between what is unbuilt and built, ancient and up-to-date is evident, despite the anachronism this coupling represents, as is the fact that the accent on verticality when approaching this chapel is contradicted by the emphasis on horizontality when leaving it. That Asplund intended this coupling, or complementarity, is plain when one considers his own description:

> *The requirements did not allow a large monumental building to emerge from nature. The building was therefore suppressed, and without any compromise, subordinates itself and merges with nature, the surrounding pines and spruces rising to twice its height.*[11]

No less inconspicuous, or perhaps even more so, is the low, earth-covered building nearby, among those in the Chapel's precinct. This construction, a mortuary, was meant for temporarily housing caskets in cool temperatures before funeral services in the Chapel began. With a descending entry, *dromos*-like, earthed in on its other three sides, and covered with a turf roof, the building is as much a hollow in the soil as a work placed upon it. The "merge" is plainly evident, though no one mistakes the work for an outgrowth of nature.

Throughout the architecture of the Cemetery there are well-reasoned provisions that anticipate likely patterns of use. Knowledge of cultural patterns sustained this provisioning. One's vivid, though easy, sense of architectural anticipations conveys a sense of the architects' care and generosity. Consider, for example, a localized but rather inconspicuous treatment of the stone flooring: grieving mourners sitting on a wooden bench facing the casket of someone now gone will doubtless, as some point, find the image they face, and the loss it affirms, unbearable. The inevitable downward glance is greet-

View from the portico of the Woodland Crematorium toward the Almhöyden meditation grove in the distance.

Mortuary, near the Woodland Chapel; view of entrance.

Next spread: Chapel of Resurrection designed by Sigurd Lewerentz, completed 1925. Chapel of Resurrection, interior detail.

Art and Architecture

___Cathrine Vigander

The quality of a project, independent of size or function, plays a crucial role in a bigger system of spaces, the health of our planet, and future lives. Every project should give something valuable back to the user and to society. Art can be an intrinsic part of architecture and an instrument to add quality. Daylight, equally, can be vital for the betterment of occupants' health. Foremost, the architect can take an active, yet critical, stance toward rules to achieve better architecture and more sustainable solutions on material, economic, and social levels.

The Teachers' House and D36 Green House are small infill projects in the city center of Oslo. Both have artwork integrated as part of the facade strategy and as part of the identity of the buildings, but with two different intentions: one facade symbolizes the importance of the work done by the users of the building, while the other reflects the importance of "blending into" the project's location within a vulnerable green stretch.

The projects build on two fundamental approaches to sustainability, one solving the energy concept by deviating from the mainstream Norwegian practice, and the other exploring a means of achieving social sustainability.

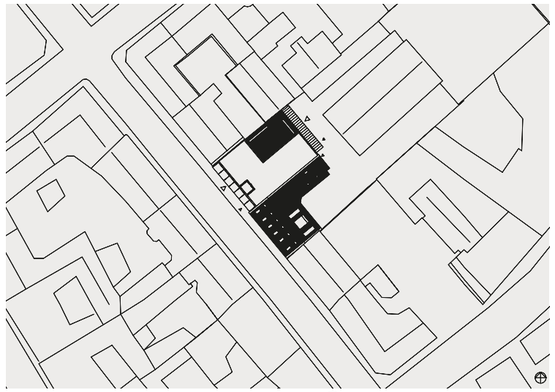
The Teachers' House and D36 Green House have an important factor in common: daylight. In both cases, this architectural element works to ensure better health. Daylight is a key factor in the work of all architects; an architectural quality that is becoming extremely important as cities around the world are becoming denser and buildings are being built higher.

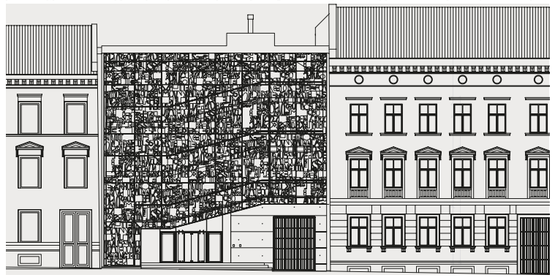
The two projects also exemplify how design strategies that question pre-accepted ways of thinking can imbue a project with future relevance. To do this, one must challenge rules and conventions and maneuver around them through dialogue and negotiation. Complaints are passive. These projects show how an architect can question contemporary practice by demonstrating new solutions in built examples. In this sense, each project participates in a discussion on a 1:1 scale on how to develop better design strategies.

The Teachers' House ("Smykkeskrinet")

Category: Conference Center
Address: Osterhaus Gate 4, Oslo, Norway
Client: Union of Education Norway
Architect: Element Arkitekter AS
Artists: Jorunn Sannes (main facade) and May Bente Aronsen (acoustic art piece in lobby)
Engineers: Dr.Techn. Kristoffer Apeland AS, NEAS Norsk Brannconsult, Brekke og Strand Akustikk AS, Norconsult AS, Skandinaviska Glassystem AB
Entrepreneur: Tronrud Entreprenør AS
Floor space: 1,794 m²
Completed: August 2009

Art as an intrinsic part of architecture; the southwest facade of the Teacher's House. Photo: Element Arkitekter AS.





The Union of Education is Norway's largest union for teachers, with more than 150,000 members. To accommodate their need for a conference center, they purchased an empty plot and an existing apartment building from the late 1800s on a parallel street, adjacent to the existing headquarters of the union. The Teachers' House project was awarded through an invitation-only competition in 2004. This project is an example of how architecture can work as a catalyst for improving the quality of a neighborhood and provide a new identity for a street.

Projects are often designated with a nickname that emphasizes the main concept of the architectural design. The Teachers' House was called *Smykkeskrinet* (jewelry box), which refers both to the artwork on the main facade and to the large conference room, or box, which is the heart of the project. The artwork on the main facade symbolizes the importance of education and learning and embeds these cultural values and aspirations in the identity of the building. At the same time, the printed glass envelope serves as an instrument to reach the building's energy goals.

The project began with an invitation to the chosen architect to join the project's building committee, and take part in a total of 73 meetings with the client and the client's advisor, learning, negotiating, discussing, and dealing with the ups and downs of the project. The committee entrusted the architects to appoint the engineers of their choice and the two most cutting-edge Norwegian artists to the team. The resulting close collaboration between the artist Jorunn Sannes and Skandinaviska Glassystemer AB was very important to the development of the main street-facing facade. It is composed of two layers of glass with a mirroring art screen print on the outer surface of the inner glass. Due to the fact that the design of the Teachers' House deviated radically from mainstream thinking, it took five years before it opened.

Philosophy of sustainability

The main strategy for the sustainability approach is architectural quality and long-term thinking. The durability of all the building materials chosen ensures that future operational and maintenance expenses will be minimized. This strategy is paired with a complementary focus on minimizing the use of materials. In part, this is also a reaction to the influence of the Norwegian insulation and mechanical ventilation industry. This influence has resulted in the excessive and unnecessary use of materials, raising huge environmental challenges and also leading to health problems, since airtight envelopes are frequently combined with the use of low-quality materials. Instead of three layers of highly insulated glass units, "poor" double glass was chosen for its capacity to allow the collection of free solar heat. Also, the weight of two layers of glass required less material to carry the loads. Slender concrete walls with moderate insulation were used instead of thick and highly insulated concrete walls.

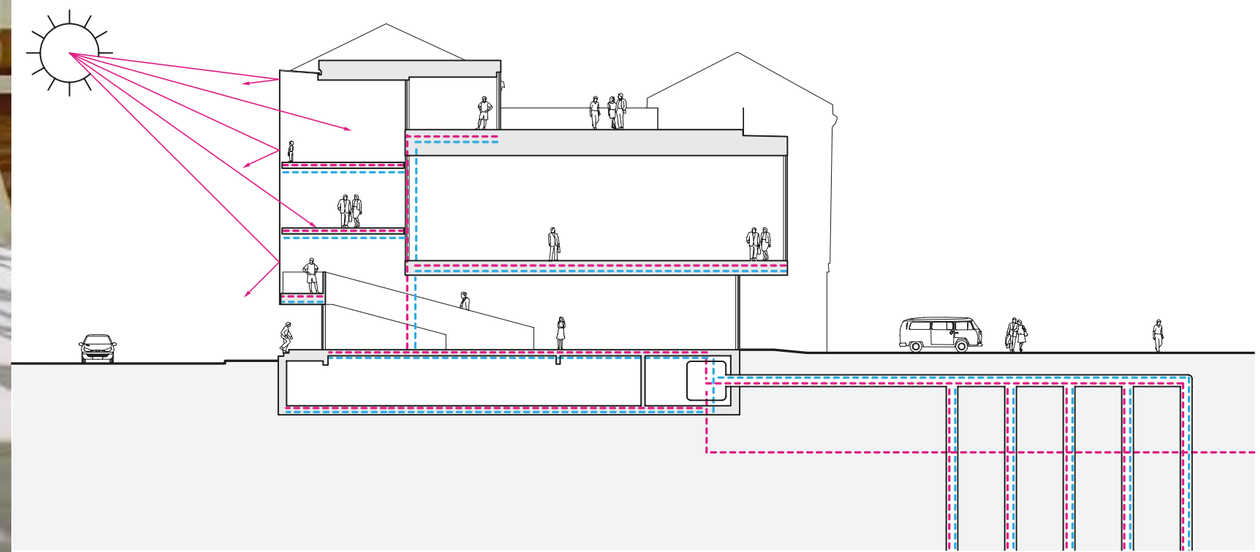
The conference center is a "low energy house," with an energy concept that opposed then-contemporary mainstream

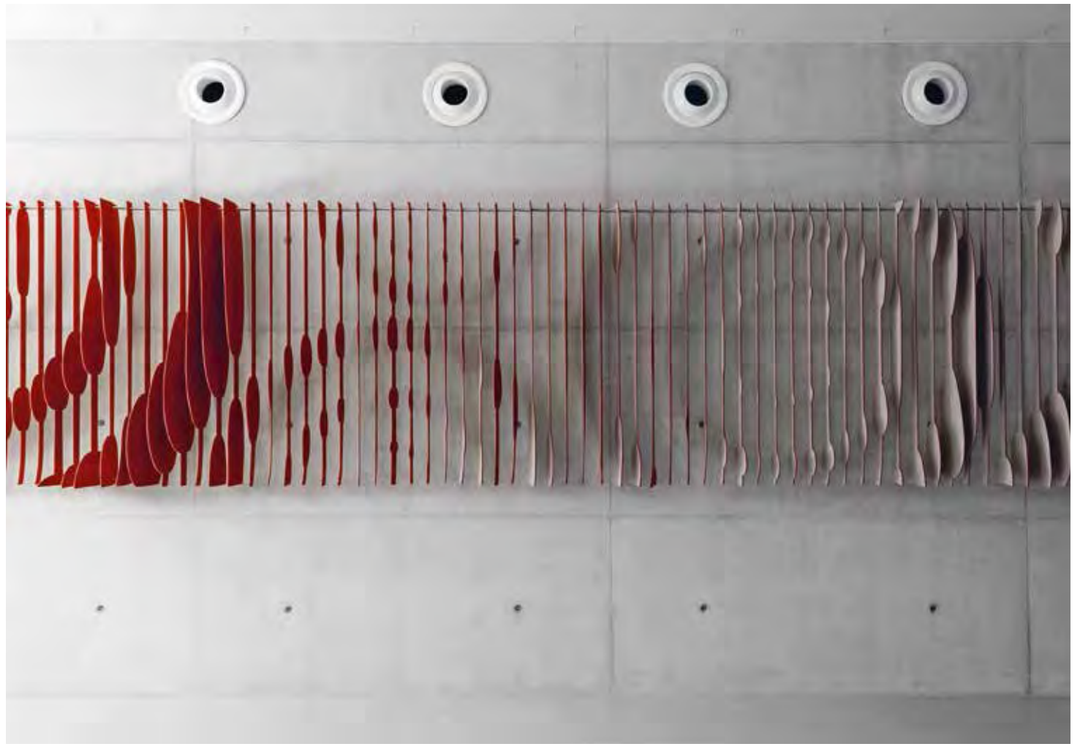
Site plan of the Teacher's House and surrounding buildings. Drawing: Element Arkitekter AS.

View at night of the main staircase seen from the interior of the conference hall. Photo: Element Arkitekter AS.

Concrete staircase capturing sunlight through front facade. Photo: Element Arkitekter AS.

Section showing the energy exchange between sun, concrete floors and energy wells. Drawing: Element Arkitekter AS.





thinking and political guidelines, as well as many of today's passive house energy strategies.

In *Smykkeskrinet,* heat from the sun is collected in the thermal mass of the concrete structure. Both the southwestern and northeastern glass facades work as sun collectors, and the artwork on the main facade doubles as a sun screen to reduce overheating. The solar heat collected in the concrete is stored in ten energy wells reaching underground depths of between 150 and 200 meters. In the winter, heat pumps extract heat from the wells, and in the summer, the wells are used for cooling. The water that facilitates this heat transfer circulates though pipes integrated into the floor slabs and the main concrete staircase. Since glass walls and exposed concrete surfaces are key parts of the energy concept, acoustics became a matter of great concern. In the lobby, an art installation made of felt was designed by May Bente Aronsen. The seventeen-meter-long artwork solves the acoustic absorption challenge without reducing the area of exposed concrete. Another important acoustic strategy was to work with different sound zones. For instance, the main staircase has no acoustic absorbents, just exposed concrete. The reverberation is distinct, but once you enter the conference room, the sound is soft and well modulated. These acoustic transitions are important not just because of the spatial experience of contrasts in sound, but also because the use of acoustic material is reduced to a minimum.

Another important challenge for the project's sustainability was to work around a law that states that the project must be connected to the district heating plant. This regulation does not distinguish between heat generated by fossil or renewable fuel. The solution was to connect to the district heating system, but just for peak periods (50–100 hours a year). *Smykkeskrinet* exports excess energy to the existing buildings in the headquarters.

Key turning points

The first turning point in the project related to the core function of the Teachers' House was the conference room. As the design developed and demand for programmed spaces evolved, the space available for the conference room became increasingly diminished. The client initially planned to sell the adjacent apartment building, which they owned and used temporarily for office space, once *Smykkeskrinet* was finished. However, after this strategy was questioned, functional spaces for storage, the kitchen, toilets, and the main fire escape were integrated into the back house of the old building. This permitted the realization of the client's original goal of making the conference room as large as possible. The second turning point was convincing the client that concrete should be the building's primary material, which was critical to achieving the project's energy goals. In the end, a design process that began with the client asking for slate (because concrete was considered "ugly") concluded with the client insisting that nothing should be placed on the walls because the concrete work was so beautiful. This was a wonderful example of how sharing new knowledge with a client may lead to new perspectives and preferences. It was a great risk to propose exposed, in situ cast concrete, simply because Norway's traditions with concrete are less developed than those in southern Europe. In the case of *Smykkeskrinet,* the finished construction was able to transcend preconceptions. This was primarily due to one man on the contractor's team dedicating his fullest enthusiasm, talent, and understanding of the material toward ensuring that the project would have beautiful concrete work.

Future relevance

Smykkeskrinet is built for the future, allowing for the exchange of technical components as technology moves on. For example, a CO^2 heat pump that only consumes one-sixth of the electricity used by the existing heat pump can be installed.

The users state that the new building has enabled them to develop better courses and better lectures, and the key success factor mentioned is daylight. In a broader perspective, this can lead to better education and insights for teachers—and thus improved teaching and learning for the next generation.

In 2015, *Smykkeskrinet* received the *Houens Fonds Diplom* from the Ministry of Culture, Norway's foremost architectural prize. Through this distinction, it has become part of Norwegian architectural history and will remain a reference with future relevance.

Felt artwork by May Bente Aronsen which also works as acoustic absorber. Photo: Ivar Kvaal.

Lounge and kitchenette. Photo: Hans Petter Smeby.

Green House D36

Category: Housing: twenty-one apartments, ranging from 29 to 82 m²
Address: Dælenenggata 36, Oslo, Norway
Client: Infill AS
Architect: Element Arkitekter AS
Artist: Element Arkitekter AS/Hallvard Huse
Landscape Architect: Gullik Gulliksen Landskapsarkitekter AS
Engineers: Sweco AS, Fokus Rådgiving AS, AJL AS, GK AS
Entrepreneur: Eide-Entreprenør AS
Facade entrepreneur: Element Arkitekter AS, Uppe LTD, Modum Glassindustri AS
Floor space: 1,750 m²
Completed: October 2013

The project aimed to explore how a small plot could contain more dwellings and, at the same time, add architectural qualities to the surroundings. Building densely and close to transport hubs implies an environmentally efficient development that contributes to a better use of resources. The concept is based on a political strategy of urban repair and densification, which involves building housing on very small and complicated plots of land—tiny voids or wastelands within the city. We initially cooperated with the client to identify 400 small plots inside the Ring 2 (ring road) around central Oslo. Each of these sites offers an infill opportunity whereby development might alleviate the city's desperate need for more housing.

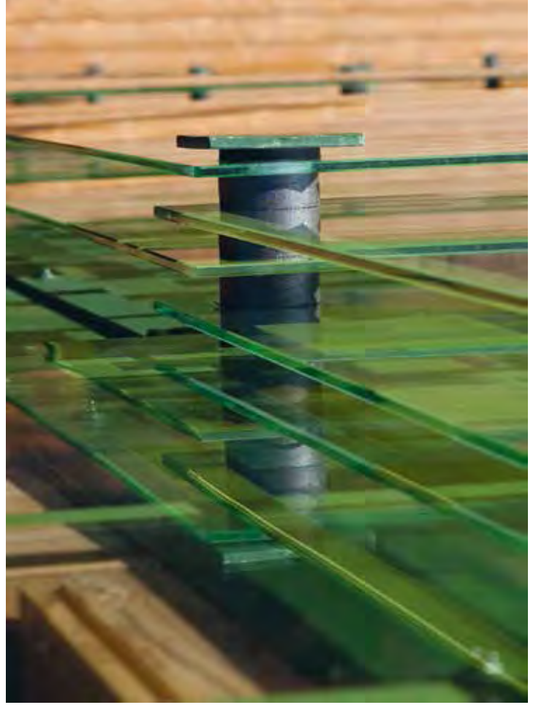
D36 is located alongside a green path for pedestrians and bicyclists. The neighboring buildings are brick apartment blocks from the late 1800s in distinctive colors such as ocher, red, beige, blue, and green. The idea was "to give something back" to the city by respecting the lush green stretch. The house is a symbolic tree, a six-story artificial evergreen with a roof garden that allows for urban farming. A street-level shoe shop serves as a reception area and space for interaction with the neighborhood.

As in Smykkeskrinet, artwork is an integrated part of the concept. In this case, multiple layers of printed glass create effects similar to those of light filtering through a canopy of leaves. Conscious of the huge local intervention that a building in a park represents, this artwork aims to render the project both distinct and unobtrusive.

Planning the framework and regulations for D36 started back in 2003. The project's approval was dependent upon several exemptions to codes and planning guidelines, and as a result, it took ten years before construction was finalized. Since the footprint of D36 is the same size as the plot, the project faced major challenges from the very beginning. According to Norwegian law, a percentage of the outdoor common space has to be provided on the ground. The garden was, therefore, moved to the roof, but with major resistance, as this did not comply with the regulations. Secondly, there are rules for a

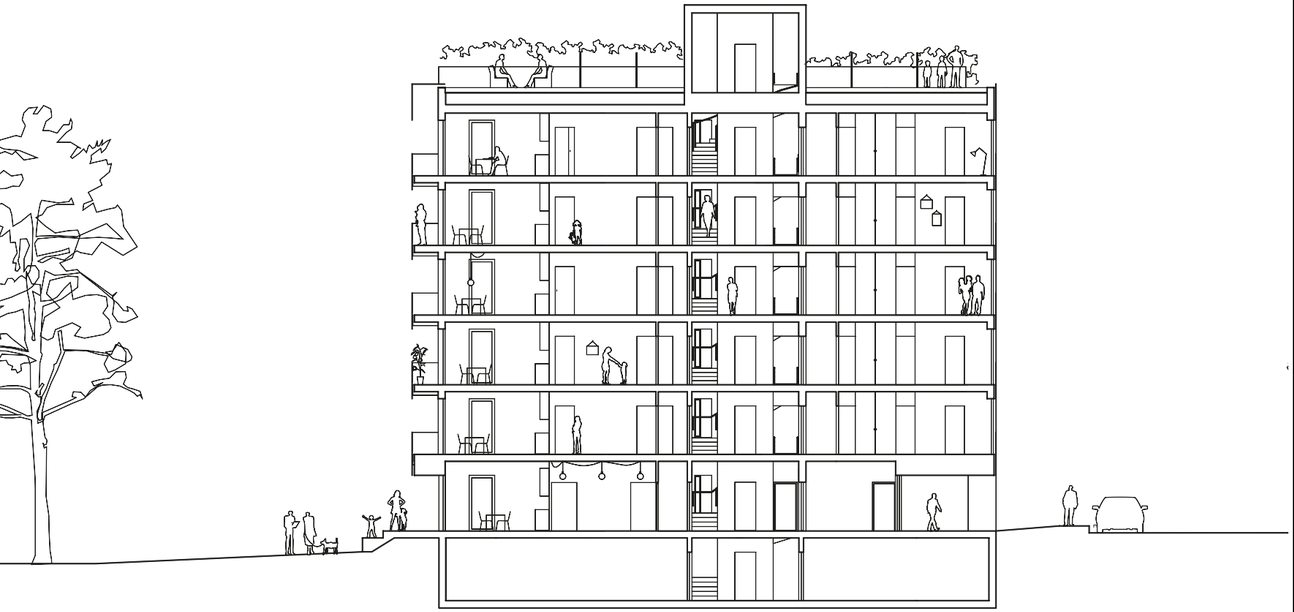
Site plan showing location within a green park. Drawing: Element Arkitekter AS.

Aerial photograph: Artificial evergreen with a roof garden. Photo: Finn Ståle Felberg.



Previous spreads: Interior and exterior view of glass facade. Roof garden, including shared terrace and individual plots. Multi-layered glass facade detail. Evening photos of exterior. Photo: Adam Stirling, Finn Ståle Felberg.

Roof garden, including shared terrace and individual plots. Photo: Finn Ståle Felberg.



Longitudinal section. Drawing: Element Arkitekter AS.

Floor plan, floors 1-3. Drawing: Element Arkitekter AS.

minimum amount of parking space within the project. This was solved through a contract that gave the residents access to rental parking spaces within 500 meters of their homes, and space for bikes was given priority within the project.

Philosophy of sustainability

D36 is highly sustainable in the sense that dense and compact living close to public transport nodes reduces area demand and greenhouse gas (GHG) emissions from cars. A general shift toward a sustainable building industry requires that the goals and aims of reducing emissions first have to be set by politicians. The building industry rarely aims higher than the minimum standards; this is how economy works. As in the Teachers' House, durable materials were chosen to reduce operational and maintenance expenses. Examples include glass with ceramic print, solid wooden flooring, and thermally modified wood on the balconies. The climate in Norway is getting warmer, wetter, and more mercurial. Sudden heavy showers in cities are a bigger economic problem for society than seasonal flooding. The 50 centimeters of soil on the roof garden not only allows for urban farming, but also plays a crucial role in retaining rainwater and delaying it from pouring into the public storm water system. Also, the social effect of gathering on the roof for both private and common events is highly valued by the residents.

Quality of living is not just a matter of the standard of a person's apartment and how they interact with the neighbors, but also how the neighborhood works once that person steps out into the street. It is also about how the community works, where a person meets others, where she or he works, goes to school, or buys groceries. Architecture can serve as a health factor as well as a safety factor, and thereby contribute to social sustainability.

The emphasis on economic sustainability is reflected in the choice of a rational 2.4-meter grid and a compact technical system organized in the core of the building. Considerable efforts were made to repeat building elements, optimize material, avoid wastage, and efficiently organize every inch of living space. For instance, an innovative window niche was designed that was capable of preventing the spread of fire, thereby enabling each floor to contain four apartments rather than three.

Key turning points

The first turning point arrived when, after an eight-and-a-half-year struggle, the authorities granted approval for the project to be constructed.

The second turning point related to the supply of materials. The inner house was initially designed with a cross-laminated timber structure. But before construction could begin, the supplier shut down production. The primary structure was changed to concrete in order to allow construction to proceed, but the project was ultimately weakened in terms of conceptual integrity and sustainability, as the concrete structure was not integrated into the building's energy/thermal strategy. Effectively, the potential thermal advantages of the concrete construction utilized in the Teachers' House went unharnessed.

The most critical turning point occurred when the final costs of another project by the same client were revealed. The numbers were alarmingly high, and D36 was put on a "budget diet" overnight. The project's most conspicuous expense was the planned green planted facade, and so the client requested that an alternative be found, more specifically, a color with which to paint the facades. Three weeks were granted in which to find a collaborator willing to deliver the facade based on a revised budget. The strategy succeeded by teaming up with Uppe Ltd and Modum Glassindustri AS. In the end, the outer facade was mounted—on budget and on time—on a separate contract. To facilitate this change, a new facade system was designed. The new facade consisted of an inner skin of aluminum, which protected the wind barrier, followed by numerous layers of glass with artwork in ceramic print.

The last turning point related to the project's new fire-safe window design, an innovation that enabled one additional unit per floor. Due to the window niche's unconventional design, the solution was turned down by the authorities just one week before opening day. However, when the fire engineers produced additional simulations for heat radiation during a fire, they were surprised to find that the design performed far better than the pre-accepted solution recommended by the authorities. This is a powerful reminder that innovation and non-traditional thinking are risky. Top expertise is needed to verify that a new design matches or surpasses the performance of conventional and pre-accepted solutions.

Future relevance

The concept of delivering the facade as a separate subcontract was used again in the next project. And, more widely, D36 has been an important catalyst in the debate on compact, quality living in Norway. The residents state that their daily life has improved since moving into D36, emphasizing daylight as the most important aspect. Research shows that daylight has a direct effect on health and well-being. In 1887, the Norwegian *Sunhedsloven* health law stated that the ceiling height in apartments should be a minimum of 2.4 meters. The same law is in effect today, but since that time, the average height of Norwegians has increased by approximately 20 centimeters. Therefore, Element Architects AS has set the goal of increasing minimum interior height to 2.7 meters. The idea of "2.7" was launched on Facebook[1] and in the ROM Gallery in Oslo in the fall of 2015. This "health project" is truly idealistic; the work is not being paid for, but the problem is too important not to be pursued.

1 2,7meter/facebook.com

Embracing Complexity

___Tine Hegli

One of the dimensions of sustainability is to strive for public ownership of the built environment. The goal of responsibly managing common resources through social awareness and knowledge is key to success. The use of land and the appreciation for local culture and democratic values are also critical. Embedded in this mindset are strategies for a sustainable society. These strategies differ from project to project, and from site to site, but share a single motto: *Be generous!*

New large-scale structures occupy land, and, when they are constructed in dense city centers, the public will experience a loss of view and daylight or, if constructed on virgin land, a loss of ground that was already considered public. In all design processes, these matters are vital and are consciously analyzed to inform decision-making. Also, the knowledge of how to reduce energy use and related emissions of greenhouse gases to a minimum adds complexity to the decision-making process.

To balance concerns from these different levels—to evaluate, conclude, prioritize, and to see the big picture—are important exercises throughout design development. How can the design approach give value back to the local environment and enhance site-specific qualities? How can architecture stimulate new and unexpected experiences? Designs that manage this work as "testbeds" where new knowledge can be found. They hold iterative processes whereby architecture constantly can evolve and improve along with ambitions for the greater good of a society.

All parties that can enlighten the search for a successful built result should play a part in the design process. This includes representatives from the client and potential users across all relevant disciplines, stakeholders, artists, and people with knowledge of how to absorb, transform, and improve local conditions.

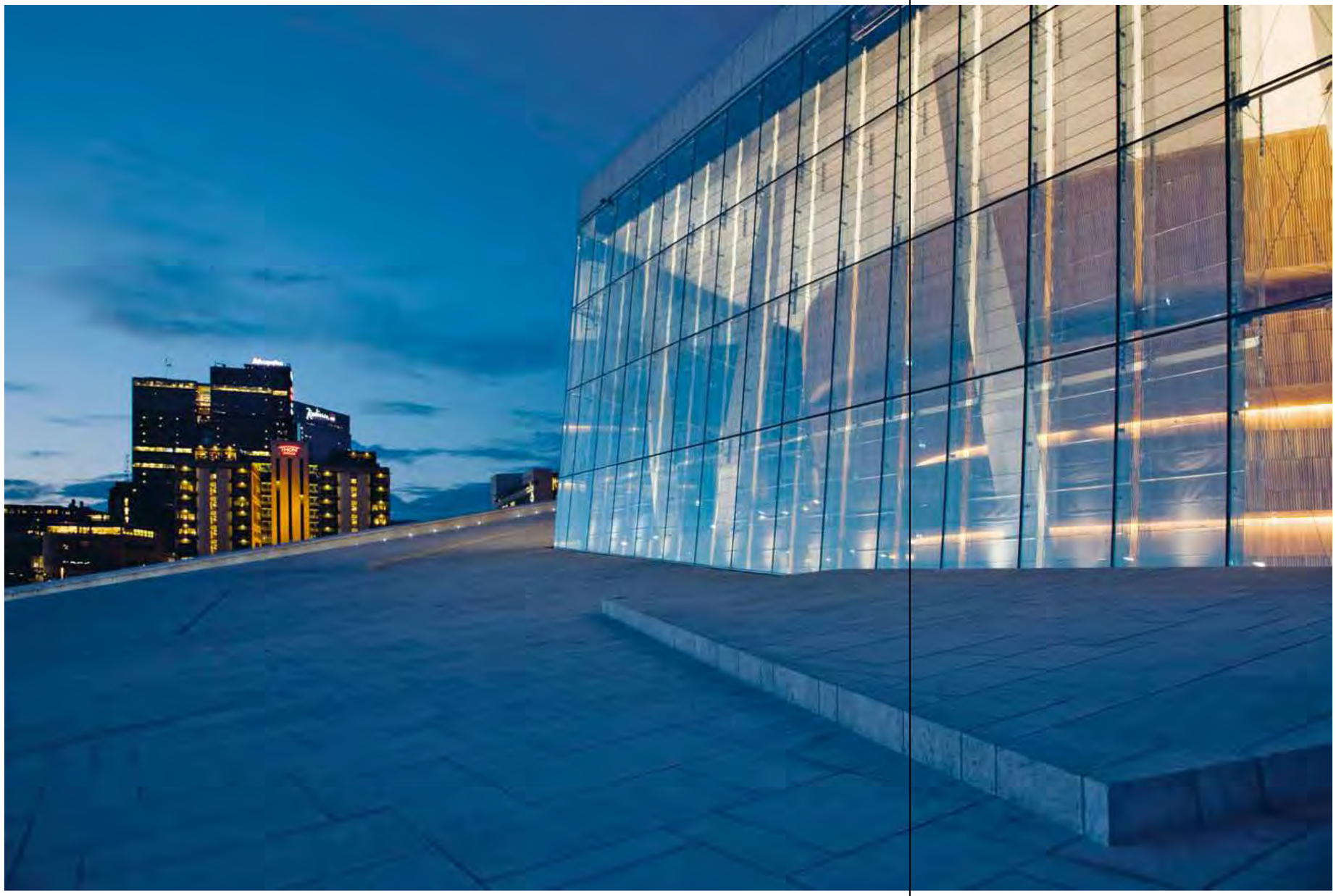
A collective design process results in a shared knowledge base and a shared investment in the "winning scheme." This will, in turn, encourage all parties to take on the responsibility required to guard the ideas through later phases.

By gathering a broad mix of competencies, the process is less likely to be colored only by well-established roles and hierarchies. Narratives, diagrammatic concept sketches, analog work models, and intense dialogue are tools to communicate, translate, and merge ideas. Digital simulations, both to illustrate spatial potentials and performative achievements, are tools to make evaluations and iterations through which the design is optimized towards the goal. The two following projects focus on how ambitions concerning sustainability have influenced both teamwork and the architectural result.

Norwegian National Opera and Ballet

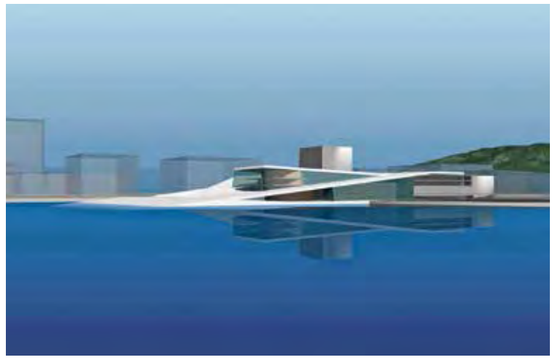
Category: Cultural building
Location: Bjørvika, Oslo
Client: Statsbygg
Architecture, Landscape and Interior: Snøhetta
Team of Artists: Jorunn Sannes, Peder Istad, Henrik Hellstenius, Axel Hellstenius, Inger Buresund
Team of Engineers: Erichsen & Horgen, Engineer Per Rasmussen, Reinertsen, Brekke & Strand Akustikk, Theater Projects Consultants/Rambøll Norge
Floor Space: Building: 38,500 m^2; marble-covered public plaza, foyer, and roof: 25,000 m^2
Completed: 2000–2008

Opera house, exterior. Photo: Christoffer Haglund.



Illuminated lantern on rooftop plaza at dusk. Photo: Jiri Havran.

Public gathering on the rooftop plaza. Photo: Erik Berg.



Building exterior. Illustration: Snøhetta.

Opera during construction. Aerial photo: Courtesy of Statsbygg.

Sloping plaza along waterfront. Photo: Snøhetta.

In 2000, when Statsbygg held an open international competition for the new National Opera and Ballet in Oslo, the area of Bjørvika was untouched. The site on the harbor front was cut off from the city center by heavy infrastructure and left as an industrial landfill. The plans for developing Bjørvika into a new attractive neighborhood with a mix of cultural institutions, service, and housing were on the table. The Opera was to be the catalyst in making this transformation possible.

Among 250 entries, Snøhetta won the competition with a scheme evolving from transformation, including the reinterpretation of the institution itself. The design approach included a democratic statement, where the central site was designed to accommodate the desires of both a rapidly growing city as well as the established cultural audience. Organizing the programmatic functions and volumes with the aim of keeping a low building silhouette, the design allowed for an accessible "roofscape" that could offer spectacular views for everyone visiting the site. This scheme seamlessly tied the Opera to future infrastructure and integrated the building into a continuous public space spanning from Jernbanetorget to the fjord, connecting the urban density of the city center to the unique qualities of open nature.

The public foyer space was presented as a continuation of this landscape, "the carpet," where the visitors entered the building between layers of white stone, eliminating the threshold between exterior and interior. The balconies and main auditorium were wrapped in a wooden "wave wall" to enhance the same atmosphere, adding layers of associations to nature to the experience. The back-of-house functions, arranged around a courtyard to give daylight to the production areas, were labeled the "factory," and designed for future flexibility. Large windows are main features of the rehearsal rooms and workshops that engage the Opera and Ballet machinery with the surrounding city.

Key elements in the design process

Awareness of daylight and its changing conditions in the Nordic climate played an important role in translating the nature narrative into the characteristic architecture of the Opera. Daylight is a nature-given resource crucial for human well-being at many levels. Yet daylight is also challenging to obtain as an interior quality because of heat loss and heat gain through glazed areas; the use of daylight requires additional energy for technical systems to balance heating and cooling. The efforts to resolve the Opera foyer, with its focus on light, exemplifies how design offers sustainable solutions with multiple dimensions. Developing the winning scheme from conceptual sketches into 1:1 construction details covering all functional and technical aspects of the sophisticated program required eight years of intense interdisciplinary collaboration. Several artists worked closely with the team of architects, landscape architects, and interior architects in defining strategies to materialize the narratives, and great attention was paid to keep these artistic intentions and qualities alive throughout all phases.

The size and scale of the marble landscape set the agenda for the "front of house" areas—the public spaces. In order to maintain the scale and atmosphere of this landscape, the absence of typical building elements was crucial. This ambition led the team to develop solutions where all technology required was integrated into the architectural design.

Natural light

Technical solutions, from the stormwater management on the marble roofscape to the integration of sprinkler systems in the foyer ceiling, were coordinated through the strategies described above. All strategies being equally important to the totality, the design process is best described through the daylight experience of the foyer.

To enhance the level of daylight and emphasize the notion of being in a semi-outdoor environment, the upper glass facade, the "lantern," was solved as a structural glazing construction. Glass fins, with a depth of half a meter, were designed to tackle the wind loads, and to transfer the loads of the facade itself to the superstructure hidden within the brim of the stone roof along the perimeter. Also, the glass quality was carefully studied to fulfill the vision of full transparency. The iron-free glass hardly changes the color of the transmitted light. During the day, the "lantern" appears to be made of crystal, like a prism playing with the light. At night, and even in the day during the dark seasons, the same facade qualities allow the warm colors of the wooden interior wall to be exposed to the city, indirectly lighting up the outdoor marble and transforming the house into a giant lamp.

Such tall glass facades are incredible sources of daylight, but at the same time they are challenging in terms of energy use for heating and cooling, as well as the discomfort of drafts. These hurdles were resolved by combining active technology, like radiators and fans, and passive design strategies based on the interaction of indoor airflows, architectural spaces, materials, and building parts.

The main heating system was based on thermal energy from district heating and distributed in the floors. Due to the large volume and thermal capacity of the stone, solar gain through the facade contributed positively to a comfortable indoor climate during the cold season. To avoid overheating in summer, there were several strategies in play that adapted to the architectural expression and programmatic requirements.

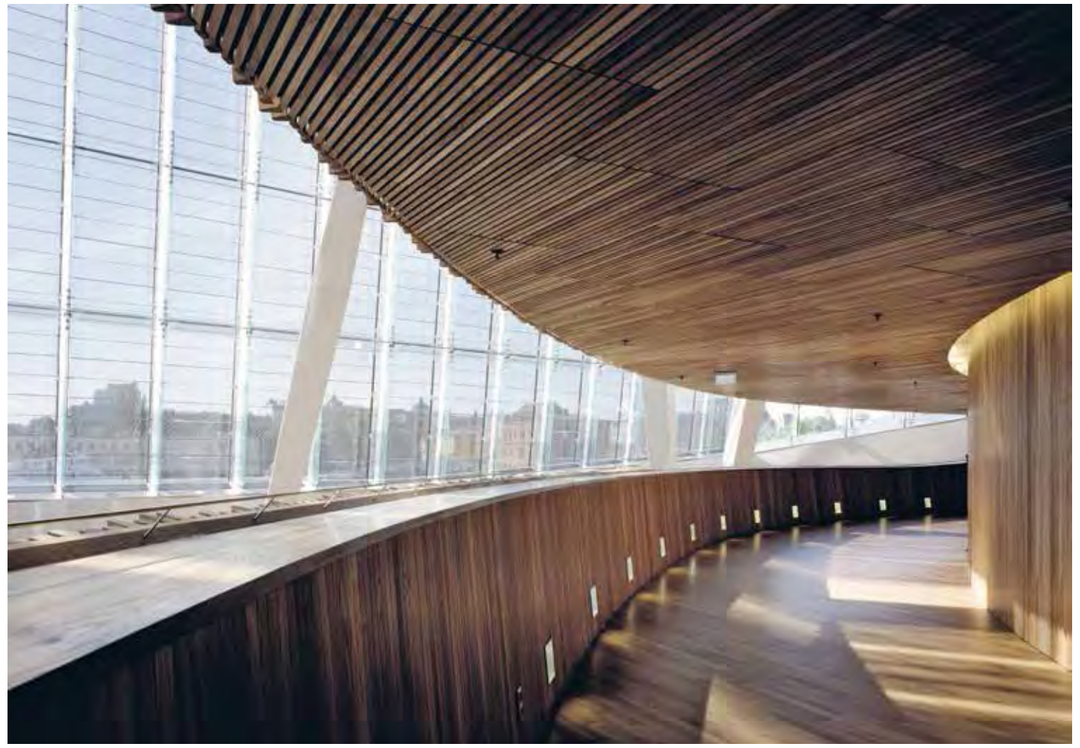
The upper part of the main glass facade facing south has a patchwork of photovoltaic cells that serve as solar shading, still leaving fifty percent clear glass for views and light transmission. The monocrystalline cells have an efficiency rate of sixteen percent and produce 20.600 kWh of renewable energy (electricity) for building operations.

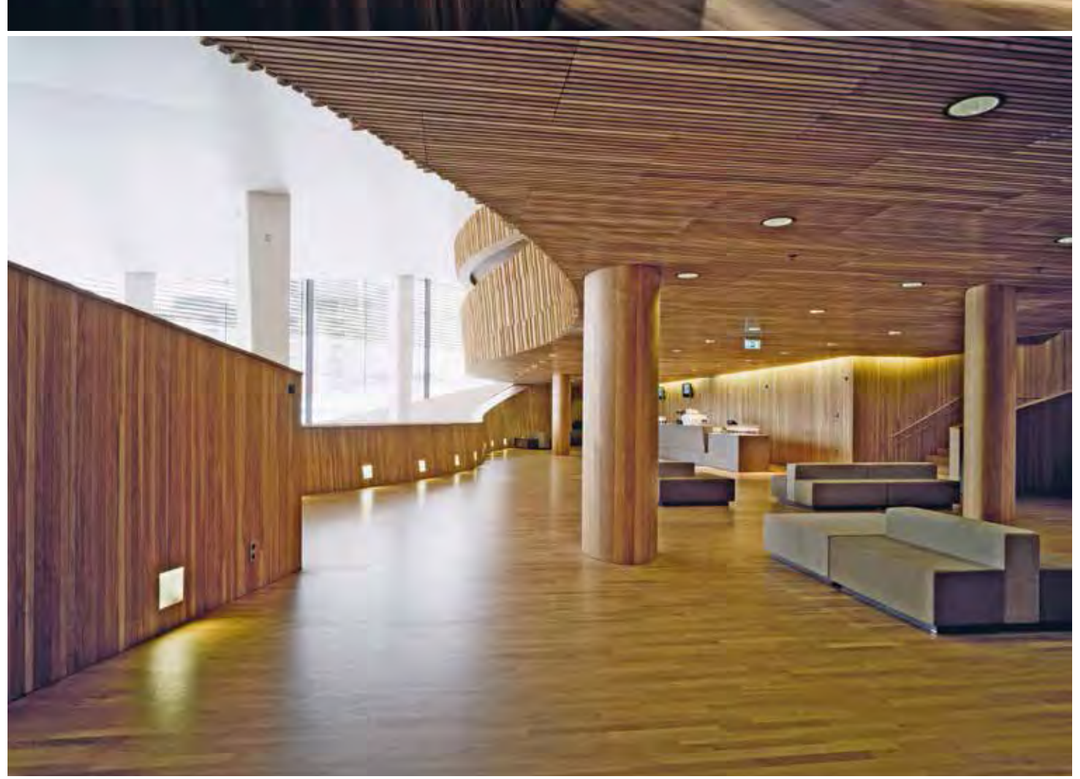
For the lantern, an inner solar screen was incorporated, reduced the total U-value of the glass facade. In the area where the central foyer floor connects to the Oslo fjord, the glass facade is recessed several meters to shade the south-facing café space as well as to protect the outdoor serving area from wind and rain.

Next spread: Wave wall in glass lantern. Photo: Helene Binet.

Upper levels of the wave wall in central foyer. Photo: Helene Binet

Balcony bar in central foyer. Photo: Gerald Zugmann.





The design of the wooden “wave wall” solves many of the air distribution strategies. Air inlets at the floor level are integrated in the pattern of the wooden slats together with acoustic panels. The wall openings are designed to provide city views from the balcony areas but, at the same time, keep the balcony separate from the foyer in terms of airflow. This displacement ventilation strategy allows the warm air to be retracted for heat recovery through the gap along the top of the wooden wall. In case of high temperatures, the air is released through hatches at the very top of the glass facades that also provide smoke ventilation. A seawater pump provides (free) cooling in the warm seasons.

To avoid cold drafts in the foyer during the winter season, fixed horizontal glass fins (one-third of a meter deep and mounted every three meters) direct cool air descending along the tall windows into the central volume, mixing it with the warm ascending air. For the coldest periods, radiators are positioned at the very bottom of the glass facade, built into the interior brim of the stone roof. This detail is also repeated at the ground floor.

The light marble floor is important for the lighting strategy of the public spaces, both during the day and at night. In the daytime, the polished surfaces reflect and spread light from the sky, from the fjord in the south, and from the open plaza on the north side. To avoid visible features of technology, the artificial lighting concept is based on the same sources, utilizing the light floor and ceiling surfaces as agents within an indirect lighting concept that includes lamps embedded into the architectural elements.

Resulting qualities

The design strategies of the Opera hold a mindset that is fundamental for a sustainable society: “Be generous!” The democratic values embedded in the public’s ownership of this grand structure gives it meaning beyond the cultural activities on show. The strategies that led to the architectural experience at the urban level also improved the performance of the building in terms of energy efficiency and environmental sustainability.

The Opera was included in the EU project “ECO-Culture” as one of three European energy-efficient cultural buildings that aimed at three main measures:

_____Demand-controlled and energy-efficient ventilation systems, including control of relative humidity

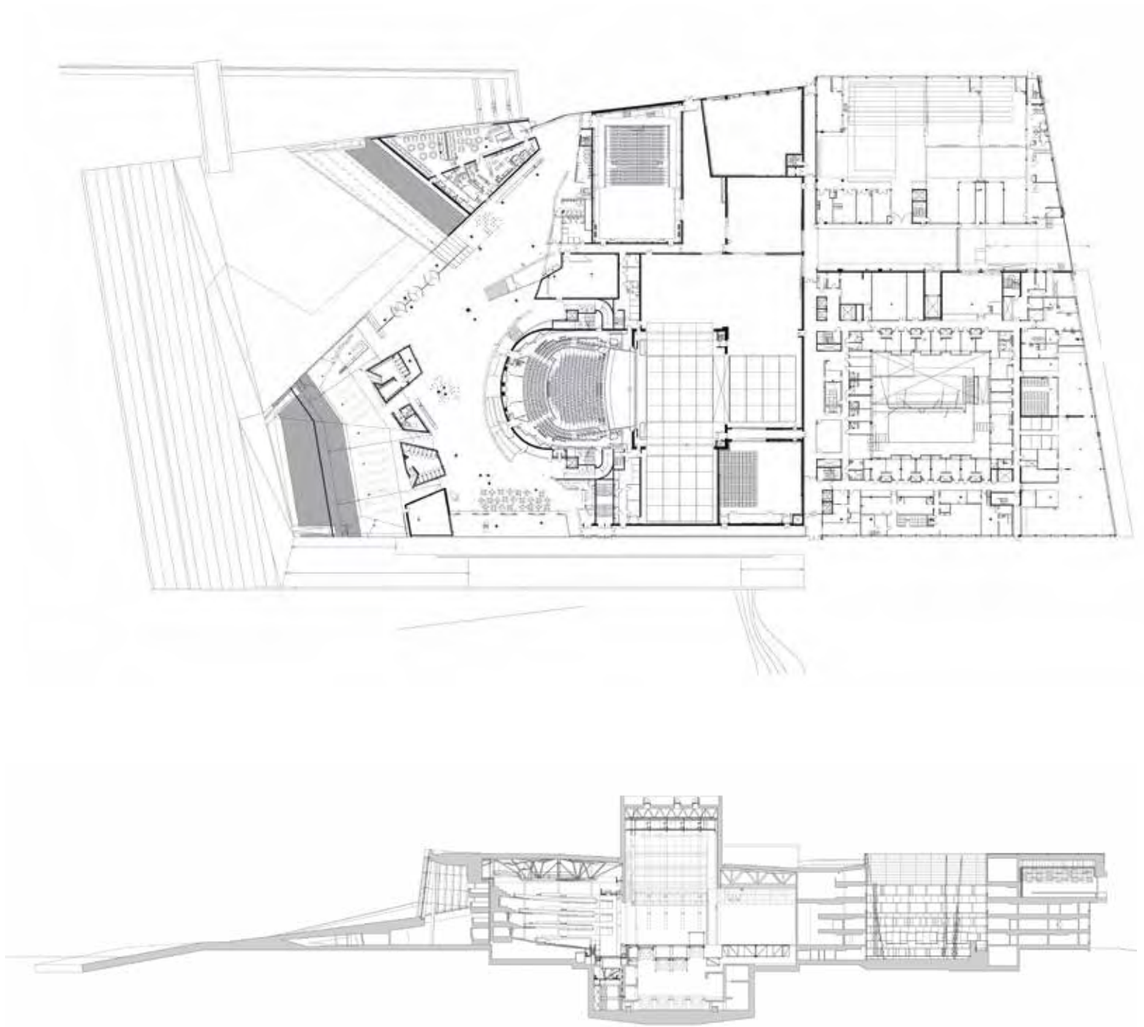
_____Daylight optimization, passive heating and cooling through facade design, lighting strategy and plumbing

_____Integration of photovoltaic (solar cells) system on the south facade[1]

Due to the diverse program and the specific functional requirements of the Opera, the solutions vary from one part of the opera house to another. The foyer and public areas serve as examples in this chapter.

Perimeter of balcony within opera hall. Photo: Gerald Zugmann.

Ground floor entry space, below the carpet. Photo: Jiri Havran.



Main floor plan. Drawing: Snøhetta.

Longitudinal section. Drawing: Snøhetta.

Sustain-ability and Value Creation

Experiences from the Transformation Process of a Modernist Icon

___Peter Andreas Sattrup

Environmental design and sustainable transformation are key aspects of architectural value creation. The masterpiece of Danish modernism, Radiohuset, by Vilhelm Lauritzen Architects, displays a wealth of design strategies that are fully relevant to sustainable design today, and it offers two stories in one: the story of its original design, and the story of the building's transformation into the Royal Danish Academy of Music.

Few buildings in Copenhagen seem more beloved than Radiohuset, the former headquarters of the Danish Radio Broadcast Corporation designed by architect Vilhelm Lauritzen from 1934–1945. Generations of broadcasters, audiences, musicians, concertgoers, journalists, pundits, and politicians have visited and worked in the building, which seems to inspire affection in people's minds.

As a first-generation modern architect and a contemporary of Le Corbusier and Gropius, Lauritzen worked with the most advanced organizational principles and building technologies of his time when designing Radiohuset.[1] Functionality was pursued with clear attention to technical performance, particularly acoustics, as broadcasting and musical performances constituted large parts of the building program. But Lauritzen was dissatisfied with the machine logic of the functionalism of his time. All scales of the building—from the articulation of a demanding urban site to the detailing of systems and surfaces—serve the purpose of creating a rich, vivid, and adaptable environment with human experience and interaction at its heart.

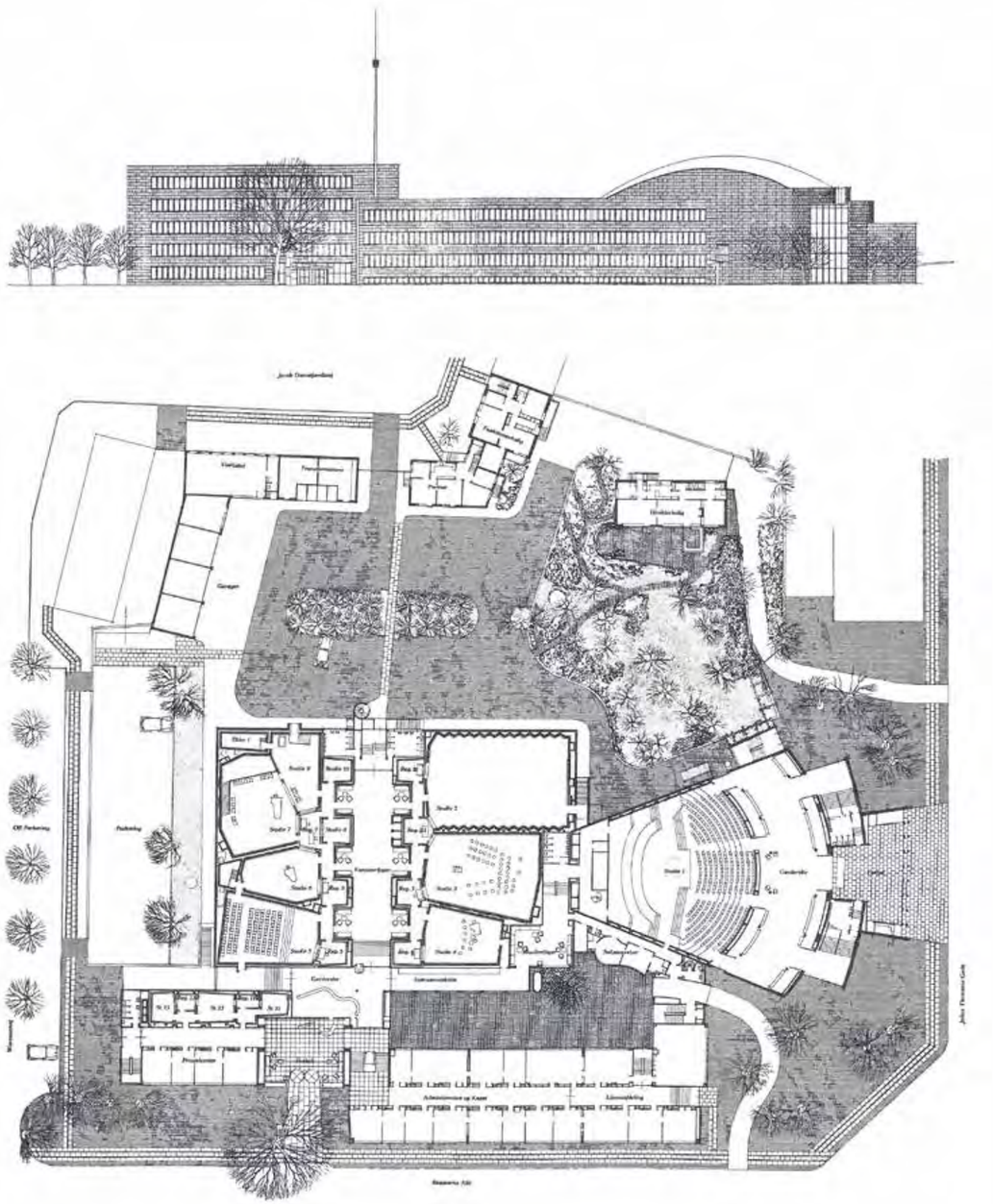
Modernist architecture has often been associated with problematic solutions, high maintenance, and expensive renovations. Radiohuset is, on the contrary, a case of sustained value creation based on original design principles established more than 80 years ago.

Fundamentally, value is an attribute rather than a property. It is socially constructed and reflects social exchanges and perceptions. In English, the word "value" can be synonymous to both "worth" and "quantity," which offers a full range of applications from ethics to utility. Value, understood as worth, is about defining meaning, making sense, and putting to use.[2] Value, understood as quantification, is instrumental: measuring things, comparing, gaining control by defining size and scale of selected qualities, and making it tradeable and exchangeable regardless of whether the exchange is social or economic.

Karl Marx was first to theorize value creation in terms of the economy of industrial production (turning raw materials into commodities), commenting on the disruption of traditional (moral) values when all material and intellectual production was essentially marketable and tradeable: "All that is solid melts into air."[3]

Since Marx's introduction of the concept *Mehrwert*, or surplus value, different concepts of value creation can be found. "Value added" is a term in economics depicting the value added by the production of a company, whereas in marketing, "added value" indicates the extra utility or attractiveness of a product or service that gives it competitive advantage on the market. Contemporary business theory combines these two dimensions into "value creation" as the core activity of an or-

Radiohuset in 1945 as seen from across Rosenørns Allé. Photographer unknown



Plan and elevation of Radiohuset 1945. The office blocks protect the central studio block from the noise of Rosenørns Allé to the south.

The distinction between sound production and office work can be seen in the varied geometry of the studios and the repetitive design of offices, that can be altered as organizational needs change. Drawings: Vilhelm Lauritzen

ganization's business model creating (or destroying) value by transforming natural, intellectual, human, etc., capital among different dimensions.[4]

When discussing sustainable value creation in the built environment through architectural design, we may apply the Brundtland Commission's definition of social, environmental, and economic sustainability as base value dimensions. We can identify both cost and benefit sides to value creation. Regarding benefits, economic value relies on social interpretations of qualities found in the environment. Economic capacity enables work to produce beneficial outcomes, but there are always costs associated, not only in economic terms, but also in terms of social costs or environmental degradation. Sustainable value creation aims at maximizing benefits while ensuring that costs do not compromise resource availability for future generations.

Architecture spans many scales, from urban planning to construction detail, but also scales of time ranging from the relative permanence of sites and life cycles of cities, districts, and buildings to the ever-changing environmental conditions and everyday interaction of building occupants and users.

Built environments are not finite objects. They require continuous work and adjustment and are susceptible to change as the activities they support evolve. As Brand noted, buildings are in a continuous state of transformation.[5]

The built environment has a metabolism of its own, differentiated through urban, building, and component scales. Buildings breathe and move with the flux of their occupants, with the seasonal changes in climate, and the daily variations of weather. Buildings change with time and adapt to the shifting purposes and preferences of identities and aesthetics. Sustainable architectural design creates value by enhancing environmental qualities across spatial and temporal scales that can accommodate changing social activities.[6] Environmental design enhances the qualities of space for social purposes, while sustainable transformation is a discipline of working out design strategies that may both resist or accommodate change over the life cycle of a building.

The key to the lasting value of Radiohuset lies in the quality of the environment it creates aesthetically and functionally, both at the time of its construction and now, after being refurbished to serve the needs of the Royal Danish Academy of Music.

Radiohuset articulates a complex urban site and a demanding functional program that lasted 60 years with many interior changes. At the level of the detail, surfaces, furniture and claddings are designed for human sensation, comfort, and the experience of space, with a particular attention to light and sound that changes from moment to moment.

Functionality was a key concern in the commissioning. Chief Engineer Kay Christiansen was entrusted to set up a competent team for the assignment, choosing Christian Nøkkentved, a renowned structural engineer and acoustician, Ludvig Birch, a mechanical engineer; and Vilhelm Lauritzen, architect. The team was set to deliver a highly integrated design from the outset. Lauritzen was a colleague of Nøkkentved at the Royal Danish Academy of Fine Arts. He would fuse a scien-

Radio technician at work. 1945. Unknown photographer.

A roof garden designed by G. N. Brandt covers the entire studio block. It has direct access from the canteen, and is a social focus point for the employees in the summer months. Photo: Jens Lindhe.

tific approach to environmental performance and construction with a sensibility for the user experience of ambience, materiality, and spatial atmosphere.

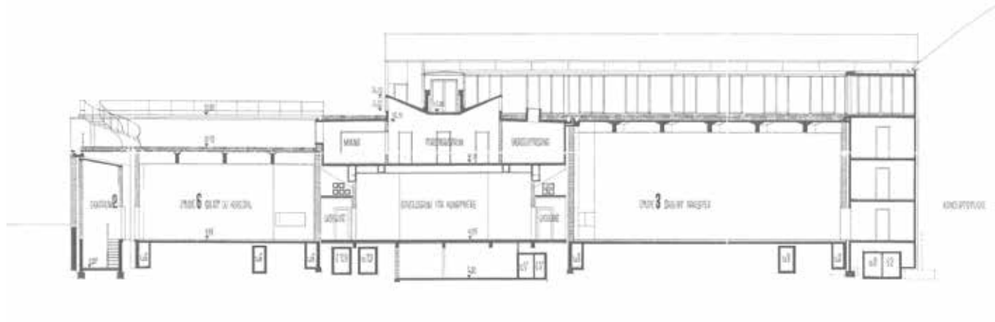
Lauritzen and Nøkkentved relied on the newest developments in the then relatively new science of acoustics in order to develop design principles that allowed the acoustics of the building to be adapted for radio sound production and for concerts. A keen naturalist and a teacher of design and the rendering of color, light, and shape, Lauritzen would develop an approach marked by an interest in how building technology and natural forces might be shaped for the benefit of human habitats.[7]

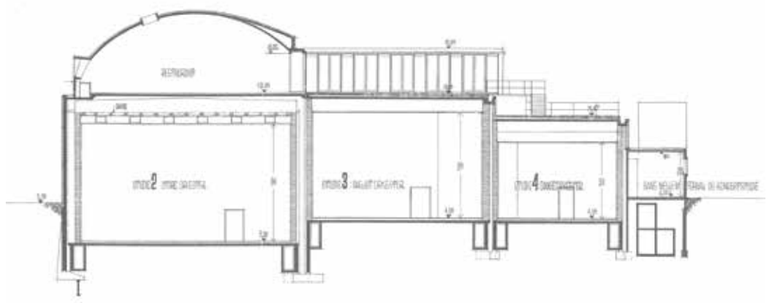
The acoustic protection of the sound studios from the noise of the adjacent road Rosenørns Allé was achieved by situating the studio block in the middle of the site, using the concert hall and the office blocks as sound barriers. On top of the studio block, a terraced roof garden landscaped by G.N. Brandt connects the buildings and offers fresh air and lush vegetation in this otherwise very urban setting. The composition of the solution is elegant, as it closes off the perimeter of the irregular urban block of which the building is part while maintaining clear identities and shapes of the buildings that constitute the ensemble.

Lauritzen uses the urban scale distribution to harness two fundamental values in the building: perfect acoustic conditions and a vibrant social space in the form of a canteen in the sunniest spot of the rooftop garden. Acoustic quality is pursued at all scales, from separated structural systems to differentiated absorption and diffusion. Acoustic quality is "stacked" by design choices at all scales. In the concert hall and the recording studios, the soundscape is shaped by wavelike geometries, diverse patterns of perforations, and the application of cladding materials, allowing the building users to interact with the building and to "tune" its acoustic response.

The environmental performance of the building was also highly adaptable with regards to lighting and ventilation. Daylight is abundant in the office wings, but is also used throughout the building for orientation and wayfinding in the meandering circulation spaces. Electrical and ventilation service systems were state of the art, and Lauritzen's office designed a range of original lighting fixtures for the building, some of which are still in production today.

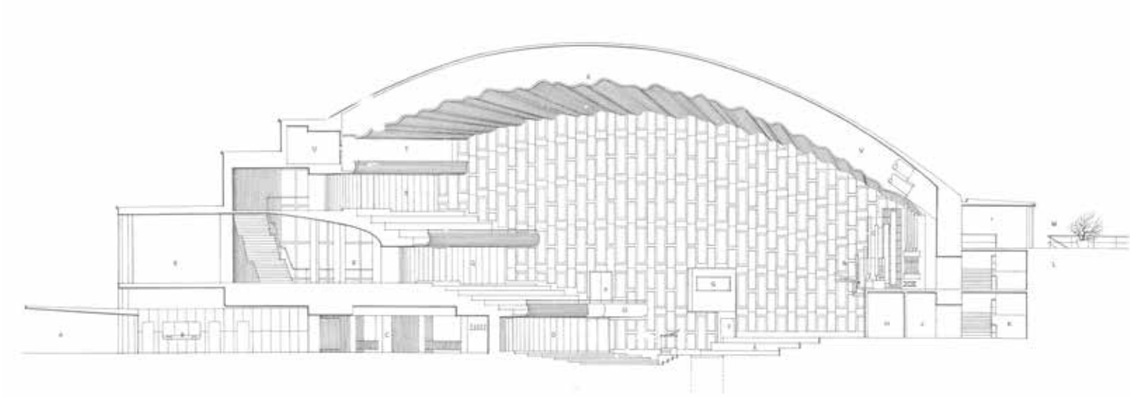
Lauritzen celebrates environmental issues as an opportunity to design, as can be seen in the attention given to natural and artificial light as well as ventilation. Uplights designed for the reception area. Skylights, lamps and ventilation supply in the canteen. Photos: Jens Lindhe.

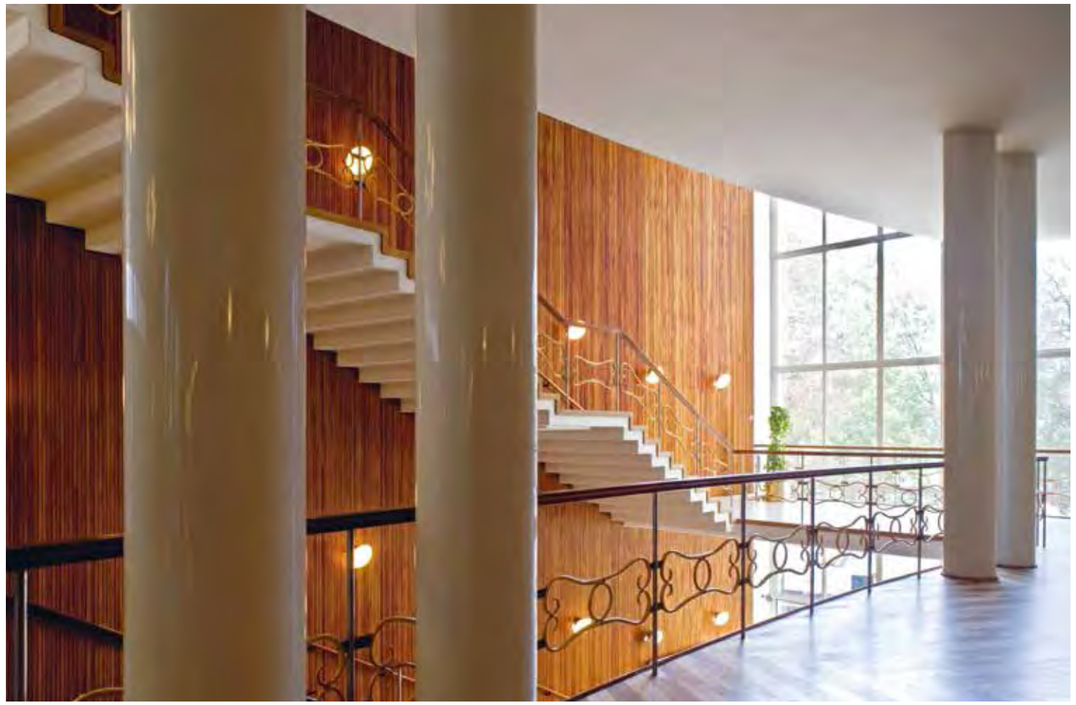




Sections of the studio block and roof garden. The studio block is further insulated from noise by separating the structure of each studio from the others.

Section of the concert hall. The dome is entirely without structural beams minimizing the use of concrete and steel. An undulating wooden soffit regulates the acoustics.





The stairs leading up to the concert hall balconies are generously lit from the sides.

The softly curved profile is a recurring theme seen at all scales in Radiohuset, from the fan-shaped and dome-covered concert hall to the detailing of railings and wooden claddings in the interior.
It is more than a formal gesture: The undulating surfaces, shapes and spaces serve a variety of purposes, from directing movement and inviting touch to regulating sound and minimizing structure. Photos: Jens Lindhe.

Next spreads: Concert hall interior. Wooden claddings are used to fine-tune the acoustics. Leather ceiling panels in the foyer. Door Handle. Photos: Jens Lindhe.

qualities made it difficult, if not impossible, to predict and guarantee the technical performance of the new solutions, which in turn meant that some components had to be changed.

Indoor environment—acoustic challenges

The main challenge of the project was to design the educational spaces in the office blocks. Yet at the same time, the process provided some interesting knowledge about the relationship between digital simulation modeling tools and the real life environmental experience of a group of expert users: world-class musical educators.

The challenge was to provide excellent acoustics and a high degree of control over ventilation, light, temperature, and humidity in a listed building that faced a very trafficked road, was poorly sound insulated, and had an obsolete service system. The solution had to provide ample sound insulation between rooms and floors. The acoustics had to be perfectly diffused with no flutter as well as being adaptable to varied use: teachers and students should be able to change the reverberation time from half a second to one second with minimal effort. Quite a challenge, considering that half the facade area was a continuous strip of poorly insulated windows with a very hard acoustic response. The ceiling height of three and a quarter meters was also less than perfect for the acoustics.

The design concept was to reintroduce a motif of undulating panels found in Lauritzen's original designs for the concert hall and one of the studios. This effectively diffuses the deeper tones. Panels with vertical ribs integrated at irregular angles in the walls scatter the higher ends of the acoustic range and ensures sound diffusion across the entire audible spectrum. Curtains can be drawn to reduce reverberation time, which can be further reduced by absorbents behind openable panels in the walls. A row of cupboards with oblique fronts scatters sound at the end walls, and all floors, walls and ceilings were sound insulated.

To test the design with the users, a full-scale educational suite was built at the beginning of the construction process. The design team had taken every precaution to analyze the acoustics. The user group, however, was quite unusual, consisting of world-class musicians who work with their bodies and senses as instruments. They are experts in indoor environments, albeit in a more human sensation-driven way than a technical performance-driven way. Accommodating their feedback, aided by the acousticians, required modifications of the design, mainly in the form of a checkerboard pattern of hard and soft surfaces on the ceiling. It added sound diffusion and absorption hidden behind a layer of acoustically transparent plaster. The experience revealed that there are finer aspects of environmental performance—in acoustics, lighting, temperature, and humidity—that even the most advanced digital modeling tools do not simulate or predict adequately. Human sensation can register differences that evade the models. As designers, we need to train our sensitivities towards environmental qualities in order to create better environmental results.

The design team found that Vilhelm Lauritzen's original design principles were so clear that it was possible to reinterpret and reapply the architectural vocabulary of the original design and achieve today's technical performance. This very humble approach to architectural interventions may not attract much attention in the contemporary architectural press.

This process can be likened to the artist's role in classical music.[11] The musician renders his or her interpretation of the composer's score as an original contribution and expression of art. The art lies in an interpretation that invigorates the original score and allows it to live on with continued relevance for a contemporary audience. This is a notably different position than that found in attention-seeking magazine architectures, but it is a very rewarding one. A project can become a transformation by sharpening one's attention and engaging in a conversation with past generations of architects.

The architectural philosophy of Vilhelm Lauritzen's "functionalism" transcends technical performance. The cultural significance of the building and its care for the haptic experience of users, as well as its attention to detail and the integration of aesthetics and functionality teaches important lessons for contemporary architecture.

Buildings with rich, diverse, and delightful environments, like Radiohuset, inspire affection. They are loveable and appreciated by their users and public audiences alike. They are the buildings that will be cared for, that will continue to find new uses, and that will have the highest probability of having extended lifetimes through successful transformations. Architectural quality is a way to create social values while managing resources wisely.

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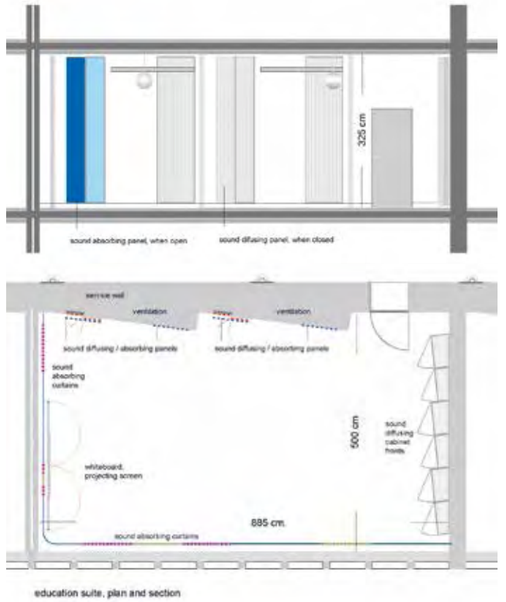

education suite, plan and section

Testing the acoustic response of space: Panels and curtains can be used to change the reverberation time according to the needs of the users. User involvement had clear impacts on the final design solution. Photos: Jens Lindhe.

Plan and section of the educational suites showing the architectural treatment of acoustics. Drawings: Vilhelm Lauritzen Arkitektur.

1 The design team and client committee visited concert halls and broadcast buildings across northern and central Europe as preparation. "One knew most about how broadcast buildings shouldn't be," Lauritzen said at the inauguration in 1945. The layout and shape of the concert hall seem to draw on the 1931 competition projects for the Palace of Soviets by Le Corbusier and for a theater in Kharkov by Walter Gropius. See Jørgen Sestoft, in *Vilhelm Lauritzen: en moderne arkitekt* (Copenhagen: Bergiafonden Aristo, 1994), 134–41.

2 Reflecting a long history in western moral philosophy, discussions of intrinsic or instrumental values originating with Plato's *The Republic*, taking here a modern (post-John Dewey) view that value is never intrinsic but socially constructed.

3 Karl Marx and Friedrich Engels, *The Communist Manifesto*, (London: Bildungs-Gesellschaft für Arbeiter, 1848), chapter 1..

4 Ernst & Young LLP, *Value Creation Background Paper for Integrated Reporting ←IR→* (International Integrated Reporting Council, n.d.); Alexander Osterwalder and Yves Pigneur, Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, 1st edition (Hoboken, NJ: John Wiley and Sons, 2010).

5 Stewart Brand, *How Buildings Learn: What Happens After They're Built* (Penguin Books New York, 1994).

6 Peter Andreas Sattrup, *Sustainability - Energy Optimization - Daylight and Solar Gains* (Copenhagen: Royal Danish Academy of Fine Arts School of Architecture, Design and Conservation, 2012).

7 Lisbet Balslev Jørgensen, "Vilhelm Lauritzen 1894-1984," in *Vilhelm Lauritzen: en moderne arkitekt* (Copenhagen: Bergiafonden Aristo, 1994), 27.

8 Stewart Brand, *How Buildings Learn: What Happens After They're Built* (Penguin Books New York, 1994).

9 A comprehensive account of the many processes of planning, design and construction that went into the transformation of Radiohuset can be found in Morten Lund's *Fra Radiohus Til Musikkonservatorium* (Copenhagen: Det Kongelige Danske Musikkonservatorium, 2008).

10 Peter Andreas Sattrup, Jens Amundsen, and Flemming Agger, "Broadcasting House: The Music of Change," in *Do.co.mo.mo: The Challenge of Change: Denmark, Estonia, Faroe Islands, Finland, Greenland, Iceland, Latvia, Lithuania, Norway, Sweden*, ed. Ola Wedebrunn (Copenhagen: The Royal Danish Academy of Fine Arts, School of Architecture Publishers, 2008), 26–27.

11 Peter Andreas Sattrup, "DKDM i Radiohuset - En samtale mellem generationer," *ARKFOKUS* 2 (2008).

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