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Inside-Out: Investigating Energy Efficient Façades

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Abstract

Placing the service systems alongside the facade is not uncommon in architecture. This “inside-out” concept can be easily seen in buildings such as the Pompidou Center in Paris or the Llyod's building in London. However, a more modern approach was taken in Düsseldorf, Germany in 2008, the Capricorn House Medienhafen Düsseldorf. This building contains a unique device in its façade, called the *i-modul*, which was designed by GATERMANN + SCHOSSIG. This decentralized service module, located behind the red glass panels, is equipped with technology to control the building's temperature and air-quality. It also features an integrated lighting system with sound absorption and room acoustic elements. This special feature eliminates the need for traditional technology and allows for more flexible space within the building. This paper examines the energy efficiency of the *i-modul* device and its relationship to preceding architectural facades, it also proposes four facades for a tower design in the New York city context. With the US being one of the greatest energy consumers on the planet, this study highlights possible design approaches that can be applied along building facades to help reduce the consumption of energy.

Keywords: i-modul, inside-out architecture, energy efficient facades

Inside-Out Architecture

It was during the Modernist movement that architects started to express spaces and programs on the exterior of their buildings. This would be the result of interpreting Le Corbusier's maxim, "The outside is the result of the inside.” (Schumacher, T. L., 2002) Two buildings that would go on to challenge this theory are the Pompidou Center and Llyods of London Headquarters.

The Pompidou turned the world upside down by turning it inside out. (Lacayo, R., 2007) This monumental work of architecture designed by Richard Rogers and Renzo Piano was completed in 1977. It was the first of its kind to take the Modernist rule that buildings should clearly express their structure and, by extension their infrastructure. It advanced this theory by placing what would originally have been the inner workings of a museum on the exterior. By putting the escalators, ventilation ducts, and steel structural framework on the outside of the Pomipidou Center, much larger uninterrupted gallery spaces could be placed within (Lacayo, R., 2007). Modernist architects just like Rogers and Piano repelled applied ornament; however, by exposing

the raw elements of a building aesthetically, they created an architectural icon whose functional components became ornamental: a building whose form strictly follows its function (Lacayo, R., 2007) .

Richard Rogers would then go on to design the Llyods of London Headquarters in 1986. Just like the Pompidou Center, it would showcase the buildings systems on the facade, but skyward. (Lacayo, R., 2007) In an interview with Dezeen, Rogers stated that "mechanical services have a short life, in other words [they are] like the engines of a car...and buildings have a hundred years of life." (Dezeen., 2013)

This was an important factor when designing the Lloyds tower, because placing the service systems along the outside of a building would not only save space, but time and money. Illustrations 1 and 2 reveal how the facades of these buildings were envisioned.

Both the Pompidou Center and Llyods of London Headquarters would go on to inspire other architects around the world and revolutionize the definition of building envelope. With the advancement of technology, a German architecture firm would go on to develop a more high-tech approach—they would invent a facade that enclosed all the building service systems inside a 20 cm thick panel. (Treberspurg, M., & Djalili, M., 2010) This structure would be known as the Capricorn Building.

Illustration 1: [Pompidou Centre Facade] ("Pompidou Centre plans to go global", 2012)

Illustration 2: [Lloyd's of London Building Model] (Kroll, 2010)

The Capricorn Building

Designed by architects GATERMANN + SCHOSSIG, this building stands out for its innovative facade cladding system. With the intention of joining the other office buildings in the harbor region of Düsseldorf, this structure was conceptualized to be more ecological and economical from the start. (Enkerli, W., 2007) Measuring a length of 150 meters, the compact form of the building is conditioned by the urban planning of its site. Four large glass atrium spaces are placed at the periphery region of the building to bring natural light into the office spaces, and also act as air-buffers. As a result, the structure has a snake-like formation. This design concept offers space for around 800-1000 employees. (Enkerli, W., 2007)**.**

Illustration 3: [Inside the I-modul] (Treberspurg, M., & Djalili, M., 2010)

Illustration 4: [Behind the I-modul Facade] (Treberspurg, M., & Djalili, M., 2010)

the *i-modul*. Developed after further prototype studies by the firm GATERMANN + SCHOSSIG, this device is equipped with more advanced technology than previous conceptualized *Intergral Fassades.* (Enkerli, W., 2007, *Interview*, p. 40) *I-modul*—standing for *integral modular*—is a compact unit located in the facade of the Capricorn House building that offers a high level of heat efficiency. Each one is placed inside one of the 867 facade elements of the Capricorn Building—measuring 2,70 m x 3,35 m. (Enkerli, W., 2007, *Interview*, p. 40) Not only does this device reduce the overall energy consumption of the building, its size enabled the architects to develop a comfortable and aesthetically pleasing building envelope. Illustrations 3 and 4 reveal the design and technology of the *I-modul*.

With the invention of the *i-modul,* there the ability to remove most or all of the duct work from the sections of the building, thereby allowing to reduce floor heights, saving on construction materials and increasing the number of floors for the given height limit. Dipl. -Ing. Elmar Schossig, co-founder of GATERMANN + SCHOSSIG stated in an interview in 2007 that,

> The main advantage of the *i-modul* is the elimination of the distribution network, especially the air, but also the other media across the surface. Furthermore, we gain valuable rental space because we need much less vertical shafts...With this concept, we achieve story heights of 3.2m at clear room heights of 2.80 m. The entire ceiling construction moves by 40 cm. Other concepts need 50, 60 or even more. (Enkerli, W., 2007, *Interview*, p. 41)

energy efficient design. By placing the *i-modul* in the building facade of the Capricorn House, the overall energy consumption dropped below the required ENEV (*Energieeinsparverordnung*) values by 25%. (Enkerli, W., 2007) The ENEV—Energy Conservation Act—is a strict German law that all buildings must address. Achieving a heat demand underneath this prescribed level is virtually unheard of and highly sought after. Dipl. -Ing. Elmar Schossig, stated in the interview that,

> When compared to a generic double-facade, the effort and performance of the *i-modul* Facade is just as powerful, making it cost-effective and above all, more efficient. (Enkerli,W., 2007, *Interview*, p. 40)

Photovoltaic elements are also integrated into the facade as well as the so-called “energy bored piles”, which are used to gain energy from the soil, adding to the overall efficiency of the facade. ("Pro - day: Integral Facade ", 2007)

Inspired by the case-study of the Capricorn Building, I and my studio partner Rachel Sauer conducted a group project where the focus was placed on the abstraction of mechanical systems. This study is addressed in the following section.

New York Tower Proposal

This was a team effort completed within a six-week period in the Fall semester of 2018. Based in New York City, the tower design is intended to rest in a narrow site located on W 45th St. The primary function of the building is to serve as a private hotel for watchmakers; however, other spaces included are as follows: individual watch-making studios, a convention center, a public restaurant/cafe, a public out-look platform, and a private rooftop event space. The width of the

tower is small, measuring 25 feet at the North end and 45 feet at the Southern end—its total length measures 225 feet. The intention of keeping the building very thin is to have it mimic the compactness of a mechanical watch. By looking at a section of the building, one can see that a tall atrium space cuts the building in two; here, there is a complex system of escalators and ramps.

The name of the tower is Olinda-Berenice. Inspired from Calvino's book, Invisible Cities, Olinda represents the North-side of the tower and Berenice represents the Southern-side. (Calvino, I., & Weaver, W., 2010) By analyzing the systems of transport that make up NYC; such as its subway plan, city streets and stop-light controls, my partner and I chose to have the building reflect these mechanisms of transport. This is where the idea of the intertwining escalators and ramps came into play—they would become the central mode of transport between Olinda and Berenice (Illustration 5).

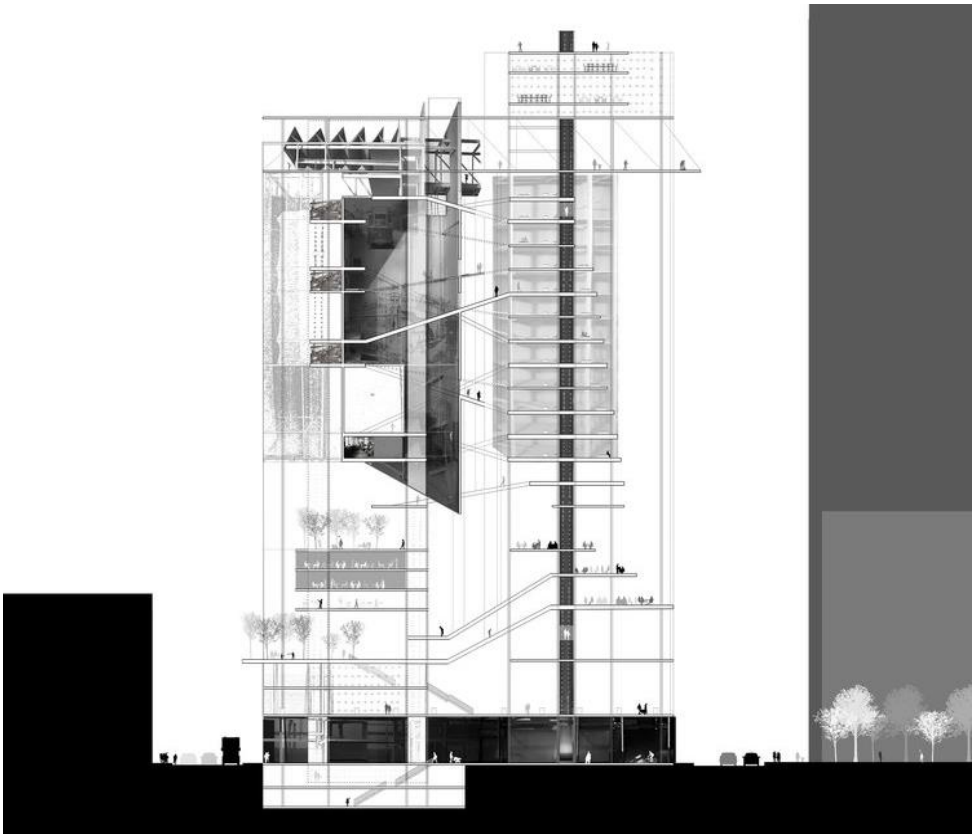

Illustration 5*: [Section of Tower Project Revealing Hidden Circulation] (2018)*

The tower is a machine in which people move and inhabit spaces, it is composed of a complexity of systems that overlap, parallel, assist, compete, rely and challenge one another, each contributing to the rhythm and itinerary of its experiences, just like New York City. Further exploration led to the production of four facades that spoke to the complexity of systems within the tower. Those four facades are analyzed in the following section titled Façade Studies.

Façade Studies

By referring to the Capricorn House and its i-*modul* design, various multi-layered building envelopes for four facades surrounding Olinda-Berenice were proposed. The four facades highlighted in this section are the: north facing facade, south-eastern facade, atrium facade facing east and north-western facade. These four facades were chosen to respond to the different programs they envelop. For example, the north facing facade houses the watchmaker hotel. This facade is the most layered and intricate out of all four facades because it also faces the neighboring park and welcomes those that pass through the building. It is layered with a screen system composed of large metallic rectangular frames that alternate from left to right along the vertical face. Running behind these repeating frames are a series of horizontal pipes that hold electricity lines, similarly to what the yellow pipes in the Pompidou Center (Pierre, 2017). Illustration 6 is a process sketch suggesting these layered systems. It also highlights the depth of the north-side facade. Rather than creating a flat facade like the Capricorn Building, it uses another strategy that groups certain systems and pulls them apart. In illustration 7, one might also note how the *i-modul* is also incorporated.

Various iterations and designs were created for the north facade. In the end a facade was chosen that played with depth and used a combination of rectangular screens, discrete pipping and *i-modules*. Only one *i-modul* would be placed on each hotel floor and would be visible through the screen frames, creating an alternate pattern. The placement of these devices would follow the primary structure of the building, but they would also aid with the appearance.

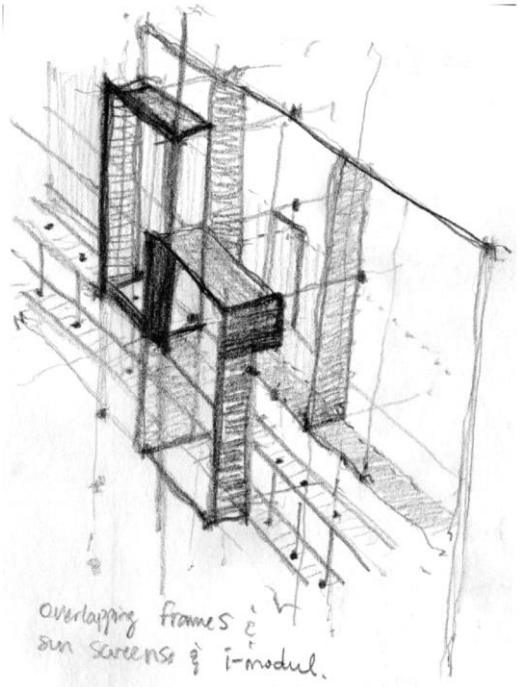

Illustration 6: [Axonometric Facade Sketch] (2019).

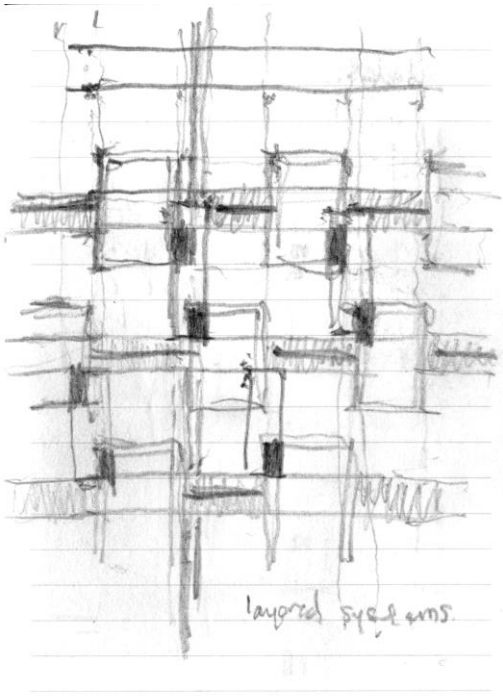

Illustration 7: [Layered North facade sketch] (2019)

Unlike the north facing facade, the others do not face a street; instead, they face the neighboring buildings. However, the facade studies shown below show what these three remaining sides might look like, once Olinda-Berenice rises past these structures. The south-eastern facade is also layered but is much denser. Due to the harsher sunlight this side of the building will receive, it was necessary to cover this side of the buildings with a large perforated panel. Since this facade houses the studios of the watchmakers it made sense to limit and control the amount of sunlight entering this side. Electrical conduit would also run alongside this face of the building, behind the perforated sheet, but no *i-moduls* would be present. These would be located on the southern side of the building. Illustration 8 expresses what the final four facades look like.

I-moduls would also not be present on the atrium facade or the north-western facade. Instead, these facades would be less layered with sun-shading devices and more open. Glass becomes more visible on these two facades. The glass panels follow the rhythm of the structural columns that run vertically along these faces.

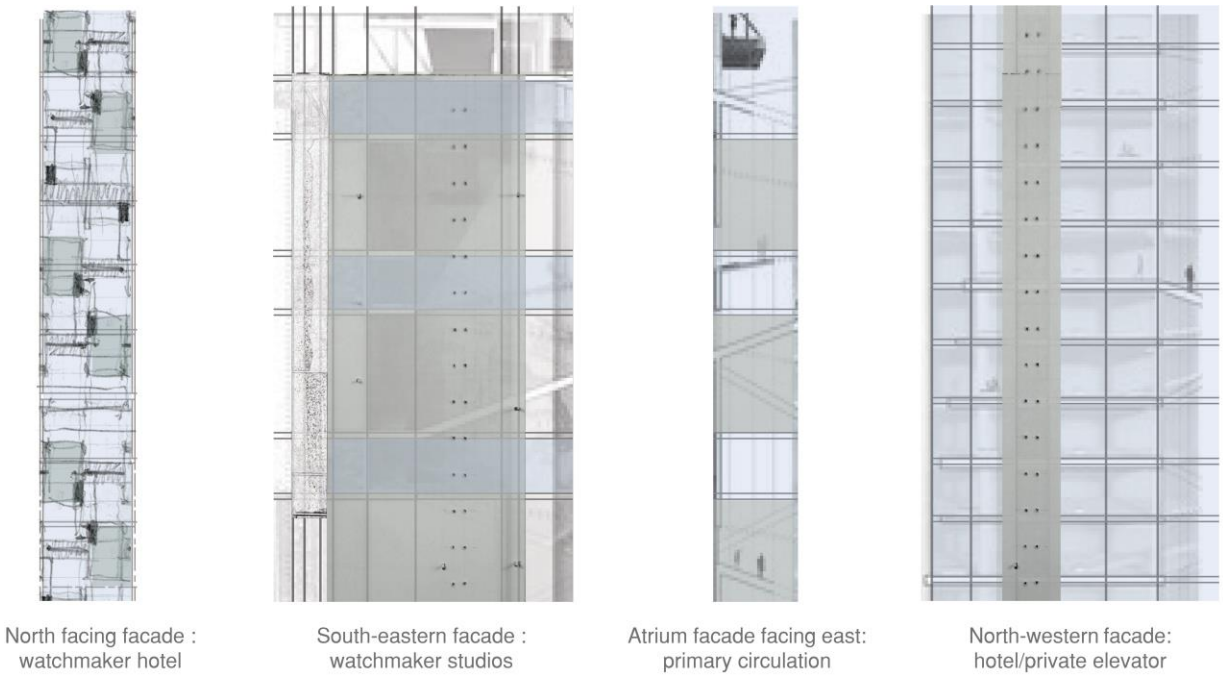

Illustration 8: [Final Facade Proposals] (2019)

As this study highlights, recent technological systems like the *i-modul* could provide new opportunities for designing envelopes inside out and make future buildings more energy efficient. The facade proposal for Olinda-Berenice was just one proof-of-concept that builds upon the Capricorn Building design, technically and perceptually.

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