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## LIGHTNESS

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**Francisco Gonzalez-Pulido**

### Biography

Born in Mexico City in 1970

Francisco Gonzalez-Pulido holds a degree in Architecture from Monterrey Tech and a Master's Degree from Harvard University. In 1992 He founded 2MX3 a design-build practice focused on Industrial and residential projects with base in Mexico City.

In the fall of 1999 He began his collaboration with Helmut Jahn at Murphy Jahn in Chicago. Where He is a Partner and the Firm's Executive Vice-President. Since his early projects Francisco has created uncompromising Architecture under the principles of Integrated Design.

Francisco teaches and lectures regularly, his own work and in collaboration with Murphy Jahn has been widely published and exhibited around the world.

### Abstract

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Sometime before I joined Helmut Jahn some 14 years ago, I was exploring possibilities in building with less. Not in the line of aesthetic or material synthesis but in the path of 'weightless' Architecture. Construction methodologies in our industry, unlike materials have not evolved significantly; they can still not radicalize the way we put buildings together. Our focus gears towards using less material, less components, less connections, less weight, less embodied energy, minimizing distance and resistance and generating less waste.

This presentation will focus in the aspects of our practice that deal with the issues that we consider relevant for the future of design and evolution of our industry. Murphy Jahn has been a pioneer in Sustainable Design, we have done buildings like Sony Center in Berlin, the Deutsche Post Headquarters in Bonn, Veer Towers in Las Vegas, Suvarnabhumi Airport in Bangkok and most recently Leatop Plaza in Guangzhou, that were built and/or design in the last 10 years and use an average of 30% less energy and weight less than buildings that are getting built at present times. Our concern with the environment started before any GREEN checklist. Their 'Lightness' is Physical as much as it is Metaphysical.

**Keywords:** Lightweight Construction, Sustainability, Mat vs. Super-tall.

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## Lightness

In the last decade we have been exploring transparency, as a media to dematerialize physical boundaries and create continuity between our buildings and the City. Glass has become our Invisible, Infinite and Irreplaceable ally. However, in our quest for total transparency the weight of things whether material or immaterial has become a critical parameter.

Lightness as we call it is as much a question of matter as it is a question of meaning. It refers to the physical and metaphysical properties of time and space. It is through Lightness where I foresee the next technological opening.

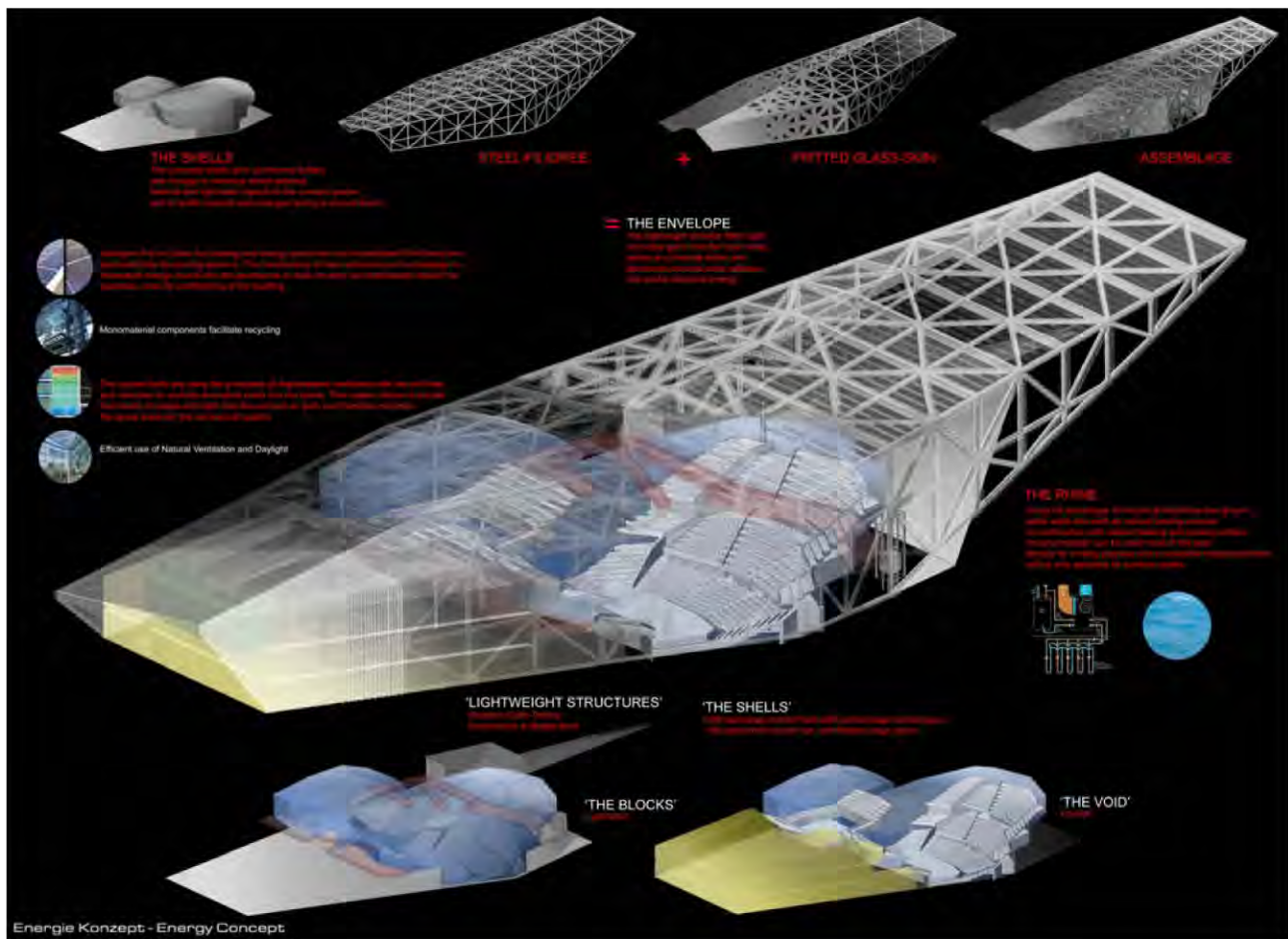
Sometime before I joined Helmut Jahn some 14 years ago, I was exploring possibilities in building with less. Not in the line of aesthetic or material synthesis but in the path of 'weightless' Architecture. It was 1997 and I managed to build one structure, it was a small house addition. The budget was limited and the only way to control it was to compress the schedule, reduce the labor and to industrialize the manufacturing as much as possible. Simply put, the addition was a kit of parts: 1 steel box column, 1 steel pipe beam, 5 stainless steel rod cable trusses, 12 panels forming a single glazed roof and 6 foldable textile shades. The idea of being able to create a 75m2 assemblage, produce, transport and install (in a very short time and with a crew of two Men); fascinated both, me and my client. With very little we felt we were pushing some boundaries. The total cost was 4000 USD.



De la Mora House

Construction methodologies in our industry, unlike materials, have not evolved significantly; they can still not radicalize the way we put buildings together. Buildings are still the outcome of a 'Wet Industry', victims of long construction schedules and relying on obsolete trades. In the meantime the 'Dry (assembly) Industry' is developing fast, carbon cars, clothes and sails out of extreme textiles, spacecrafts containing aero-gel, 'Lightness' in its broader sense seems to be playing an important role in this transformation.

The point is: less material, less components, less connections, less weight, less resistance, less distance, less waste and less embodied energy which by the way represent 15% of the Total energy in the total building's life cycle. Could challenge and ultimately transform our industry allowing for optimization in construction sites, enhancing safety, reducing lead-times, transportation, neighborhood nuisance and environmental impact. Structures in which death loads are minimized, Facades and building components that are easy to handle, transport and install, and require less support from staging equipment. We have been in that quest since the early 90's.



Naturally, we have explored lightweight concepts in pavilion type structures. The goal has evolved and the question now is how far we can push physical 'lightness' in the context of the Super-tall? As we know Aerodynamic tuning is critical since the structural system is the most important criterion for the development of super tall building as it inter-relates with the plan shape, floor plate, lease span, floor height, building form, service core and vertical transportation. But beyond the boundaries of its physical properties there is the understated reduction of its embodied energy. Which should be considered in respect to:

- 1-the durability of building materials
- 2-how easily materials can be separated
- 3-use of locally sourced materials
- 4-use of recycled materials
- 5-specifying standard sizes of materials
- 6-avoiding waste
- 7-selecting materials that are manufactured using renewable energy sources.

The focus today is to present buildings in our practice that deal with the issues that we consider relevant for the future of design and evolution of our industry, if in fact our true global concern is to build sustainable futures. Murphy Jahn has been a pioneer in Sustainable Design, we have done buildings like Sony Center in Berlin, the Deutsche Post Headquarters in Bonn, Veer Towers in Las Vegas, Subarnami Airport in Bangkok and most recently Leatop Plaza in Guangzhou, that were built and/or design in the last 10 years and use an average of 30% less energy than buildings that are getting built at present times. Our concern with the environment started before any GREEN checklist. Their Lightness is Physical as much as it is Metaphysical.

### **The Lightness of Energy Leatop Plaza, Guanzghou, PRC.**

As the world's largest construction market and being home of 1/2 of the buildings built around the globe is critical for China to focus on strategies to cut their energy consumption. China uses 45% of its total energy on manufacturing, transporting building materials, building new buildings, heating and cooling. If this construction rate continues the World Watch Organization in its 2007 report, 'the status of the world'; estimates that by 2020 it will be difficult to provide enough energy. Furthermore, Its reliance on coal to satisfy energy demands makes China the biggest emitter of Green House Gases.

When we won the competition to design Leatop Plaza in Guangzhou we focused in the aspects that we can control by Design and we pushed for innovation.

The building's innovative High Performance Façade (triple glazed, low-e coated, fritted and shingled) in combination with, daylight sensors and the automated shading system maximizes the use of daylight and transparency (90% of the users have a visual connection to the outside) while supporting an energy efficient concept. The cooling and heating system is based on Adjustable VAV Technology with high efficiency fans supported by Fresh air Intakes at Mechanical Floors.

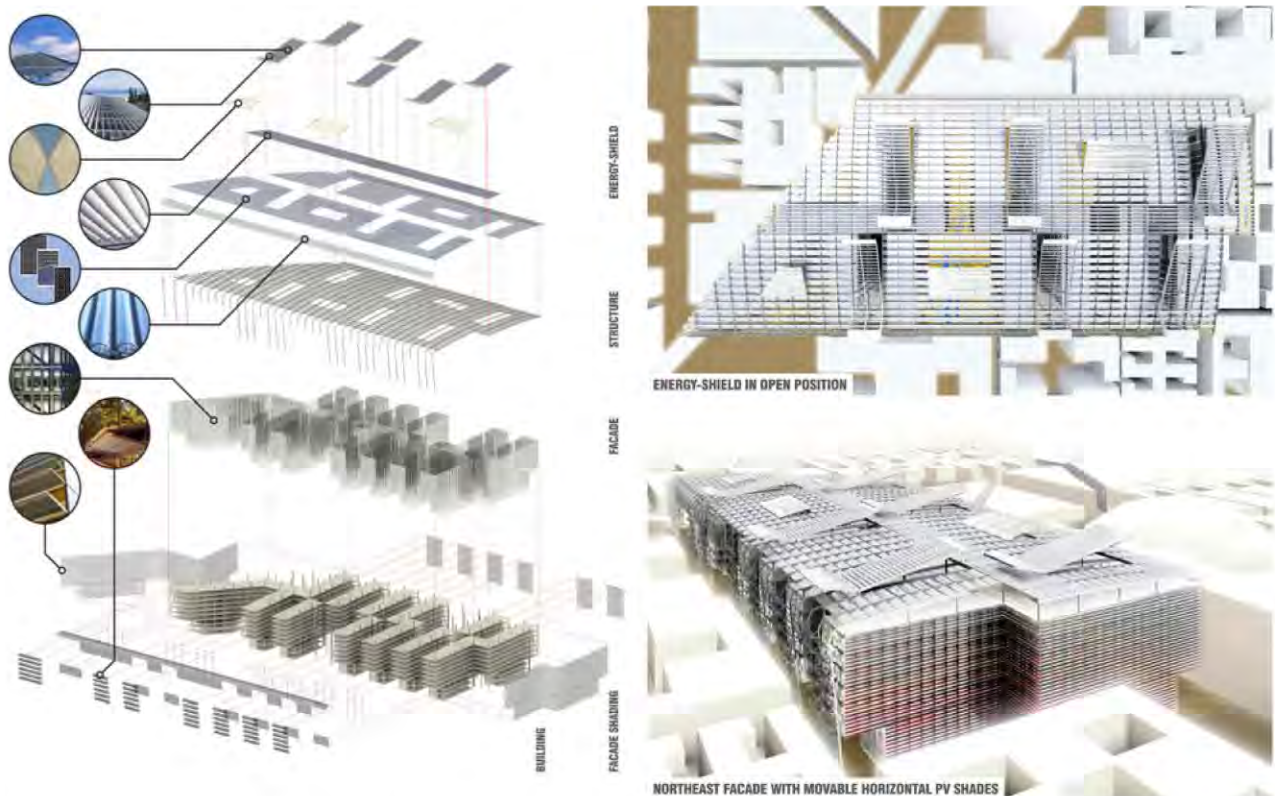
The Monitoring of Carbon Dioxide, Thermal Comfort, the use of refrigerants that reduce the damage to the ozone layer, elevators operating under energy recycling technology, high performance filters to provide the highest indoor air quality levels are all an essential part of the integrated design approach. Outdoor and Indoor quality levels met the requirements of ASHRAE 62.1.



### Masdar/Merck

Around the same time we entered a competition to design the corporate headquarters building of Masdar in Abu-Dhabi, we develop what back then was defined and trademarked as the 'Energy Shield'. An outdoor enclosure designed to collect, transform save and generate energy; tube collectors, solar panels, wind catchers, PV frit in the façade, foldable and movable roofs, all working at unison to achieve an efficient building model in a harsh context. All that translated into a building that combined represented 75% less Energy than a traditional building and a significant reduction of operational cost.

The façade's double layer is conformed by an operable screen that actively collects energy and passively shades the interior. During the Day the enclosure remains closed to control daylight, temperature, maximize collecting surface and increase comfort. At night when temperatures drop and the sunlight is gone, the operable roofs and screens cool down the interior space through the courtyards.



That experience led to many developments like this building in Switzerland originally for Serono which later on was bought off by Merck. A building complex that operates under similar principles. Low Energy Spaces, Operable Roofs and Breathing facades.

### Spatial Lightness

#### Sony Center, Berlin, Germany.

The construction of the roof began in fall of 1988 and lasted almost two years.

Ironically not included in the developer's program the 4000 m<sup>2</sup> Roof covering the Forum became the central element of the Sony Center.

The structure for the roof is based on the geometry of a tilted and cut hyperbolic cone and picks up the principles of a bicycle wheel. It spans 102 m at the main axis and 77 m at the minor axis.

The whole system is pre-stressed to stabilize the surface created out of cables, fabric, and glass. The ring beam is supported vertically at seven points on the top of the roofs of the buildings surrounding the Forum.

The unique form of the roof, whose installation required the highest technical expertise, consists of 750 tons of steel, a safety 16 mm glass area of approximately 3.400 m<sup>2</sup>, 160 tons of cables and a self-cleaning, Teflon coated textile membrane of 5800 m<sup>2</sup>.



In general roof structures require evenly distributed openings of only 15% of their surface area to provide sufficient daylight, and average light transmittance of 85% can result in undesirable heat gains. This is the factor that contributed to the use of Teflon-coated fiberglass with a translucency of 17.5%. In the center and at the connections to adjacent buildings the roof is open continually bringing fresh air through the open circulation areas.

ARUP was appointed to provide engineering services for all design stages. This included preparing construction documents, negotiating with the building department and their respective representatives, assisting the client during the tender and bidding stage, supervising the materials testing, site supervision, and assisting the contractor during erection. The complete continuity in engineering services for the project proved to be a key element in the process of building this roof.

## Kit of Parts

### Deutsche Post, Bonn, Germany

A Headquarter Complex with a 40-story, fully glazed office tower and a low-rise building situated near the Rhine. High demands on flexibility, increased workplace quality with natural lighting and ventilation, as well as user-friendly elements, such as manually operable windows and limited individual control over heating and ventilation. The main objective was to reduce operating costs for heating, cooling, and ventilation by taking advantage of natural energy

Deutsche Post is an example of the application of object-oriented building techniques, where building components are pre-designed / pre-engineered / pre-fabricated for inclusion in joint-based (linear element), panel-based (planar element), module-based (solid element), and deployable (time element) construction systems.

The Kit-of-parts construction not only achieved flexibility in assembly and efficiency in manufacture, but also by definition required a capacity for demountability, disassembly, and reuse.

The main building energy saving features are:

- Double-skin façade with reflective solar protection
- Allow individual window ventilation to the double-skin Façade
- Condition supply air to the offices via decentralized Supply air units integrated into the façade
- Utilization of waste heat by directing exhaust air through the atria
- Building component activation of the massive ceilings
- Cooling via groundwater wells



Building monitoring became a critical aspect to determine the estimated 50% versus the actual building efficiency 35%.

## Structural Lightness

### Highlight Towers, Munich, Germany

The Highlight Towers are proof of the design, structure and construction of a high-rise tailored to outmost efficiency. The two towers are designed as reinforced concrete structures with vertical steel framework bracings for support. Following the requirement of airiness and flexibility, the internal finishing was executed throughout in dry construction – using Knauf systems. The highly sophisticated structures and detailed solutions in terms of civil engineering physics and fire protection technology are the result of an intensive cooperation between the M/J, STRABAG as the general contractor, Knauf, and the ARGE dry construction.



A special feature of the design is the supporting structure, which is of a simple steel composite construction. A characteristic of this type of structure is its considerable slenderness coupled with a minimized loss of construction area. Both the cross-sections of the framework elements and the supports are made of solid steel, which is housed in a jacket pipe and then filled with concrete; achieving a fire protection requirement of F120. Lean supports, 28-centimetre-thick cast-in-situ ceilings as well as the arrangement of two vertical framework structures for each tower comply with the MJ's requirements of maximum transparency. This type of structure also enables a speedy installation: It was possible to erect one floor for each tower per week. Due to the arrangement and form of the load-bearing cores, which in the ground plan extend as an open U across the entire width of the building and are located in each case at both ends of the building, a considerable flexibility was achieved in the floor-plan composition.

The most important wall in the dry construction is the Knauf Fire Wall system, W131, which flows concentrically through both of the towers. This divides the building into two 400-square-metre fire compartments. The planning had the task of solving practical details, like the penetration depths of the wall in the area of the stairs, connections of the firewalls at the diagonals of the framework structures or at the round columns as well as on the facade. As building movement was expected – the specific deflection of ceilings under load totals around 16 millimeters – the main part of the connections had to be designed so they could move.

It took two weeks to execute the basic dry construction installation for each floor. After concluding the installations, a follow-up of one and a half weeks was required. The integrative cooperation in an early planning phase was an important foundation for Murphy / Jahn, for being able to achieve the considerable aesthetic and structural level in dry construction. The slender structure could only be realized using this dry construction.

### Integrated Design

#### Veer, Las Vegas, United States

The manifesto for the project is to exhibit *urban responsibility*, pay attention to the building's *performance* in terms of function and systems, *use advanced and available technology*, accept the *aesthetic of construction* and elevate it to a level of art, be *sensible towards energy and ecology* through the use of natural resources like daylight and fresh air combined with minimal technical equipment and maximize the *user comfort*.



Responsible uses of appropriate technologies provide an expressive means to realize this project in a sustainable way. The use of construction waste management techniques including diverting 50 to 75% of construction waste from landfills, the use of materials locally or regionally produced and manufactured, recycled materials and wood certified products, result in a significant reduction in environmental impact. Storm water filtration systems controlled flow drainage, use of storm water for irrigation and grey water systems all contribute to water conservation and the reduction in the use of potable municipal water resulting in saved utility charges and reduced impact on natural resources. Veer towers has received a LEED's silver rating.

The façade of Veer is perhaps the more visible of its sustainable elements, the extensive use of High performance Low-E coating glazing maximizes the introduction of day lighting and views to the outside, which in conjunction with the use of exterior shades and a 57% ceramic frit in 50% of the building's envelope, provide all the shading to control and reduce the solar loads.

Veer will be the First truly transparent building in Las Vegas, in that context, that alone represents a great technological and even cultural challenge.

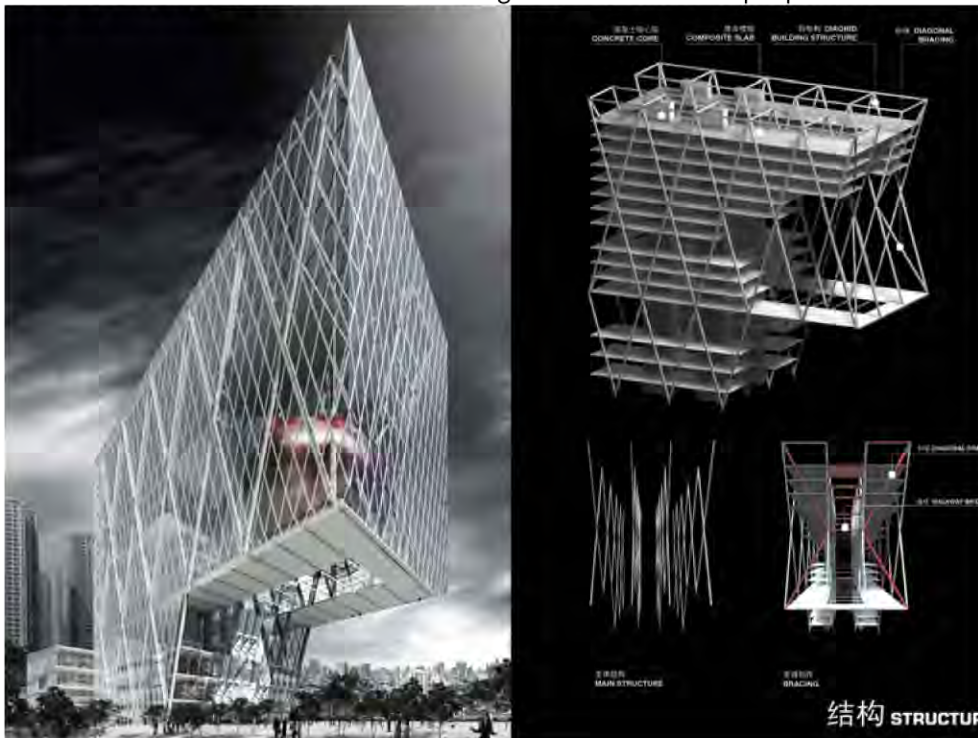
## The Future

### Alternative Solutions/Composites/Chongqing Landmark Tower, PRC

This is a Building in Chongqing that Helmut and I designed with the idea of using composites for all major building components including the envelope and the structure.

Architecturally, the project consists of a 'floating' volume conformed by two interconnected wings that house the office program and a podium that contains all retail and support functions, including a museum which is partially buried on the North side following the terrain's natural slope.

By replacing Steel-reinforced concrete with Plastics reinforced with various forms of fibers; we achieved significant reductions in weight due, in part, to the specific properties of the individual components and low dead weight, and partly because of the possibility to produce composites designed with a view to specific load-bearing capacities, while providing a number of advantages in relation to traditional materials, such as high strength and low weight, resistance to chemicals, as well as electrical and thermal insulating and fire resistive properties.



## The Future

### Alternative Solutions/Textiles/Shenzhen Energy Mansion

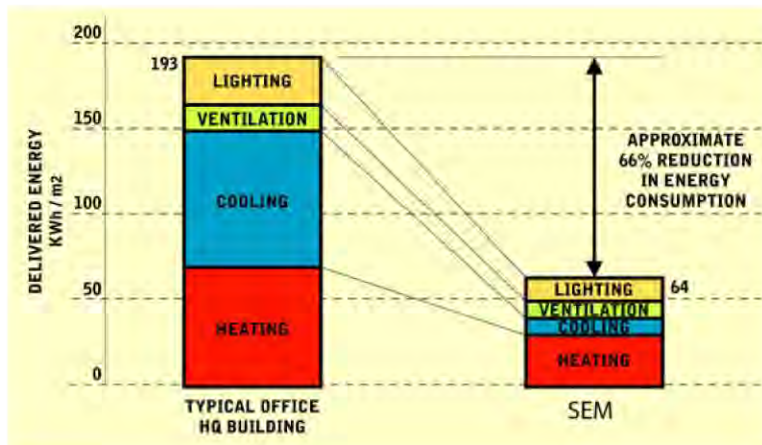
In the last fifty years, new fibers, such as aramid and carbon fibers, have encouraged engineers and designers to re-examine the structural capabilities of traditional textile structures like weaving, knitting, braiding and embroidery.

The Energy Mansion in Shenzhen was a very important project because it led to the exploration of Alternative lightweight Panels in building envelopes.

The headquarter building composition was simple, two slabs connected by a lightweight atrium, the façade was conformed by a random array of Glass Reinforced Plastic, Fabric Panels and exterior sunshades, with the idea of creating a physically Stronger, Lighter Environmentally responsive and Safer building complex.



The Fabric Panel was designed out of translucent textile, composed of layers of glass fiber textile and ETFE Foil, surrounding air cavities and a layer of transparent acoustic baffles. The preliminary analysis demonstrated that the Lowest U Value in the façade composition was achieved by the Textile panel. The chart below presents the advantages of the advanced skin over traditional systems.



## Reflection

Our vision for the Super tall has shifted over the last years, not a mirror of the change of times but surely influenced by a new hierarchy of lost values, we MUST do more with less. Somehow the world for mega-structures, solar chimneys, sun tracking enclosures, and endless peaks, seem to be disconnected from the issues that a sustainable society is demanding.

The wisdom of skyscraper development has been often questioned; the verticality has to match the horizontality, (infrastructure, transportation and level of development (context), the question still open, can this building be a valid path towards urbanization?. We know that the 'Super tall' can also be dangerous, many Cities have failed in avoiding the Fantasy of designed to impress, we want to believe that meaning will win over size in our quest for the realization of a new Architectural and Technological Vision.

'The second industrial revolution, unlike the first, does not present us with such crushing images as rolling mills and molten steel, but with 'bits' in a flow of information traveling along circuits in the form of electronic impulses. The iron machines still exist, but they obey the orders of weightless bit'

## References

Ross Clarke, Bruce Danziger Markus Schulte. Forum Roof, Sony Center, Berlin: Innovation beyond 'form follows force'

Carmen Richerzhagen, Tabea von Frieling, Nils Hansen, Anja Minnaert, Nina Netzer, Jonas Rubild, (2008) Energy Efficiency in Buildings in China. Policies, Barriers and Opportunities. HGerman Development Institute.

Fabian Schmid. Institute for Lightweight Structures and Conceptual Design- ILEK, University of Stuttgart

Fisher J.W. and Wright W.J. (2001) High Performance Steel Enhanced the Fatigue and Fracture Resistance of Steel Bridge Structures, International Journal of Steel Structures, Vol. 1, No. 1, pp. 1-7.

Best Practice in Steel Construction. Euro-Build in Steel Magazine 2009.