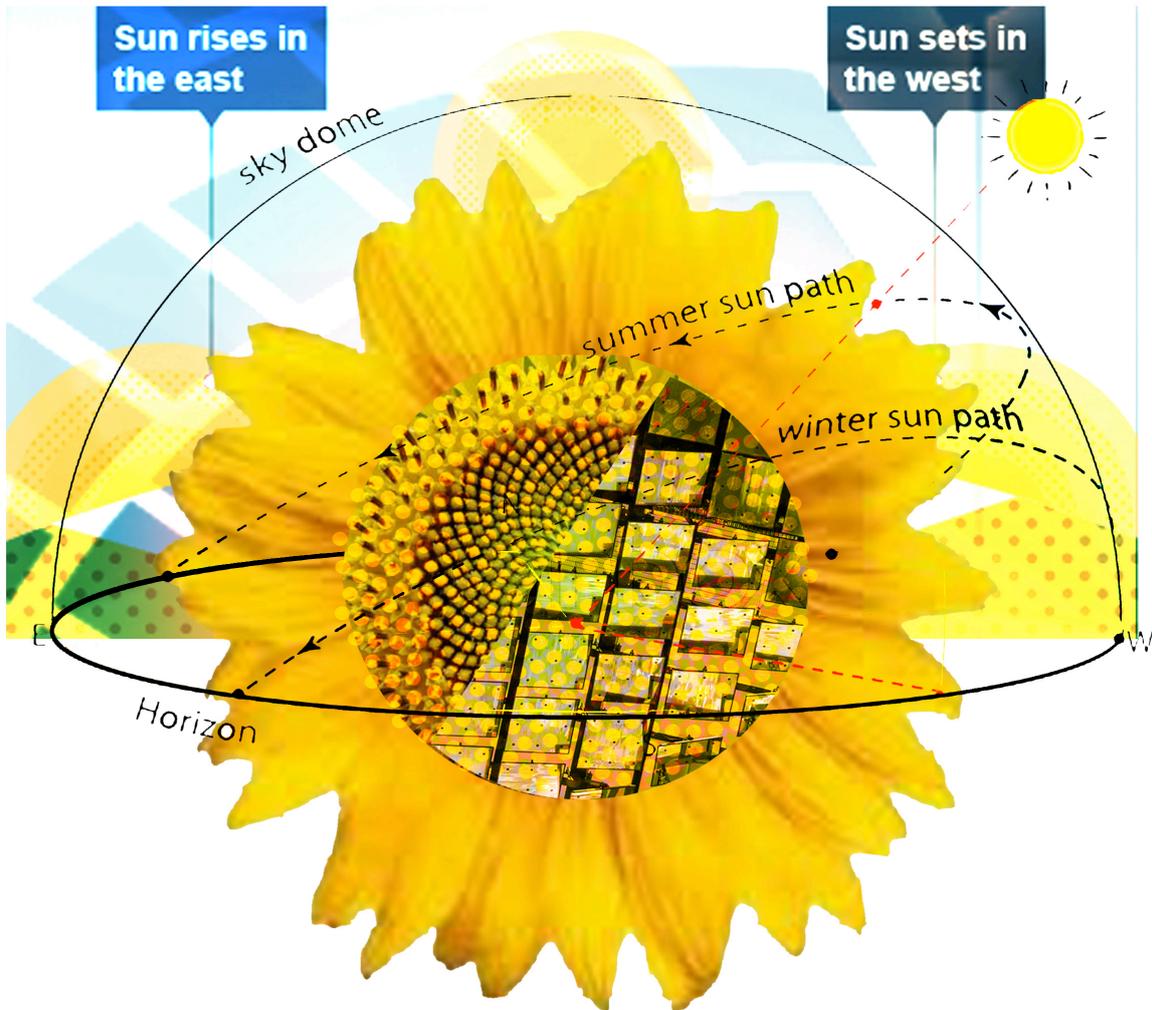


DARE TO BE A WILDFLOWER

LOOKING TO THE NATURAL WORLD FOR ANSWERS THROUGH AN IN DEPTH STUDY OF HELIOSTAT TECHNOLOGIES



“To bring in the Sun, that is the
new and the most imperative
active duty of the architect

(Dirckinck-Holmfeld 10).”

—Le Corbusier

Article Purpose:

Revealing the direct impacts of solar penetration within a building’s surface.

Consequently, establishing the importance of the sun’s solar path, as it plays a key role in the sustainable design market. Principal focus will be placed on heliostat technology.

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Dare to be a Wildflower:
Looking to the Natural World for Answers through an in depth study of Heliostat
Technologies

Abstract

Through an in depth study and analysis of heliostats, this paper will explore the concepts and attributes offered through the emittance of indirect daylighting within structures. Heliostats, hence bears a dual function in having the capability to provide versatile aesthetically pleasing design formations and/or operable units that ultimately tracks the sun's daily movement. Thus, it ultimately orients itself in relationship to the most desirable position.

Examples provided fully explain this growing sustainable technology as the support from nature through the comparison and contrast of heliostat technology to that of the sunflower is utilized in that it also directly follows the path of the sun. The relationship is therefore evident as this movement occurs all in an attempt to maximize its exposure to the sun's rays.

Case study assessments of differing projects are also explored as they provide for examples of imbedded heliostat technologies. Their range in differences from building design/orientation, site climatic factors, and latitude, etc. either aids or hinders in the success of this sustainable technology within their corresponding built environments. The Reichstag building in Berlin, Genzyme Headquarters in Massachusetts, and most recently One Central Park in Australia, are all heavily explored and criticized.

All are then investigated through the analysis of solar integration's purpose within each building from both micro and macro levels. Their benefits to users and its lasting effect and greater impact on future climate change and the environment of the future generation are also placed in greater context.

Introduction

From vast enhancements in technology as well as man's understanding of nature's biomemetric potential, the understanding of solar gains and its impact on building's infrastructure has led to the development of present day heliostat technology. In the discussion of the overall benefits of heliostat technology, this article highlights heliostat's reflective daylighting function from both micro and macro perspectives. Its impact is therefore analyzed through precedent case studies, establishing its role within the sustainable design community. Heliostats therefore provides for the optimal illumination of interiors through integrative daylighting strategies, constitutes to the natural positive response witnessed in user activity, all while aiding in the overall building's visual aesthetic and functionality.

Biomimicry

Architecture and the Natural World

Biological organisms display the unique tendency of closely embodying similar characteristics to man-made technological advancements found throughout today's society (Pawlyn 1). This comes as no surprise when identifying precedents for our built environments, since architects have commonly looked to nature for inspiration within their design processes. Biomimicry, defined by Julian Vincent as 'the abstraction of good design from nature,' has thus served an important role in providing design adaptations that in return reflect the natural processes undergone within our natural world (Pawlyn 2).

The Sunflower

The aspect of biomimicry heavily focused on throughout this paper is heliotropism within sunflowers. Heliotropism is a directional growth movement in plants that is induced by sunlight as it is commonly referred to as solar tracking (Mathias).

Evident throughout various time-lapse studies and videos, the sunflowers tendency to follow the daily trajectory of the sun allows for the maximization of sunlight to penetrate each leaf in an attempt to maximize it's solar absorption rate. Leaf blades bear a near vertical arrangement during both sunrise and sunset, while they continuously adjust throughout the day orienting themselves perpendicular to the sun's rays for optimal sunlight exposure (New Passive Solar Tracker Mimics Sunflower). At night they return to a horizontal position beginning the solar tracking cycle over again before dawn (New Passive Solar Tracker Mimics Sunflower).

Sunflowers' heliotropic tendencies therefore are evidently a direct example of nature's processes being incorporated

within technology; subsequently integrated within heliostat design.

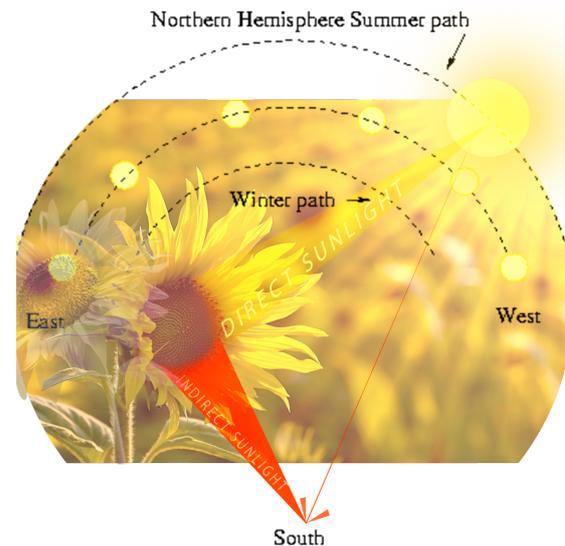


Image displays an analysis of solar path and the direct implications/role the sun plays in the rate in which heliotropism can occur within the sunflower evident throughout the day.

Author: Lyka Williams

Heliostat technologies, thus displays the tendency to “transcend the mimicking of natural forms from its attempt to understand the principles that lie behind its various formations and systems” (Pawlyn 2). By studying biomimetic tendencies within nature and its incorporation within design, heliostats collectively mimics the functional basis of studied solar-tracking biological forms, its processes and its systems.

History of Heliostat

Astrological Conception

The seventeenth century brought forth the exploration of studying the abundance of light radiated from the Sun. Telescopes became the primary device utilized to truly investigate these means, as it provided users with visuals that magnified instances it was set to focus on. By directing light into the fixed telescope through a reflective mirrored piece, Hooke and others began to develop the conceptual beginnings of the heliostat (Mills 89). These beginning stages of heliostat development required users to orient the

mirror in such a manner that when one was to view the angle of the exit beam, the appearance of the Sun stood stagnant (Mills 89). Thus, the mirror and its rotating drive constituted the technology we presently refer to as the *heliostat*.

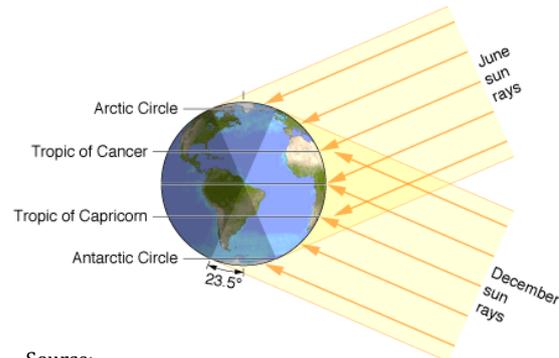
As defined by Mills a heliostat is “an instrument which reflects a beam of sunlight in a fixed direction”. Its etymology is derived from the Greek word for sun “*helios*” and “*stat*” for stationary. Although the original inventor of the device is unknown, credit is commonly given to Dutch physicist William Jacob’s Gravesande, as he first mentioned the term in his 1742 textbook (A New and Complete Dictionary of Arts and Sciences).

Today, heliostats have two basic functions: used for either daylighting through indirect solar gains or as solar thermal power stations from direct solar radiation/energy exchanges. Both versions of the heliostat utilize mirrors for reflectivity and at minimum a single computer for precise monitoring. This article; in particular, will specifically explore heliostats as integrative daylighting systems within building designs throughout our built environment.

Attributes

As stated by Le Corbusier, “To bring in the Sun, that is the new and the most imperative active duty of the architect (Dirckinck-Holmfeld 10).” Analysis of solar path; therefore, must be explored within the elements of a building’s conception. Looking back at the ancient world, architects and engineers built for the sun. (Dirckinck-Holmfeld 10). However, today we accept the aftermath of poor decision making by restricting the penetration of solar radiation into interior spaces. Instead, we should seek to integrate natural lighting by passive means with its introduction serving as a core principle in building’s design (Dirckinck-Holmfeld 55).

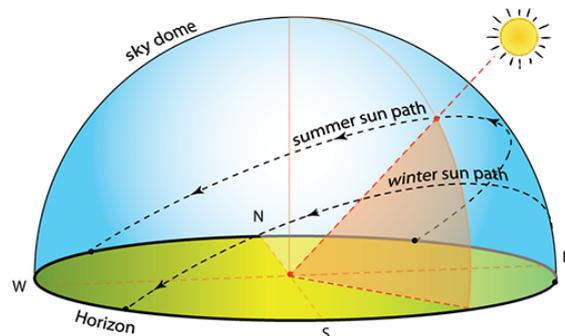
As mentioned in *Daylighting for Sustainable Design*, “Nothing influences the earth’s biological systems more profoundly than does the seasonal migration of the earth around the sun, or as it appears from our point of view, the sun’s migration through the sky.” The sun’s path therefore provides for seasonal changes and the defining of locations through geographical and spatial orientations.



Source: <http://physics.weber.edu/schroeder/ua/EarthCirclesAndSunRays.png>
<http://physics.weber.edu/schroeder/ua>

Seasonal changes are generated from the sun's ability to distinguish time by marking diurnal cycles of night and day (Guzowski 4). While geographical orientation are observed from calculations of it's altitudes and azimuths, and spatial orientation by distinguishing the cardinal directions (Guzowski 4).

The importance of solar radiation evidently becomes essential towards integrating it within building designs based off of its emittance levels of either direct



Source: https://www.e-education.psu.edu/eme810/files/eme810/images/Lesson_0

radiation or indirect sunlight. Direct radiation occurs when light travels in a straight line from the sun and is transmitted onto a particular surface, thus

bearing a definite direction and path (Guzowski). Indirect sunlight, on the other hand, occurs when radiation becomes diffused as the particles and molecules that makes up the light source is scattered within the atmosphere, but still manages to come in contact with a corresponding surface (Guzowski). Throughout this article, heliostats, thus displays the proper use and effects of utilizing indirect solar radiation.

Benefits of Exposure to Indirect Light

From analyzing the importance of solar radiation we can infer that suffice solar gains penetrable throughout a buildings life-span effects users and the surrounding built environment. From this we have broken down the impacts of indirect solar exposure into two categories: bearing its effects on both a micro and macro level.

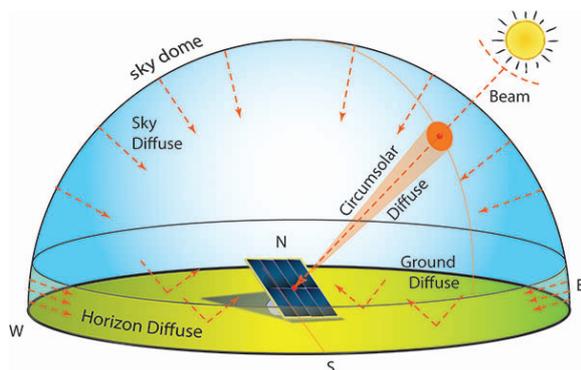


Diagram illustrates the Ratio of indirect sunlight being reflected off of heliostats, while also fully accounting for the significant amount of diffused light that will be emitted off of various surrounding surfaces.

Source: Source: https://www.e-education.psu.edu/eme810/files/eme810/images/Lesson_04/4.4.jpg

Since its incorporation, heliostats served to illustrate the importance of being knowledgeable of solar movement. Ultimately allowing for designers to be equipped with the understanding of its effective lighting qualities, heliostats provides comforting indirect solar radiation within interior user occupied spaces. Articulated by Lisa Hescong, “Light is a drug that stimulates the production of serotonin, dopamine, and

gamma-aminobutyric acids in the human body, enhancing impulse control, motivation, muscle coordination, calmness and focus (Dirckinck-Holmfeld 2).” Solar integration into buildings from daylighting thus equips users with: increased user productivity and comfort, providing for the mental and visual stimulation necessary to regulate human circadian rhythms—the biological processes that regulate our sleep-wake cycle (Leslie). It furthermore displays the increased overall energy performance data for a structure, simply from decreasing the use of artificial lighting.

When acknowledging the break down of heliostats’ benefits from indirect solar exposure, the main factor to consider is realizing that: “It is the daily—and possibly seasonal—variation associated with the day-to-night and dark cycles that supports human health” (Van Den Wymelenberg). This means that as a result of heliostats reflective units, available daylight is constantly redirected within structures to provide sufficient ambient light illumination for various tasks.

This function of heliostats also proves to be beneficial in context to its relationship with the surrounding built environment. The Journal of Green Building states that, “The energy used during its [buildings’] lifespan causes as much as 90% of environmental impacts.” And according the U.S. Department of Energy and the U.S. Energy Information Administration, electrical lighting within buildings comprises for the consumption of more than 15% of all electricity generated in the United States alone! (Van Den Wymelenberg) Thus, through utilizing integrative daylighting systems—both daylight apertures and heliostats—one can obtain optimal daylighting emittance levels within structures. Therefore, by naturally illuminating the interior spaces utilized by building occupants, the range of use of artificial lights will drastically decrease. This in

return will reduce the building's energy costs. If neighboring structures were to then integrate this daylighting system into their building design, we would generally see a drop in the overall effects of building related environmental impacts.

Drawbacks

Acknowledging that the sun plays a vital role in heliostats, climate and weather conditions directly impacts the ability for solar radiation to be redirected into interior spaces. Weather is the primary cause of drawbacks within heliostats, for sky conditions generally become subjected to seasonal and geographic location changes. Daylighting conditions are heavily based on the dominant sky condition of the specific building site area. Both clear and partly cloudy sky conditions offer optimal performance opportunities for the integration of heliostats within building design, whereas overcast skies clearly acts as a deterrent for sunlight gains and reflectivity. Thus, posing as a threat to the success of heliostats functionality within regions prone to this sky condition.

Heliostats Introduction within Design

How it Works

Heliostats primary use is for deflecting sunlight so that diffused light may reach into the depth of buildings' interior spaces (EGIS-Heliostat). A typical heliostat consists of "three constructional and functional groups: the reflector (mirror or lens), the twin-axis rotor and a computer" (EGIS-Heliostat). The mirrored or lens surface enables its reflectivity of sunlight. The twin-axis rotor serves as the object that stabilizes and rotates the mirrored/lens piece, while also providing high solar tracking accuracy (EGIS-Heliostat). The tracking device embedded within it typically measures 1m diameter and focuses the receiving beam of light to

a minimum patch of about 10 mm across; however not all heliostats concentrate at these levels (Tregenza and Wilson 180). Lastly, the attached computer utilizes a culmination of programs including an astronomical program and a clock that has calendar recordings and collected data of the earth and its relationship to the sun (EGIS-Heliostat).

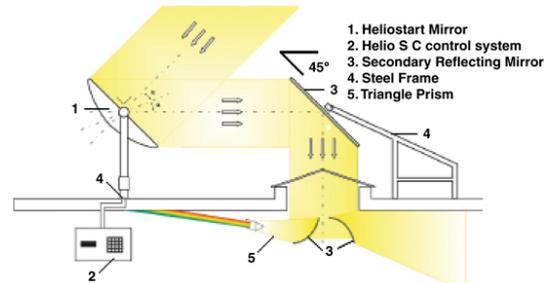
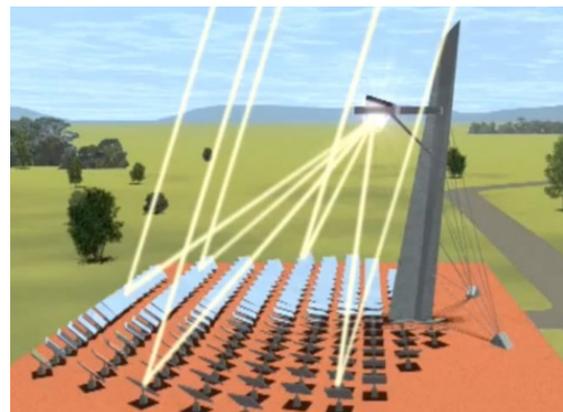


Diagram illustrates the above-mentioned parts that make up a heliostat.

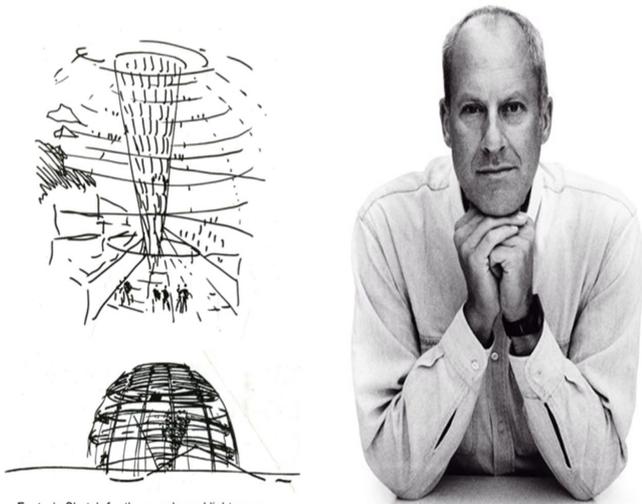
Source:
<http://www.palgrave-journals.com/jba/journal/v4/n4/images/jba20091f2.jpg>

Heliostats are usually positioned outdoors north of the desired reflected target point, allowing for the dispersion of light to illuminate interiors. As a result of this, they are designed to withstand the vast wind loads that are typically generated from tall structures and skyscrapers.



Heliostat in action displaying that "the angle of the light coming in equals that of the angle of the light falling out"

Source:
<http://images.gizmag.com/inline/braytoncyclesolar-0.jpg>



Foster's Sketch for the cupola and light cone

THE CUPOLA (THE DOME)

ARCHITECT:
LORD NORMAN FOSTER

Height: 23.5 meters (78.3 ft.)
Diameter: 40 meters (133.3 ft.)
Total Weight: 1200 tons

Clad in 3000 square meters of laminated safety glass—flat glazing with an intermediate layer of vinyl foil—panel size 5.10m x 1.80m max.

1.6 meter-wide helical ramps integral to structure of cupola, providing lateral stiffening and vertical loading.

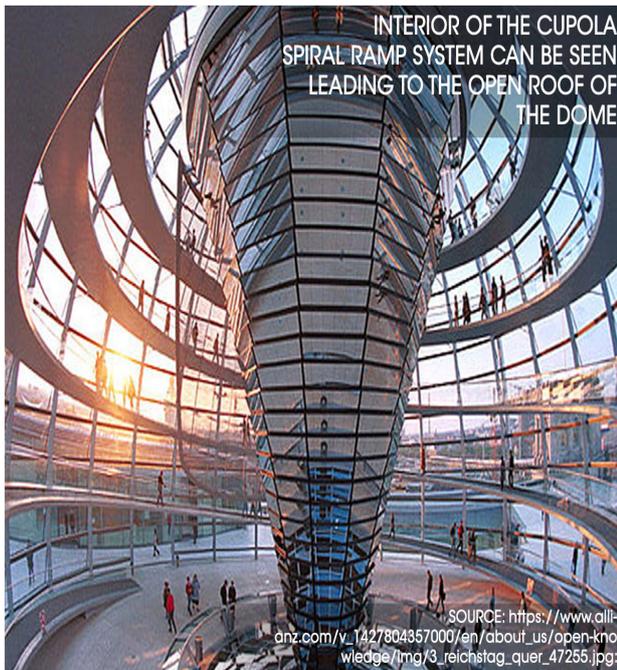


VIEW FROM PUBLIC ROOF SPACE
SOURCE: https://doostetdoram.files.wordpress.com/2013/08/img_6105-.jpg



VIEW OF THE REICHSTAG BUILDING & ITS BLEND OF ARCHITECTURAL STYLES.

SOURCE: <http://www.lowcostholidays.com/blog/wp-content/uploads/2014/12/shutterstock-18326842-Reichstag-Building-Berlin-Germany.jpg>



INTERIOR OF THE CUPOLA SPIRAL RAMP SYSTEM CAN BE SEEN LEADING TO THE OPEN ROOF OF THE DOME

SOURCE: https://www.gllanz.com/v_1427804357000/en/about_us/open-knowledge/img/3_reichstag_quer_47265.jpg



PERSPECTIVE VIEW OF RAMP SYSTEM ALSO SHOWING VARIOUS LARGE SHADING DEVICES UTILIZED IN SUNLIGHT DIFFUSION
SOURCE: <http://1.bp.blogspot.com/-wmFF->

Although the discussion of heliostats functionality may be complex, it is really only important for readers to understand the basic breakdown of its overall processes. In a simplified explanation of how heliostats work one can think of its function as, “the angle of the light coming in equals that of the angle of the light falling out” (EGIS-Heliostat). Once the amount of sunlight received by the device strikes the surface of another at the appropriate angle for reflectivity, ideal indirect light can be used to light spaces that were otherwise dim and/or opaque.

Case Studies Reichstag Building Berlin, Germany

In investigating the transformative uses of daylighting technologies within precedents, we will look at the Reichstag Building in Berlin, Germany. Norman Foster’s Reichstag Building ultimately displays the vast arrangement and use of daylighting technologies, while its presence itself speaks to its intuitive integration of its new architectural finishes with the contrasting old historical edifice (Schulz and Foster 40).

Paul Wallot originally designed the Reichstag Building, as he was granted commission for the project in 1882 after winning the Reichstag’s second design competition, due to unforeseen setbacks (Schulz and Foster 19). Through his leadership and knowledge of architectural styles widespread at that time, the Reichstag neither embodied sole design influence from either of them. Wallot instead created it as the sole example of what was coined the “synthetic imperial style” (Schulz and Foster 20).

Premier focus in the design was placed on the dome. However, its design wasn’t fulfilled based off of Wallot’s specifications. Kaiser Wilhelm I took lead in the project creating the dome from glass and steel instead of stone (Schulz and Foster 20). When he died in 1888, his son

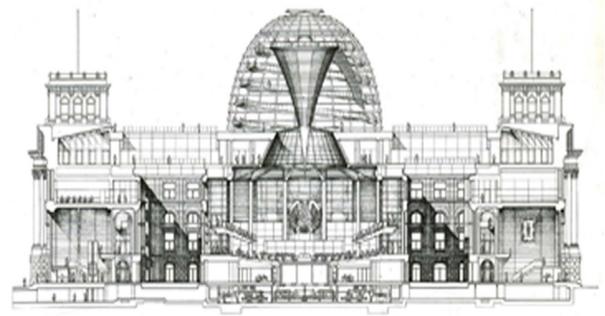
succeeded him and opened the building in 1894 (Schulz and Foster 21). The building was introduced to the world as *Reichsaffenhause* or “Imperial Ape House” (Schulz and Foster 21). From numerous interruptions within its conception, upon completion the building not only represented the growing sovereignty of the people, but the dome in particular was seen as being higher than the Berlin Stadtschloss—the royal and imperial palace in the center of Berlin (Schulz and Foster 21).

Today, the Reichstag Building stands as a symbolic representation for all the “ambivalence and ambiguity of German history”, because of great innovations provided by architect Norman Foster (Schulz and Foster 8). When Foster took on the role of redesigning the prominent German Parliament building, he prioritized the execution of the renovation project based off of three main principles; one of them included labeling the design to be “environmentally friendly and oriented to the future” (Schulz and Foster 40). Without a doubt, the Reichstag Building has accomplished this and much more.

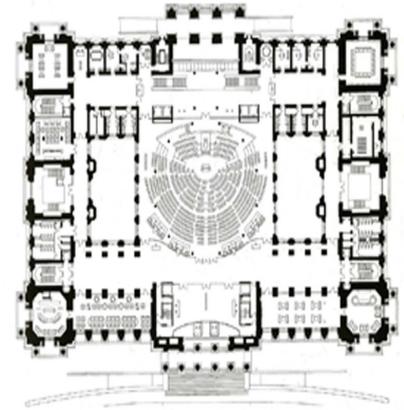
Foster’s main concept heavily focused on revamping the functionality of the historical cupola, as the dome played a vital role in the distinction of the building within the Berlin skyline (Schulz and Foster 11). Foster took on this task to display evidence of the building’s transformation through communicating the themes of lighting, transparency, and public access from the trademarked dome (Schulz and Foster 11). Here the concept of envisioning the cupola as a “lantern” came to place.

The cupola does exactly what comes to mind when one thinks on it being the lantern of the structure. Within the dome, it provides the main processes of building lighting from natural means of emitting sunlight. At its core, arranged in a monolithic sculptural cone mass is its heliostat. The mirrored cone works like a

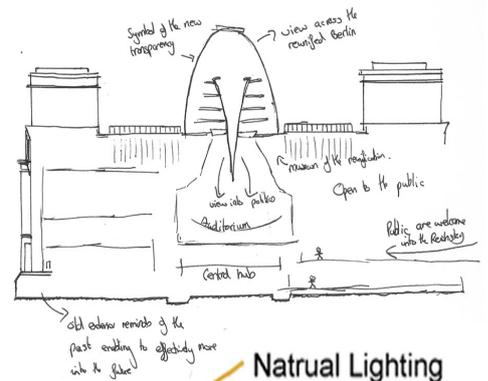
The Reichstag Dome
Illustrations of How the Heliostat Works in Emitting Natural Light



A north-south cross section through the new Reichstag

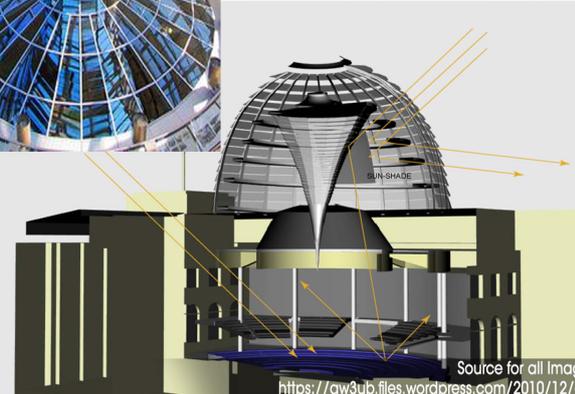


The plan of the first floor—the principal parliamentary level



Natural Lighting

The Reichstag cupola represents most valuable idea of Forster's work with sunlight. He creates a transparent dome in the way of letting sunlight come through. What's more, amazing rotatable mirrors on the light cone directly reflects sunlight into the chamber room below which is very efficient to reduce most of energy of lighting in the interior space. The big shade which can move around in 36 degree in cupola blocks extra sunligl which brings glare and dazzling.

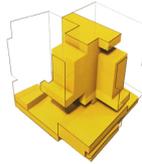




ARCHITECT:
BEHNISCH ARCHITEKTEN

The project placed premier focus on the atrium, which is surrounded by the buildings main functions.

The two axonometric diagrams illustrates the empty and solid areas of the surrounding area described earlier within this paper.



They describe the volumetric complexity of the project characterizing both internally and externally

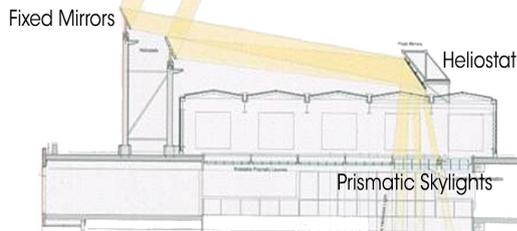
Source: Spirito, 179.



Its high ceilings are therefore defined by the masses and flat areas that protrudes out or windrows along the structures 12 levels.



Image depicts the process in which the heliostats function throughout the Genzyme Center. Placing focus on the reflectivity of sunlight off of multiple surfaces, ultimately leading to its penetration into the structure.



Source : <http://www.solarpedia.com/images/large/3288.jpg>



Shot of the reflecting sculptural panel placed in the center of the atrium used to reflect light into the surrounding work areas.



Daylight reflected throughout the atrium reaches the bottom-most floor of the lobby area exhibiting the great lighting experienced within the facility.



Source: http://uk.archello.com/sites/default/files/imagecache/header_detail_large/104_main_entrance_Haupteingang_41011_PC_Photo_A.jpg

lighthouse, but in reverse! (Schulz and Foster 14). It works by reflecting daylight from a 360° horizon, thus allowing light to reach regions down in the chamber (Schulz and Foster 14). A moveable shield tracks the solar path allowing for it to block excessive solar gains and glare when necessary, but still permits sunlight to reach the lower chamber floors (Schulz and Foster 14). From this change in the structure of the cupola, users have articulated that Foster, not only created a working space for the parliament but his design successfully shows history through detail “through reflecting the building’s present and future through architectural means” (Schulz and Foster 8).

Genzyme Headquarters
Massachusetts, United States of America

Previously the abandoned, contaminated lot bearing remnants from a former coal degasification plant is the new Genzyme Headquarters in Cambridge, Massachusetts. Placed within this site, it was created to be both aesthetically pleasing and environmentally responsible. Although Behnisch & Partner was the firm that won the design competition held for the innovative structure, it was their close collaboration with the developer client, Lyme Properties LLC and tenants, placing premier focus on the environmental awareness for the structure (Davey). The building itself is therefore seen as a “conventional transfer of European values across the Atlantic” (Davey).

Becoming widely known for its use of natural daylighting throughout adjacent workspaces and office areas, Genzyme’s central atrium plays a key part in the success of the daylighting system that had been set in place. Skillfully creating a vertical urbanity throughout the architecture, Behnisch & Partner designed the atrium to serve as if it were the spine of the structure as the main workspaces are arranged around its center in the form of terraces, balconies and platforms (Davey).

From the core of the atrium hangs what is described as a ceiling prism that functions to reflect diffused light into these radiating spaces. The Austrian firm Bartenbach Lichtlabor designed Genzyme's heliostat system (Davey). The system comprises of seven solar-tracking mirrors that are mounted on the northern portion of the roof that acts to reflect sunlight to fixed mirrors on the south side (Davey). The sun's rays are then deflected downwards to the pools at the entrance levels, but only to be reflected down its entire length bouncing off of the "roof-hung chandeliers" (Spirito 179). The reflection and diffusion of the sunlight itself is further enhanced from the use of reflective surfaces that were placed along the surrounding wall area and parapets that surround the atrium (Spirito 179). Ultimately this allows for sunlight to become further reflected at the base of the building by reflection off of the interior pools (Spirito 181).

Because of the hanging tendencies of these reflective mirror pieces, the angle at which the sunlight deflects from its surfaces always changes. This results in optimal sunlight penetration into the adjacent office rooms and spaces. Thus, the Genzyme Headquarters is described to be almost the complete opposite of the "normal U.S. office block". As it serves as the product of the inspiring belief that North American offices can be made more decent to work in through the unusual trust and vision between developer, tenant, architect and all consultants (Davey).

One Central Park Sydney, Australia

Now in stepping into the peak of our generation, we witness the highlights and significant landmark qualities heliostats provides from analysis of Jean Nouvel's One Central Park in Sydney, Australia. One Central Park serves as an immense mixed use development in the heart of the city originally designed to serve a role of bringing "much needed

pedestrian porosity" to the "disused industrial site" (Farely).

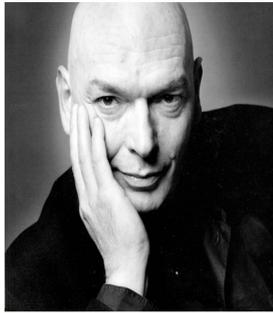
Like many of the case studies discussed within this report, One Central Park also had its share of issues regarding its site development. The idea of the skyscraper developed in early 2003, decisively conceived for its erection on the lot of an old brewery that spanned 14 acres adjacent to Central Station (Farely). Many disruptions stymied the progress of the development; however, the development progressed. This enabled its design of two encircled towers to create an ideal "public garden within the dense but fine-gained urban fabric" of the neighborhood (Farely).

Because of this placement One Central Park created the issue of blocking solar penetration onto the very idea of this central park, in contrast to casting shadows on neighboring areas. Thus, to combat this setback, the decision was made to hoist a monolithic cantilevered heliostat, which would ultimately be used to bring in daylight into the spaces that would otherwise have been shaded (Farely). The heliostat works by allowing sunlight to be bounced into the towers' shadow, the garden, and into the shopping center's in the atrium through the water topped glass roof (Farely). The system is executed from two sets of fixed mirrors: one facing down from the taller building of 34 stories and the other facing up from the shorter at 16 stories (Farely).

According to Tim Phillips, the projects design engineer, the "real" heliostat; however, is the lower 40-mirror arrangement, opposite of the 320-upper-mirror array. That mirror is actually predominantly used for aesthetic purposes as it hosts the light artistry of Yann Kersale' (Farely). This misconception is common as the lower mirrors are not visible by the public, but they do perform all the functions of a traditional heliostat in tracking the sun in a three dimensional relationship shared between the mirrors, the software and sensors (Farely).



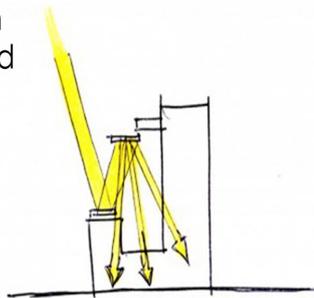
ARCHITECT:
JEAN NOUVEL



Jean Nouvel incorporation of the cantilevered mirrored surface serves more aesthetic purposes.

The real heliostat captures the light that are being bounced off of the reflecting panels from the cantilevered structure above.

Thus, allowing for natural light to penetrate surrounding areas, including the centralized park the two adjacent towers creates:



Light from the sun bounces off the heliostat on the lowered tower to then be deflected off and dispersed onto lower levels

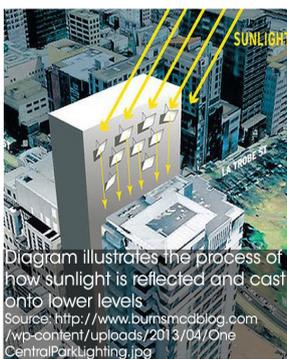
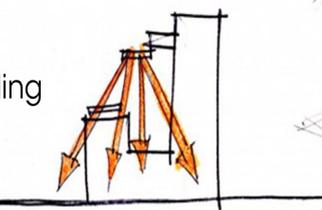


Diagram illustrates the process of how sunlight is reflected and cast onto lower levels
Source: <http://www.burnsmcdiag.com/wp-content/uploads/2013/04/One-CentralParkLighting.jpg>



Close-Up of operable mirrored surfaces
<https://www.colourbox.com/preview/12077990-heliostat.jpg>



View of Taller Tower where mirrors produces various light shows as well as dualing the function of reflecting sunlight
http://www.indesignlive.com/wp-content/uploads/2013/12/sea_mirrors_2.jpg



One Central Park Masterplan Including Surrounding Context
<https://ligabymc.files.wordpress.com/2015/03/central-park-in-context-copy.jpg>

One Central Park therefore illustrates a dynamic system in which, sunlight is reflected from the lower array to the upper array and then down onto the ground of the public garden space (Fareilly).

The heliostats within One Central Park not only serve its functional purpose of emitting daylight, but it also provides for the identity of the structure. Through its integration within the site, the technology thus seems to interrelate the sustainable attributes offered throughout Sydney by crowning its presence as a pivotal landmark. Ultimately quantifying the importance and presence of the pieces that can be seen from vast distances away.

Dare to be A Wildflower?

By understanding the pivotal role heliostats play in the overall occupant environment for users within the above-mentioned cases, it is clear that the technology can be implemented in a wide variety of settings. Heliostat technology therefore offers daylight integration on multiple levels, including, but not limited to, renovation vs. new and public vs. private.

Each case has hence offered a brief overview of how heliostats' presence provides daylighting improvements within the design realm. As evident within each example, the heliostat itself not only provided adequate lighting, but it offered the symbolic presence of the structure fully documenting its influence within its greater site and surrounding environment. These cases additionally fully highlighted the use of the technology in relation to the premier focus of this article. Fully doing so by illustrating its effects on both micro and macro levels in providing hospitable well-lit environments that equips users with indirect daylighting. This subsequently constitutes to user's participation and productively throughout their everyday activities.

However, it didn't solely stop there! Through providing optimal lit rooms and working environments, workers rarely

utilized additional artificial lighting. This can thoroughly be seen in all imagery of these spaces, as the only light that is fully utilized were that which was provided from the dispersion of natural indirect daylight within the spaces.

It is easy to question whether this innovation solely stops here— on the commercial level. Although cost is a large factor in the feasibility of its incorporation on smaller scale levels, such as the integration into residential homes, many have found that through proper understanding, education, and research on solar path and its reflectivity tendencies, it is indeed possible to create their own functional devices. Thus, many DIY (Do It Yourself) activities are available for children and adults alike to explore the relationship shared between the mirrored surfaces and the angle in which solar radiation is reflected so that it can then enter and illuminate a space.

Conclusion

The concept of daylighting and solar reflectivity has evidently served important roles within today's architectural designs; however, only one question remains unanswered. Do you now dare to be a wildflower? If so, learn the lessons offered from our natural world through taking advantage of heliostat technologies as they continue to aid in our daylighting necessities.

Through reviewing the effects of daylighting within micro and macro levels, we are able to witness the impact of solar influences within architectural expression, user activity, and natural habitats. Heliostat technology thus has become a multifaceted daylighting innovation that bears a close relationship to nature through mimicking the solar tracking tendencies evident within heliotropic plants. As it has become particularly common within various regions and time periods, as evident in the case studies mentioned throughout this report. It therefore provides architects with the ability to

equip building occupants with naturally illuminated spaces without compromising the overall functionality of the structure.

In conclusion, heliostat technology embodies our present stage in the understanding of solar path, tracking, and its relationship to our built environments. Its presence alone displays the growth we have obtained within daylighting integration and penetration of structures. And through further understanding of its astrological history, biomimetic influences, and overall functionality, we will have thus equipped ourselves with the necessary materials crucial to improving the new urban environments of the future.

It is safe to say, the era of heliostats ubiquitous incorporation into structures is near. Hopefully in the future, we can witness them sprout habitually as wildflowers.

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