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Breathe: Re-Defining the Urban Breathing Apparatus

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BREATHE:

RE-DEFINING THE URBAN BREATHING APPARATUS

by

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Melissa Mazik

Breathe: Re-Defining the Urban Breathing Apparatus

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Master of Architecture 2012

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Abstract

As a speculative vision of the future, the Urban Breathing Apparatus was designed to challenge thoughts on the hermetically sealed building. Architecture has been struggling for the ultimate hermetic seal since the introduction of air conditioning systems (artificial breathing apparatus), focusing more on the physical seal (skin) of the building and less about the immaterial substance inside, air. The urban fabric needs to be re-conceptualized. A new way of thinking is needed for the static, hermetic seals of modern buildings as breathable thresholds, through principles of biological and technological processes to metabolize the contaminated interior and exterior air.

Acknowledgements

I would like to thank my family, Roy, the Basso Family, my friends and colleagues for your continual support during my studies these past two years. I am extremely grateful for all of your input, comments, motivation, understanding and patience.

I would especially like to thank Colin Ripley for being an outstanding mentor throughout this whole process. His positive foresight of my concept and his continuous support and encouragement have allowed me to go beyond my comfort level of design and explore bigger and more challenging ideas.

I would also like to thank Maite Bravo and Willy Muller for also encouraging me to design out of my comfort zone. They have both opened up my eyes to a new world of design and I am extremely grateful for their encouragement and confidence in me.

Also, I would like to thank Frank Bowen for consistently being available to help me with my various requests for my thesis research. He has been an outstanding person throughout this year and I greatly appreciate his efforts.

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01

Introduction

Breathing is an architectural issue. Air, an immaterial substance present in all architectures and environments, responsible for sustaining life and also that which architecture seals itself from, can no longer be taken for granted. (Sloterdijk 2009) Since the invention of the air conditioner, this soft architectural element, as described by Nicholas Negroponte, occurs on opposing realms of a building's hard skin, limiting the breather's experience of air to a static, unresponsive and of predetermined regulation. (Negroponte 1975)

To modern architects such as Mies Van Der Rohe, breathing was an issue best left to engineers. With spaces focusing on hard surfaces and linear forms inspired by industrial processes, the role of the architect was to conceive of these spaces, static and sealed in nature, enveloped in hard, modular skins, deflecting atmospheric properties. This design process unmindfully assumed the insertion of a generic form of artificial breathing, with no relationship between air and space. To modernists, their role was to design spaces, not systems, resulting in an architecture as purely a product of process, such that of an assembly line.(Abalos and Herreros 2003)

However, breathing in the 21st century has become a critical cultural issue. As stated by Peter Sloterdijk, the preliminary use of air terrorism in the early 20th century, such as the experimentation of gaseous warfare was the first moment of the awareness and fear of air. The relationship between breather and air instantly changed into a state of paranoia, with the immediate development of the gas mask to protect oneself from their atmosphere. (Sloterdijk 2009) A new perception of living developed, not only changes in lifestyle but the way people breathed, thought about breathing and the architecture that had evolved from this paranoia, the artificial breathing apparatus (the air conditioning system).

The evolution of the hermetic seal has emphasized the need to isolate the breather from the exterior hybrid atmosphere of gases, smoke and exhaust, as described by David Gissen. Over the years, technology has been used as a means of defence and isolation, simultaneously decomposing our air supply. Bruno Latour, expanding on Sloterdijk's

work refers to the atmosphere of the 21st century as ‘fragile’, and of a technical and political breakdown and states that we are currently living on ‘life support‘ (air conditioning). (Latour 2006, p.106) The breather is being subjected to a life of static, unresponsive, predetermined and programmed air. What is the future relationship between breather and air? Between architecture and atmosphere?

Atmospheric architecture is currently being explored and practiced by such architects as Philippe Rahm, with the exploration of using natural properties of the site (air and wind) to sculpt the architecture and develops a relationship between air and breather in projects Windtrap and Airflux. R & Sie explores relationships between facades and urban air, suggesting architecture as breather, while the work of RVTR researches interior atmospheres through investigations of relationships between breather and space.

The discourse on atmospheric architectures should no longer be understood in terms through processes of hard objects (mechanical systems and hard skins) but one of an exploration of new thresholds between in and out using responsiveness, technological and biological principals to restore the relationship between breather and atmosphere.

Fig 2: Toronto Dominion Towers

Fig 3: Gas mask
superimposed on Toronto
Dominion tower

1.1 Air

Air began as an architectural discourse in the late 1950‘s and 1960‘s with the questioning and re-conceptualization of the atmosphere in terms of building envelope. Radical thinking in atmospheric design are evident in Yves Klien and Werner Ruhnau’s literal ‘air barrier’ as threshold proposals. Their designs involved using air and fire as partitions between interior and exterior spaces.(Ripley 2011) As an increasing number of architects were incorporating air conditioning into their designs, simultaneously critics opposing this movement were expressing concerns through manifestos and exaggerated design proposals such as the Dome Over Manhattan by Buckminster Fuller and Shoji Sadao. Shortly after, in the publication ‘A House Is Not a Home’ Reyner Banham and Francois Dallegret’s proposal of an inflatable Environment Bubble (Fig. 4), was a critique on the dependence of modern architecture on artificial breathing systems. Stating that a house has nearly become a shell to contain these artificial systems. (Banham 2007)

The idea of rebelling against the over dependence on hard systems was not a new thought, however no actions had been implemented or considered beyond paper due to economic feasibility and practicality during this time. The world was not ready for this change, for it was an

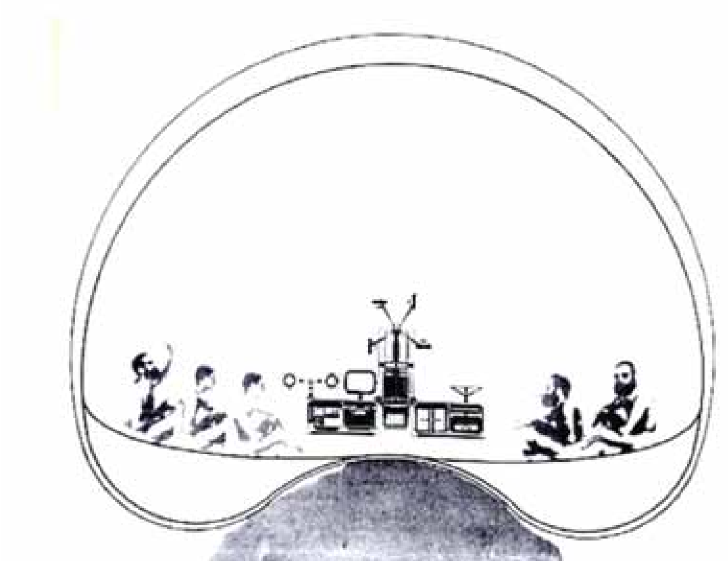


Fig. 4: Envirobubble (1965),
Reyner Banham and Francois Dallegret

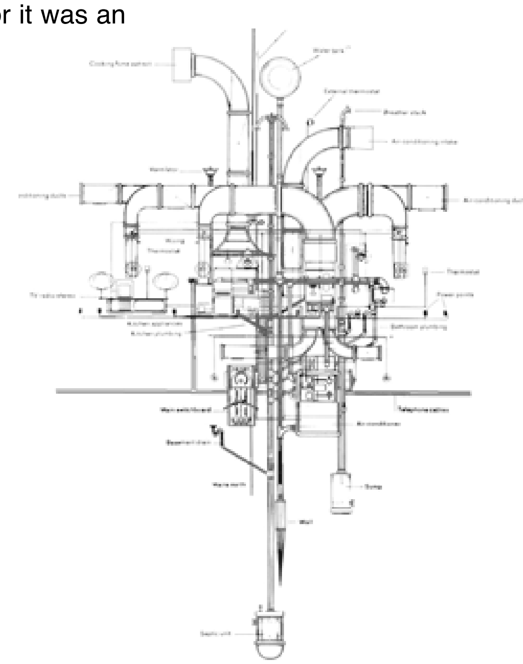


Fig. 5: Anatomy of A Dwelling (1965)
Reyner Banham and Francois Dallegret

exciting time of available technology with no thoughts of repercussion.

Many of the critiques were concerned with the space within, the internal impact of breather and machine or breather and internal environment (or designing the air, in Sloterdijks' terms) which evolved into a vital issue in the work of many modernist architects. These architectures of air, weather focusing on isolating from contamination or achieving a more poetic relationship with their exterior, have still produced introspective atmospheres using hard mechanical systems.

Contemporary work on atmospheric architecture, begins to look at internal environments and its air, and questions the impact of these atmospheres on the breather. Critiquing interior environments as spaces of social politics, RVTR introduces a proposal which alleviates this tension by mobilizing the hard surfaces and systems of buildings with a responsive ceiling application. This materialized 'atmosphere' tempers the internal environment based on occupant feedback, through use of intricate technological sensors and actuators. This project begins to demonstrate that technology and space can be a medium in detecting human comfort. (RVTR.com)

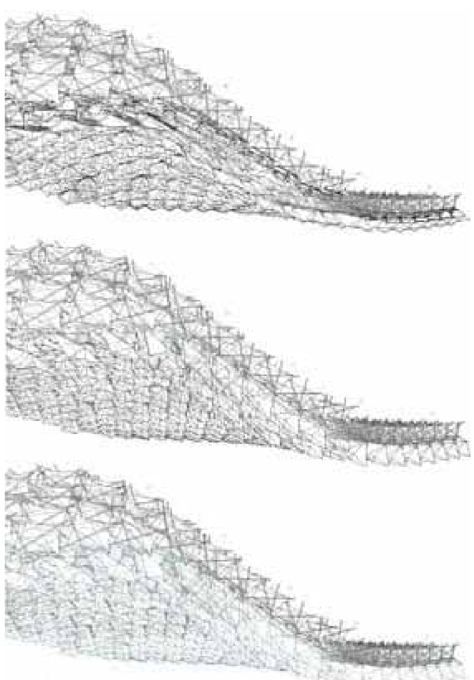


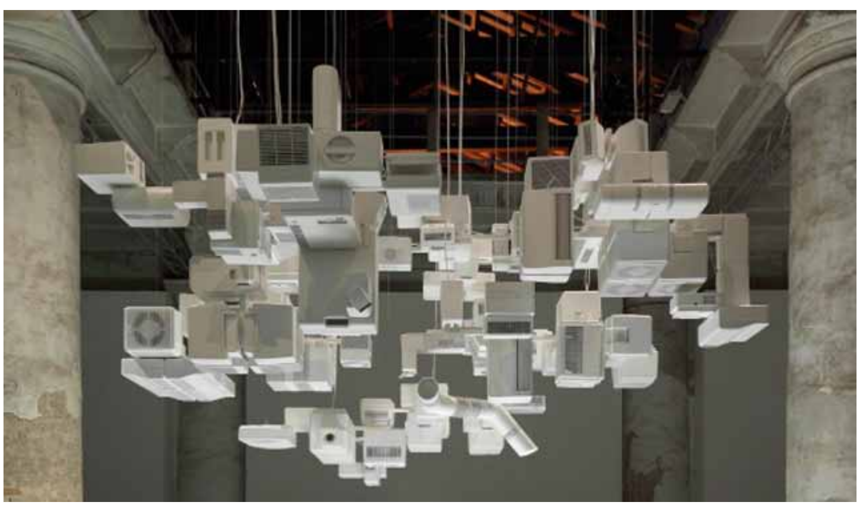
Fig. 6: Stratus Project, RVTR (2010)

Fig. 7: Dome Over Manhattan (1960)
Fuller and Sadao

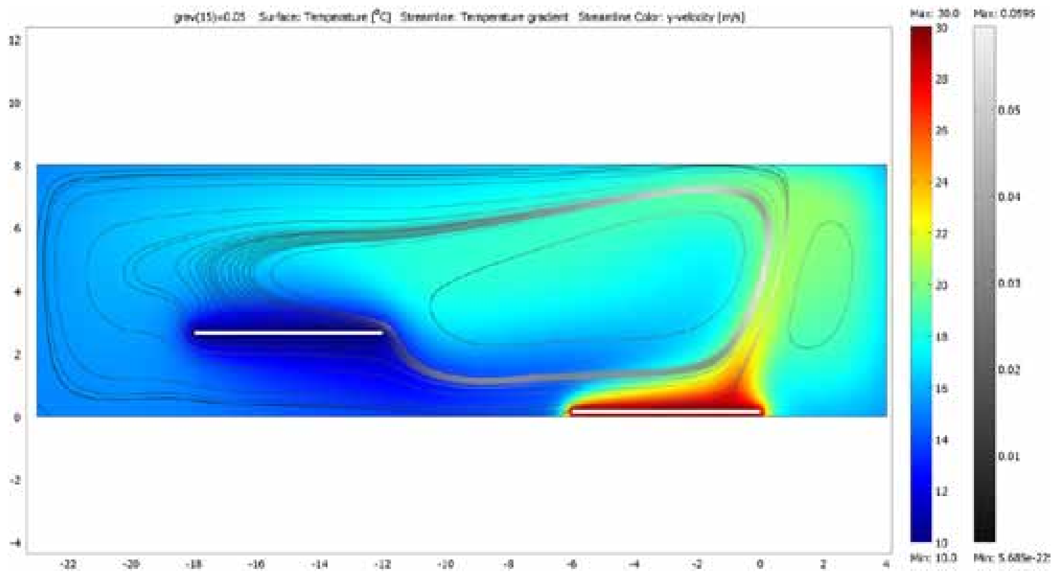
Fig. 8: Stratus Project, RVTR (2010)

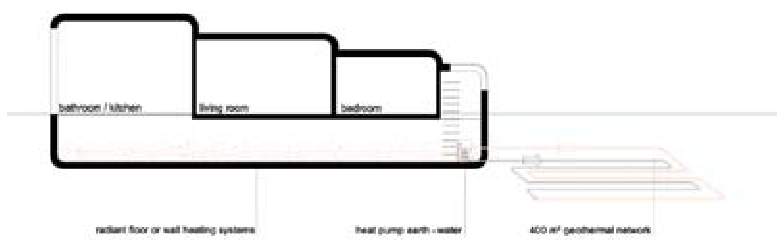
At a larger scale, Philippe Rahm is exploring the reduction of architecture to its essentials in his project Airflux (Fig. 12) and Windtrap, where the idea of internal air is understood with the movement of breathers in the space as well as the parameters of the site. The design of these sports facilities focuses on ventilation and aeration by bringing oxygen into the building and using the form of the architecture to allow continuous flow. Rahm's design approach is efficient because it eliminates the use or total dependence on heavy mechanical systems. He also uses the site to its full potential and completely integrates his architecture with the atmosphere and characteristics of site, evident in the project Underground Houses (Gissen 2009, p. 36).

The re-conceptualized breather/atmosphere relationship in RVTR's and Rahm's work emphasizes explicitness of air in interior spaces and a relationship to site. Perhaps these ideas can be expanded upon a step further by applying these techniques of responsiveness, technological and biological processes to the hard entities of existing modern design (at a larger scale), in particular the skin and artificial breathing systems. This exploration between interior and exterior air could begin to generate a new real-time dialogue between building, breather and atmosphere, understanding the architecture *as* the process, not product *of* the process.

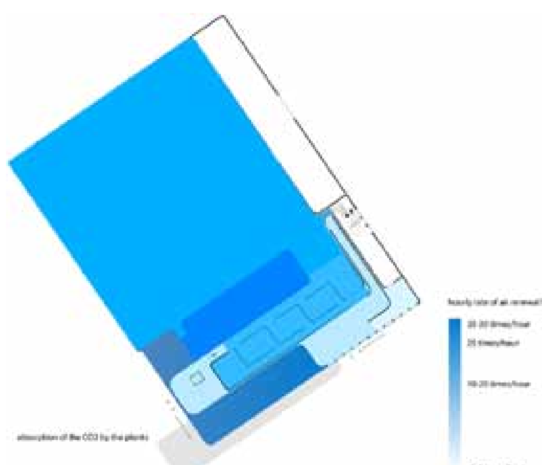


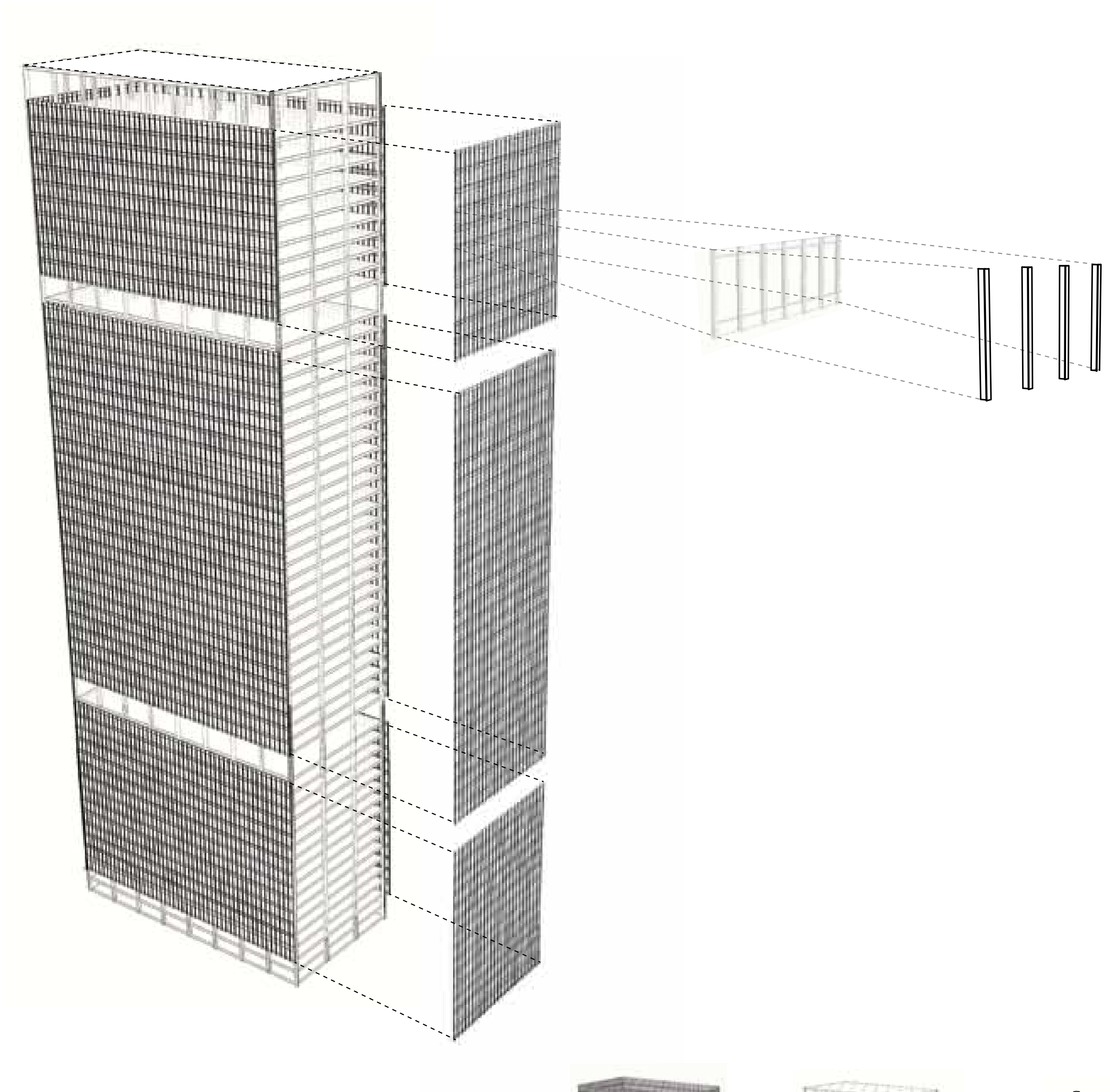
(Above) Fig. 9: Cloud, Biennale Installation, An Te Liu
(Top Right) Fig. 10: Digestible Gulf Stream, Underground Houses, Philippe Rahm
(Middle Right) Fig. 11: Underground Houses: Section
(Bottom Right) Fig. 12: AirFlux: Rahm's architecture is designed from the movement of air





heating system diagram





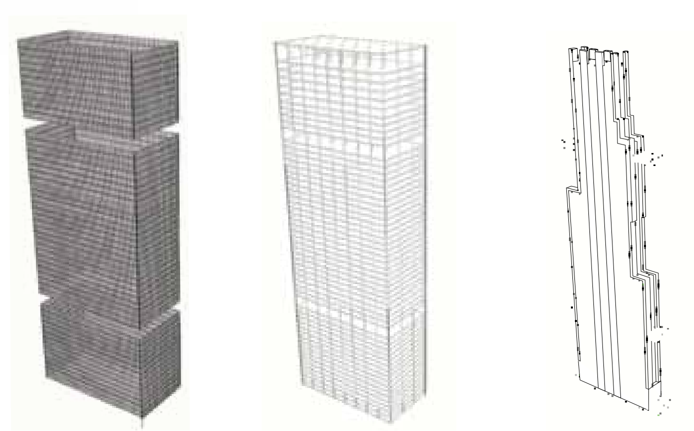


Fig 13: An exploded axonometric of the Toronto Dominion Tower along with its components, Skin, structure, systems

02

Architecture *of* Process

The development of the modern industrial complex impacted architecture in many ways throughout the past three decades. The industry of modernity was opposed to today's industry which depended on large scale processes (such as steel fabrication) rather than small scale or responsive processes (ie. biological processes). The style was formulated based on the idea of mass production, with the fabrication and separation of components so that each could be studied and implemented rather than on an integrated approach to design. (Abalos and Herreros 2003) The revolution of the modernistic style also extracted new concepts of generating artificial environments with the invention of air conditioning systems. This ultimately resulting in the development of the glass curtain wall and the sealed threshold between inside and out. (Abalos and Herreros 2003)

A prime example of this tendency towards exploiting new technologies for architectural purposes, is the work of 20th century modernist architect Mies Van Der Rohe, manifesting that architecture should be 'true to its time'. (Scherschel) Practicing during the industrial revolution and inspired by the 'technological age', Mies approached design reflecting the simplicity of the language of the industrial process of mass production and modulating components without ornamentation. (Scherschel) The architectural application of this technology generated a mass of excitement and optimism. This new architecture was so forward thinking and phenomenal that the idea erupted quickly and unmindfully, focusing solely on the present and without consideration of the repercussions it would have on the atmosphere (interior and exterior). Contemporary buildings, typically technology driven (which are ever-changing systems), are manifested in a physical manner (built form) that cannot continue to adapt with this change. Buildings such as the Toronto Dominion Tower or Lake Shore Drive Apartments in Chicago both have similar common languages of invariability, which cannot incorporate change with evolving societies. Mies may have had good intentions with representing the 'times with technology', however as society and technology continue to progress, contemporary architects must find ways to integrate these static, negatively contributing entities into what the future will require in urban fabrics.

2.1 Sealed

The continued search for the air tight building has lead to increasingly complex building skins, ultimately leading to a hermetic seal. This impermeable threshold to air and gas, has been the objective for designers integrating conditioning systems for the past 50 years. (Abalos and Herreros) Today, these skins are composed of a sequence of layers which are individually designed to filter, absorb and deflect properties of the atmosphere. (Mayer 2010, p. 244)

Between the nineteenth and twentieth century, mechanical systems were invented to generate artificial interior environments to offset poor insulation properties of single glazed skins. (Mayer 2010, p. 240) As Abalos and Herreros refer to in their book Tower and Office, at the turn of the 20th century, Le Corbusier was collaborating with engineers to develop a new type of integrated wall system with the concept of fusing ventilation and the hermetic seal. (Abalos and Herros 2003) Le Corbusier's wall, 'mur neutralisant' (neutralizing wall) took the idea of circulating cooled and heated air through a typical cavity wall, eliminating the direct effects of energy transfer from outside. (Abalos and Herreros 2003, p.103) Simultaneously, Willis Carrier, the inventor of air conditioning, was developing an 'apparatus for treating air', which at its infancy was implemented in large public buildings and years later in residential units. (Mayer 2010, p. 240) Three decades later, just after the end of WWII, the process of conditioning buildings was in high demand, (Mayer 2010, p.240) where office towers were competing for first class status by enticing the public with state of the art systems. In 1957, 20% of the office buildings in major cities designed with conditioning systems were regarded as first class living, resulting in remaining buildings competing for this status. (Kolarevic 2005, p. 64)

Although Le Corbusier was not successful with his invention due to inefficiency and cost, the concept was critical as a catalyst in discovering methods of re-conceptualizing building skins as thinner, more insulative compositions of transparent layers. (Mayer 2010) Next to be realized was the double layer glass envelope (with vacuum cavity) which was a premonition for the realization that the building could remain sealed and mechanical systems would compensate the role of ventilation. Architects

Fig. 14: Deep Sea Diver

at this time, observed this new window type as an intelligent solution, performing two functions, allowing ventilation to occur (without need of operability) and the illumination of space. (Abalos and Herreros 2003)

With the realization that solar gain would impact the temperature in a space, therefore resulting in harder working conditioning systems, Le Corbusier proposed a 'brise soleil' (Fig. 15), a concrete ledge acting as a louvre system to assist with this problem. His concept was driven by his understanding of sun and glass as adversaries, like natural air and artificial respiration. (Abalos and Herreros 2003, p. 104)

The use of air conditioning transitioned quickly from luxury to necessity as architects began designing fully glazed, unsustainable buildings for clients.(Mayer 2010, p. 241) The energy consumption of air conditioned glazed towers was quite substantial, and could only achieve a degree of efficiency if a hermetic seal was possible. (Mayer 2010, p. 241) Rem Koolhaas describes this condition as 'the generation of the endless building'. Junk-space, a term coined by Koolhaas, architect, theorist and urbanist, defines this term as paralleling the action of humans sending junk into space (space-junk), however referring to the space left on earth as filled with junk, layers upon layers of unmindful design applications. Coming from a post-modernist point-of-view, he writes about the impact of the man-made residue, (Mayer 2010, p.175) explaining that in the future, modernism will only be remembered by the static, unsustainable masses it has left behind, ultimately expressing this era as the 'meltdown of science'. (Koolhaas, p.1)

The endless building as Koolhaas refers to, critiqued the end (or neglect) of the relationship to the natural exterior, in turn having developed into individual entities, becoming sealed masses amongst dynamic environments. These isolated interior environments deprive the user from the physical connection to the exterior, only allowing a disconnected visual experience through large expanses of glass. Air conditioning is by no means a negative invention, however, the way its negative outputs are emitted without thought need to be reconsidered.

The IVAM building (Insititut Valencia d'art Modern) in Valencia Spain by team Kazuyo Sejima + Ryue Nishizawa / SANAA, was a winning competition entry for an extension to the museum of modern art. A project that begins to challenge the notion of the hermetic seal, designing an 'in-between space' where thermal properties of interior and exterior become blurred using layers of varying porous materials. The extension is a large permeable shell which encompasses the existing museum and outdoor spaces, becoming a new threshold space from outside to in, allowing weather to permeate through. The project generates an ephemeral feeling by enriching the sensorial experience of weather and skin. (Mayer 2010, p. 248) (Fig. 16) This design explores the unification of indoor and outdoor space, allowing the conditioned interior air to mix with natural exterior air. Daylight, wind and rain are able to penetrate through the light perforated metal skin.

Conceptually, this project is a utopian dream for colder climates: to have a conditioned space while simultaneously being immersed in nature. This design begins to illustrate the dissolution of the skin and explores a new relationship between breather and air manifested through a transitory space.

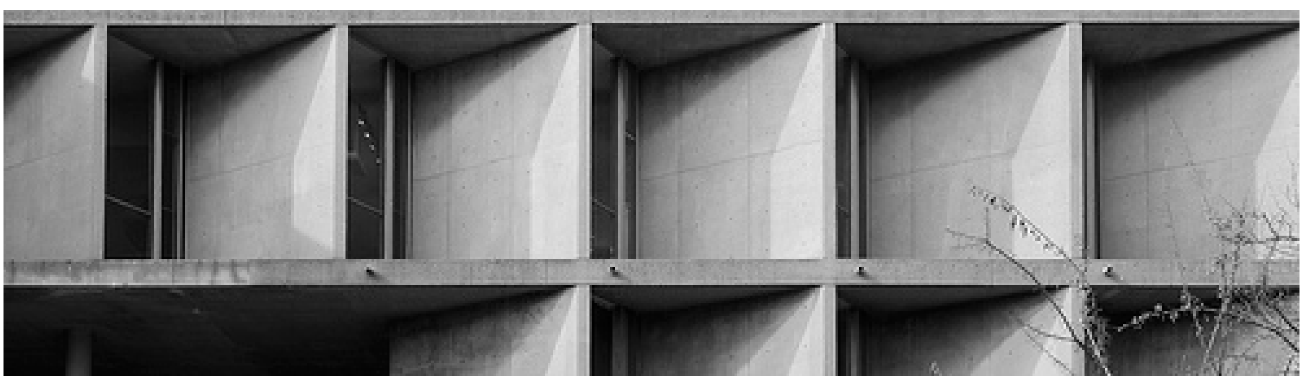


Fig. 15: Brise Soleil Detail, Le Corbusier

Fig. 16: IVAM Exterior View

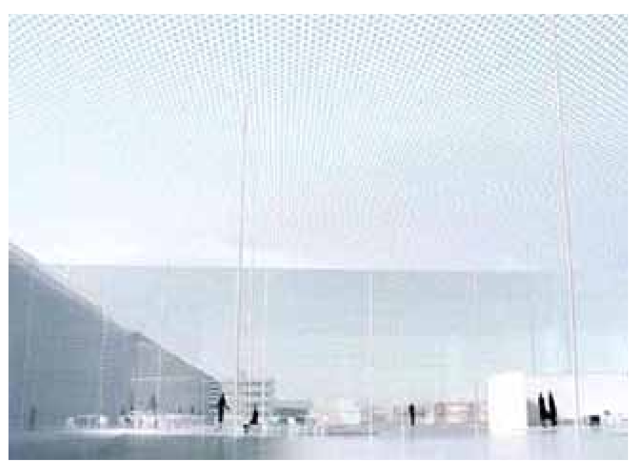
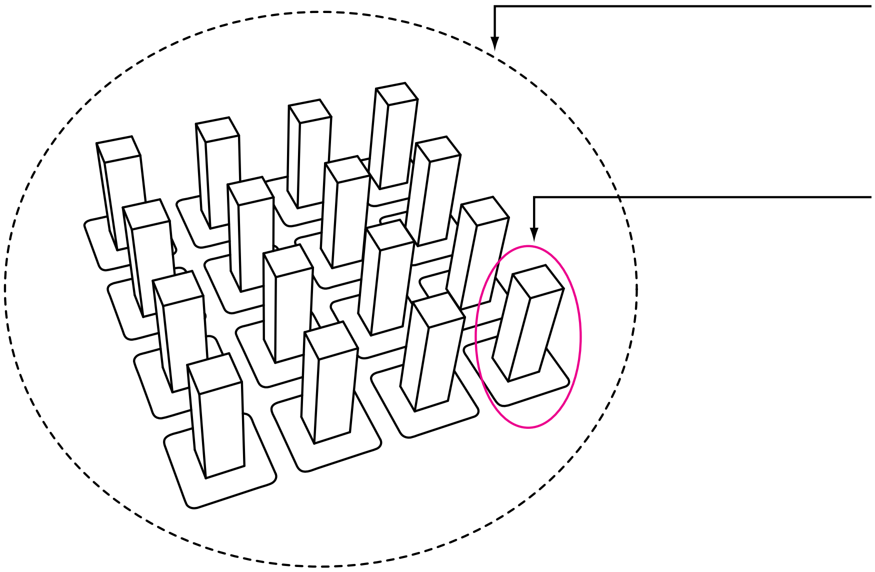


Fig. 17: IVAM Transition Space



2.2 City as Organism

Writer Herbert Girardet explains that cities over time have been viewed as ‘super organisms’, such that they are composed of many smaller working parts that feed, grow, respire and reproduce by responding to external stimuli as a whole. Herbert uses the examples of a colony of ants, termites or honey bees to describe the emergent relationship of the urban super organism. (Girardet 2006)

A successful part to whole relationship must have all of its components working in a clear, ordered, cohesive, and uncompromised fashion. For example, white blood cells In the body are specialized in performing adaptive immune functions. When functioning properly, they maintain a healthy body by neutralizing foreign antigens. If these immune cells fail to function properly in the event of an infection, the result is illness and the breakdown of biological systems.

The idea of a city of introspective buildings can be compared to that of cells in an organism or body. If all of the parts begin contributing negatively to the atmosphere, the whole will suffocate, as is exemplified by the current ‘junkspace’ condition of our air from building and vehicular emissions. Some examples of major cities already suffocating from this condition include; Bangkok, Los Angeles, and Linfen (China), which are a few of many global cities lacking in carbon-absorptive surfaces, generating heat islands, consequently creating micro climates.

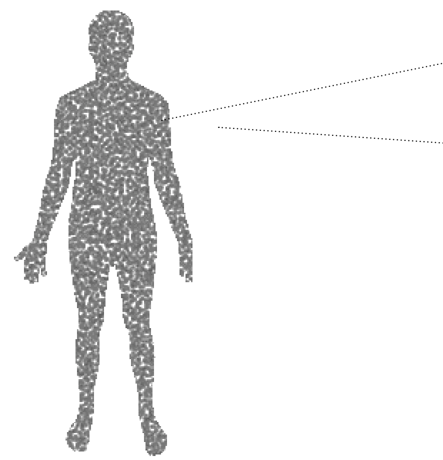


Fig. 18

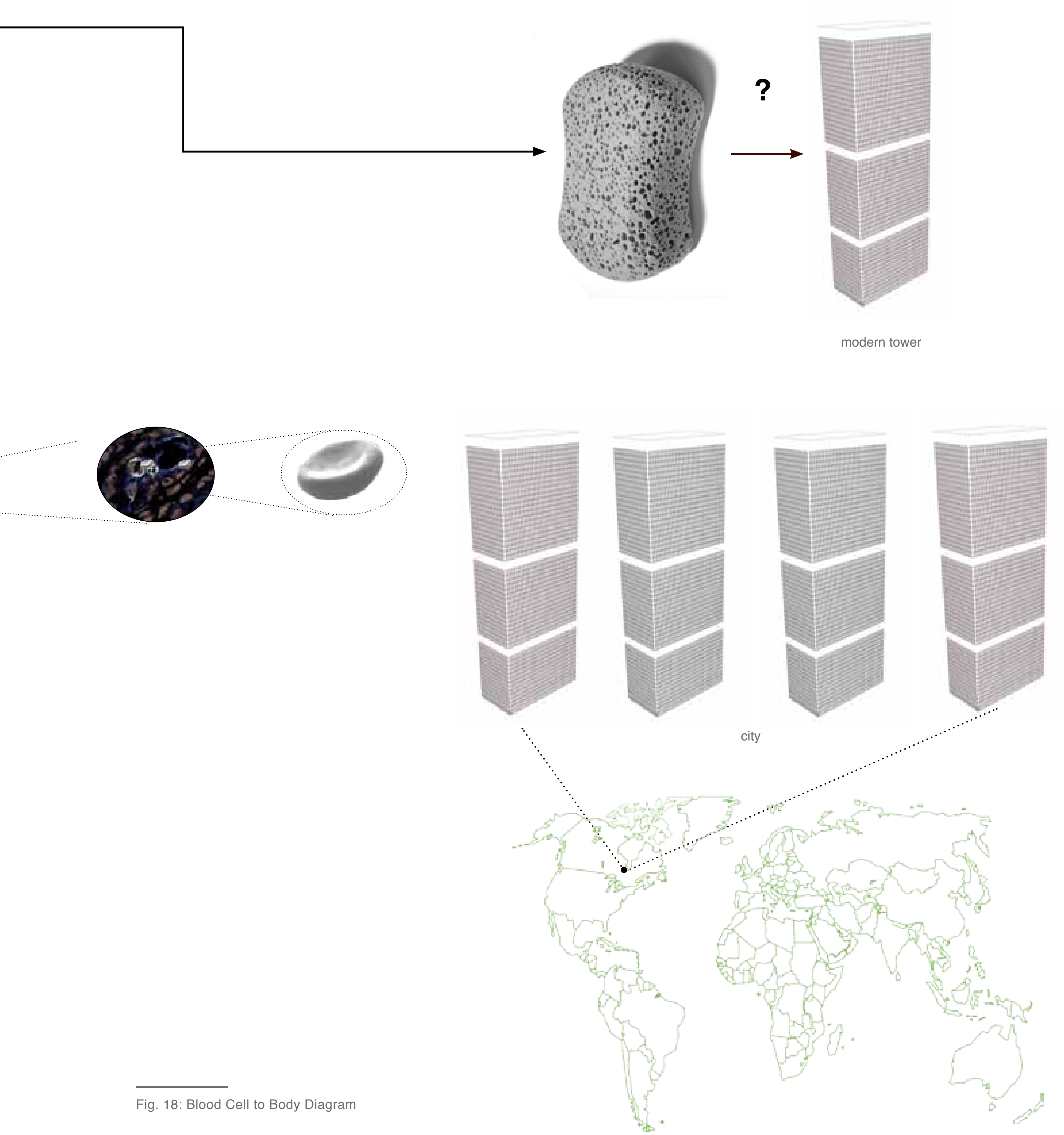


Fig. 18: Blood Cell to Body Diagram

Fig. 19: Part to Whole Relationship Diagram
(whole page)

Fig. 20: Collage of Polluted Cities

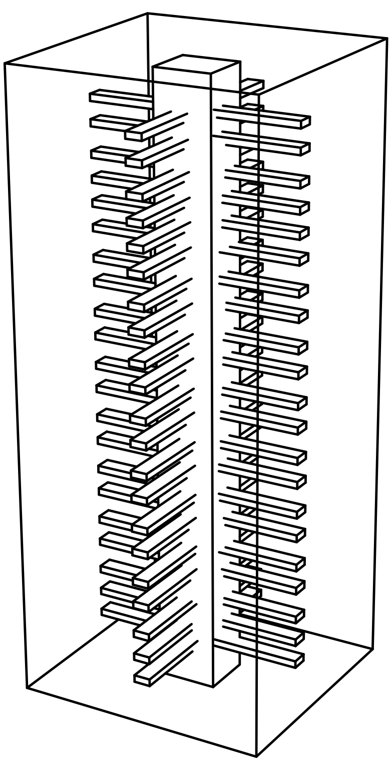
Shanghai

Cairo

Dubai

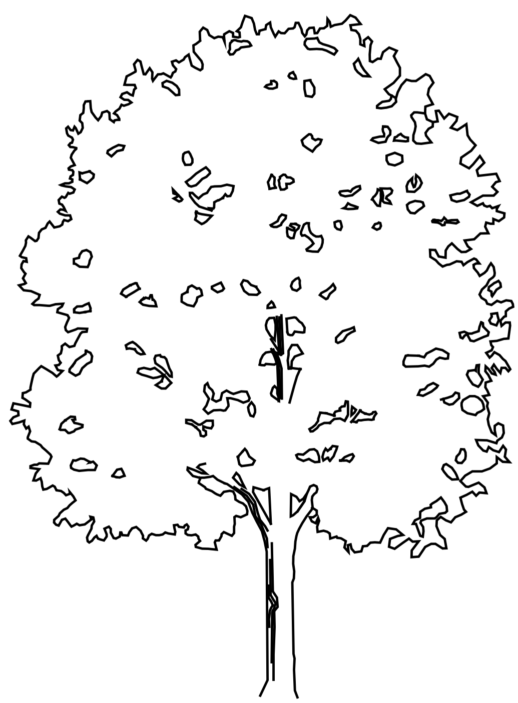
Philidelphia

In order to evaluate a new relationship between breather and atmosphere, we need to understand our main means of life support for the 21st century...



Artificial Breathing Mechanism

Fig. 21: Potential Breathing for The 21st Century



Natural Breathing Mechanism

Fig. 22

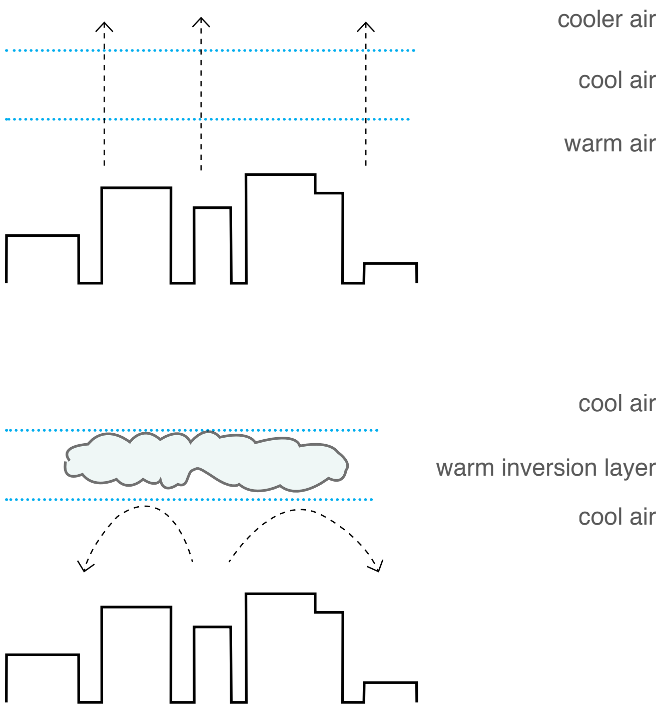


Fig. 23: Principals of air inversion; smog generation

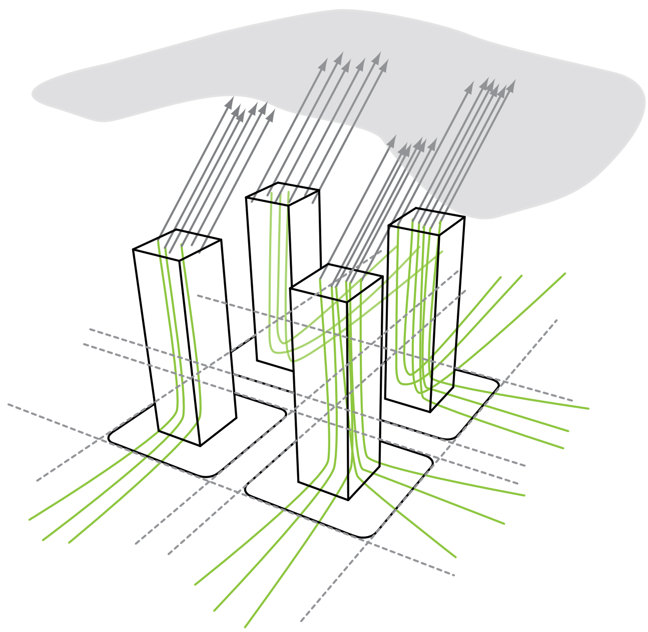


Fig. 24: Building emissions remain trapped due to air inversion

2.3 Pollution Sinks

Carbon sinks are perhaps the most logical preliminary step in addressing the problem of excessive pollution of the urban atmosphere. Buildings produce 49% of all carbon emissions, (Mazria 2011) which is rising at an average of 2.7%/year due to the continuous development of the built environment. (Mayer 2010, p. 246)

A carbon sink is a natural storage system for airborne carbon, such as a large body of water, or a large mass of trees which process carbon through photosynthesis. (Wagner 2006) The breathing pores on plant leaves or algae in bodies of water are responsible for absorbing C02 and metabolizing it into positive by-products for the environment. Ideally, placing more plants in a polluted urban environment might be a positive application to reduce the toxic, stagnant air levels. A city full of static buildings could act as a canvas for this absorption. Recently, applications of transforming inept façades into man-made carbon sinks have been a dominant topic in the field of architecture and urban design. This concept is evident in the works of Patrick Blanc (Fig 77) with his vertical garden applications on banal exterior walls, which not only perform as artistic expression, but as an aid to the air which surrounds it. Also, R & Sie have developed a project in Paris which generates a carbon sink by draping a lattice of glass flasks containing vegetation around a hard-surfaced residential unit. This beautiful and delicate application shades the interior while filtering the air before it enters the space.

With the rapid rise of emission levels, plants might not be able to absorb and metabolize at a rate efficient enough for their survival in the predicted future atmospheric state. Research proves that plants are showing evidence of genetic breakdowns due to increased exposure to pollution over the years, resulting in lower stomata (breathing pores) counts. (Wagner 2006) Introducing other carbon absorptive materials to integrate with plants, perhaps as a series of layers to filtrate, absorb and breakdown chemicals, (similar to a standard air filter or a gas mask) could be a method of application for addressing indoor/outdoor air.

Architects can expect future designs to be heavily influenced by these negative gases and vapors. Learning from the oversights of modernist design, architects can now rethink the existing fabric and re-interpret its systems to generate a new typology where a productive dialogue is maintained between breather and atmosphere.

Pollution is becoming a reoccurring theme in contemporary architecture, either focusing on the production of less emissions or generating methods of pollution harvesting. In the work of R & Sie it is evident that they are taking site analysis to a new level, embracing all qualities of site and atmospheric conditions in their design approach. Their proposals illustrate tones of seriousness and exaggeration, while simultaneously addressing critical problems, fusing visionary ideas with potential future technologies. In their project proposal Dusty Relief in Bangkok (Fig. 26), they have developed an electrostatic facade which collects suspended dust particles, generating a responsive skin condition. Dust is extracted from polluted city air and forms a textured layer on the exterior of the building, physically emphasizing the city's polluted air. (Ruby 2004, p.64) Furthermore, their project for the Social Textile project (Fig 29,30,31) uses weeds and the analogy of invading and spreading to generate a vision for an architecture which converges the threshold of nature and urbanity. (Gissen p.158)

Their visions blend contemporary architecture with that of nature (positive or negative) and delegate a new 'job' to architecture. Their style focuses on having architecture do something, catalyzing change and becoming an active contributing member in the urban fabric. While their architectural solutions draw awareness to existing problems of the urban atmosphere, these particular proposals do not go beyond the physical contact between building and atmosphere. Instead of focussing only on physically manifesting pollution, what if could not only be harvested but metabolized as well? Nevertheless, their concepts are fundamental in guiding the future of architectural solutions, painting a vision for future architects of the issues that are quickly affecting urban living conditions.

Fig. 25

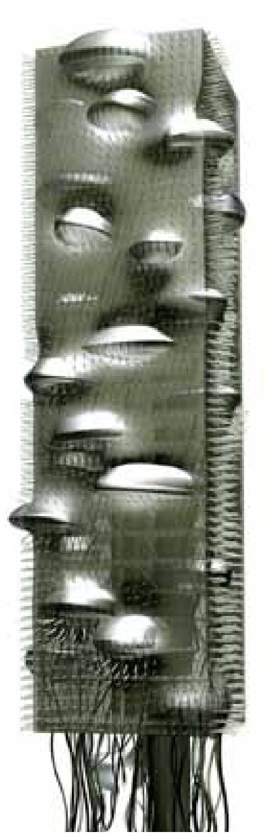


Fig. 28

Clockwise;
Figure 25 (un) Plug Tower
Figure 26 Dusty Relief
Figure 27 Dusty Relief, Dust Collection
Figure 28 (un) Plug Tower Facade: Pollution Absorbing Layers
Figure 29 Social Textile Facade Layers
Figure 30 Social Textile Facade Growth Time lapse
Figure 31 Social Textile Plan View

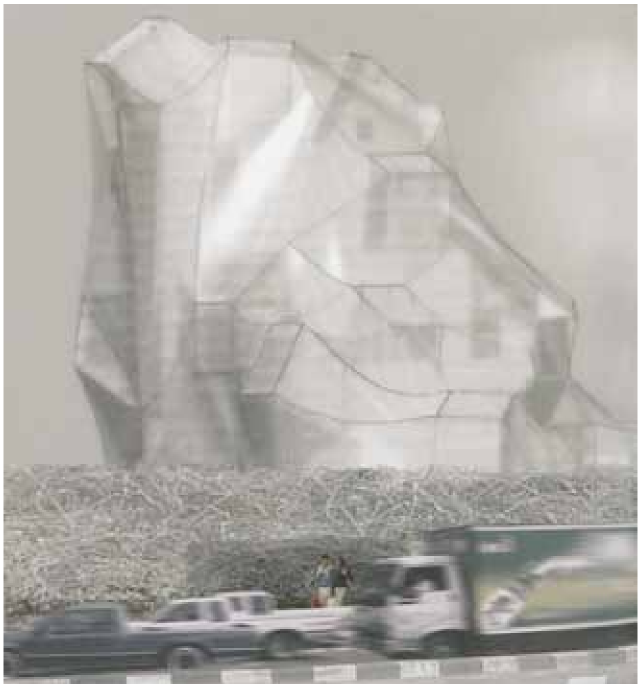


Fig. 26

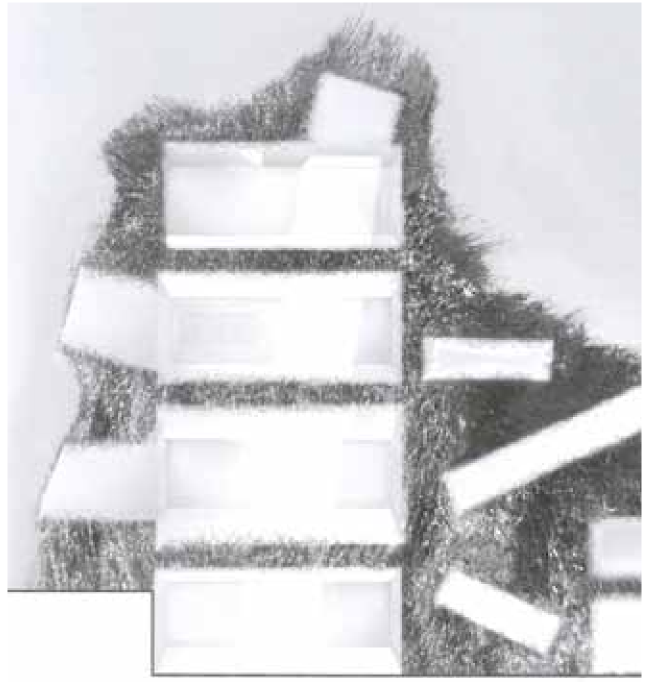


Fig. 27

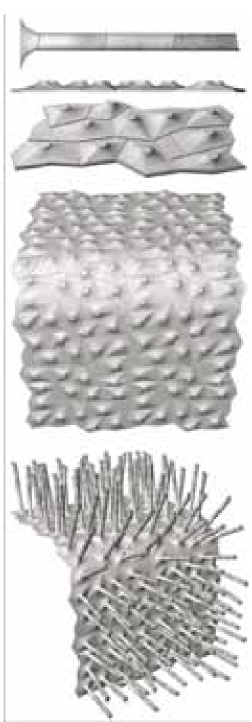


Fig. 29

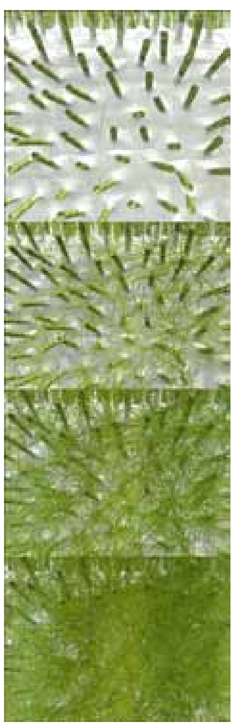


Fig. 30

Fig. 31

If we continue in the direction of total dependence on artificial breathing, (junkspace) we will be living in a sealed city interconnected with conditioned spaces, to Koolhaas the failure of architecture and depletion of the city.

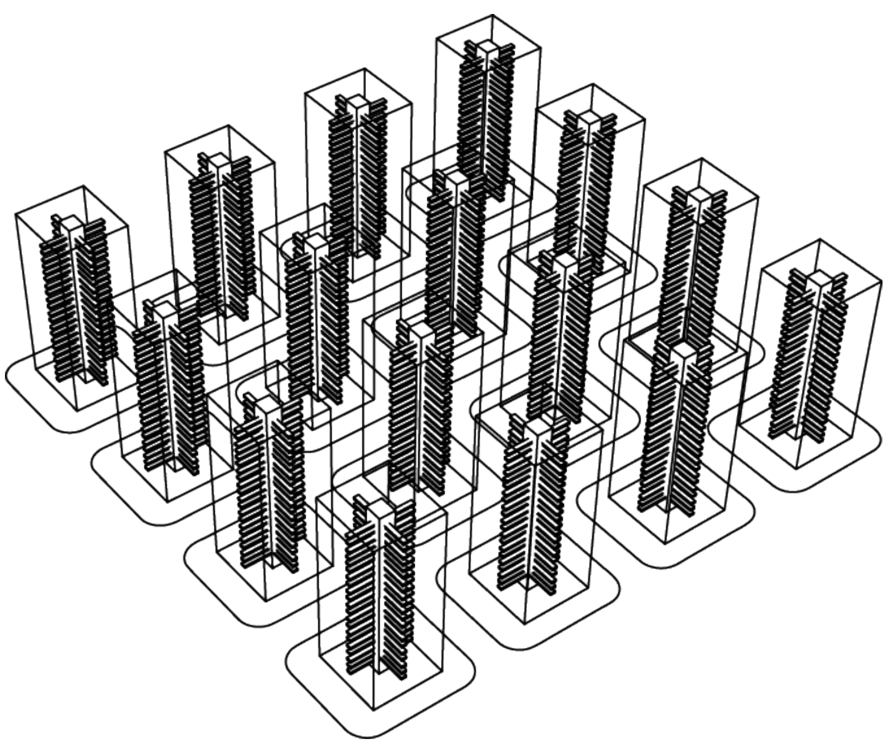
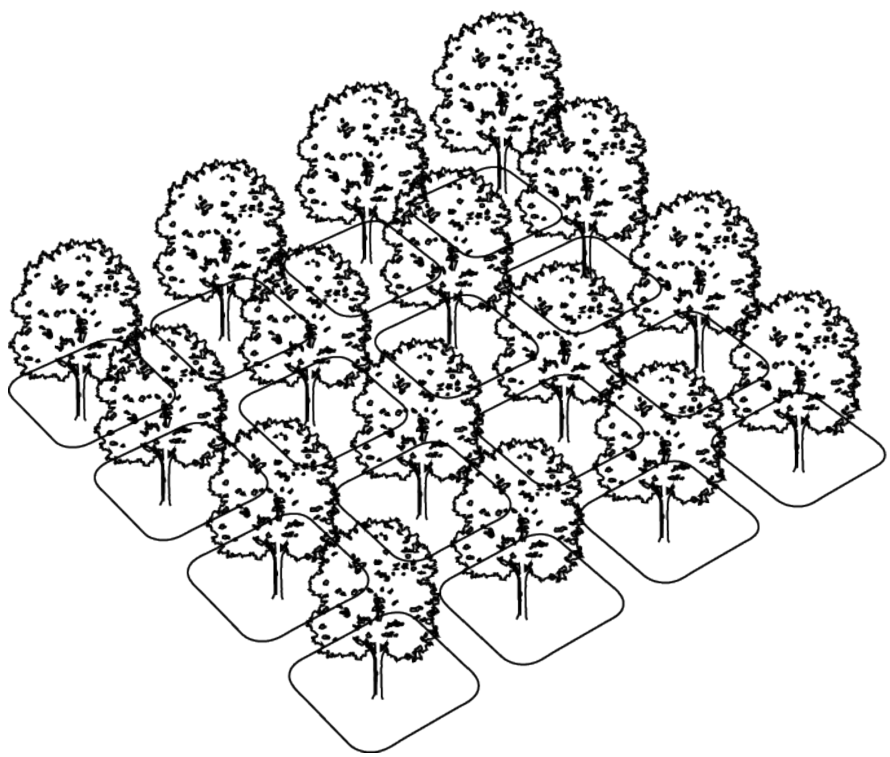


Fig. 32: Rethinking City As Carbon Sink

On the contrary, if we populate cities with natural breathing apparatuses, cities could transform into carbon sinks themselves.



03

Architecture *and* User

The dialogue between architecture and user has been constantly evolving since the 1950s. This dialogue, a study between the conversation (action and response) between user and object initially began with studies of cybernetics, analyzing potentials of regulatory systems and technology. In the 1960‘s Gordon Pask, a cybernetics researcher influenced the field of architecture with his invention of a ‘ machine intelligence paradigm ’ called The Conversation Theory. (Negroponte 1975) This theory was a study of the dialogue between human and machine focusing on there being a ‘ knower ’ resulting in an output of a kinetic or dynamic response. (Spiller 2008, p.11) Nicholas Negroponte, a computer scientist who was influenced by this research, developed ‘The Architecture Machine’ in 1974. (Negroponte 1957, p. 157) This machine was a computer designed to aid the evolution of architecture, with a dialogue between processing commands as inputs and producing drawings as outputs. Pask argued through his research that “intelligence is a property that is ascribed by an external observer to a conversation between participants if, and only if, their dialogue manifests understanding.” (Negroponte 1970)

By the 1990‘s, the work of Pask and Negroponte had transcribed into research projects involving the dialogue between user and internet via sensors and actuators. The works of Kas Oosterhuis with ParaSITE (Fig. 35) and Lars Spuybroek with the Fresh Water Pavilion (Fig. 36),

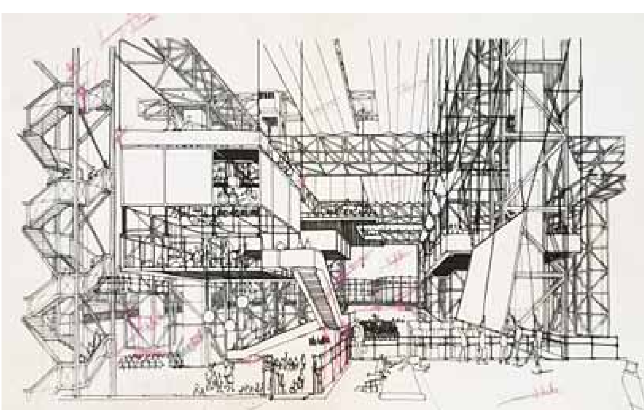


Fig. 33: Fun Palace, Cedric Price and Gordon Pask 1979

Fig. 34: Architecture Machine 1970’s, Nicholas Negroponte

Fig. 35: paraSITE 1994, Kas Oosterhuis

conceptualized a seamless boundary between user and architecture, which became palpable using digital technologies. The response by user through means of a digital interface was miraculous and a truly optimistic vision for the future of architecture. (Spiller 2008) Marc Goulthorpe (dECOI) with the Ageis Hyposurface (Fig. 37), expanded on this idea of responsiveness by physically generating a responding surface to inputs such as sound, movement, and Internet feed, outputting patterns and text.

The evolution of responsiveness stemmed from the need and passion of architects to break the mould of static masses which we inhabit and imbed our physical world with sensors awaiting connection with users. Responsive technologies have been inspiring contemporary architects to design intriguing, dynamic environments and recently have triggered a new form of architectural discourse known as performative design. This upcoming form of design understands the dialogue as a conversation between environmental data and building fabric, where technology is no longer considered just as an aesthetic and fascinating space, but where architecture has a responsible role in its context, bifurcating its former role.

Fig. 36: Freshwater Pavillion
1997, Lars Spuybroek

Fig. 37: Ageis Hyposurface
1999, Marc Goulthorpe

04

Architecture *as* User

With the concern for our diminishing climates, primarily in dense cities, there is pressure for architects to create designs with minimal impact on context. It has been mentioned that architecture has evolved and gone through periods reflecting technology of its time, whether it be methods of construction, fabrication or integrating technologies into building systems. The study of responsiveness has evolved exponentially influencing architects of the twenty first century such as Tristan D'Estree Sterk of ORAMBRA, to apply the relationship of building and environment to design using concepts of biomimicry. Today, this research has been explored in systems integration such as building skins and structures, using the environment as stimuli in a more sustainable and responsible manner. Sterk questions if buildings can function like living systems and explores how they can adapt their forms to changing weather conditions. (Sandhana 2006) One area of Sterk's research has focused on examining new approaches to building skins, paralleling the concept to the functions of muscles and bones. He has developed an integrated system called *actuated tensegrity* (Fig. 38) which pneumatically moves in the wind, adjusting itself when needed and distributing stresses from wind loads. He argues that this method is more sustainable due to lightweight material and structural composition, reducing energy consumption during construction. (Sandhana 2006) While Sterk is currently designing these revolutionary towers for the future of Chicago, his ideas are focused on a larger, more complex scale. The concern for the future of the built environment in these cities are the sites where projects will be located, for designing new towers requires demolishing old ones in some cases. Sterks' concept is promising and might be more sustainable if he were to apply his design by symbiotically attaching it to existing buildings and infrastructure, or integrating his concept with existing structures. New architecture will have to involve re-thinking the old, not assuming clean-slate sites as previously done in the modern era.

Fig. 38: Actuated Tensegrity Model, Tristan D'Estree Sterk

4.1 Performative Design

Professor and chair of integrated design at the University of Calgary, Branko Kolarevic researches the emerging practice of performative architecture, directing his studies to the impact of building performance on climate and focusing on contextual information and simulation as a future design strategy. (Kalorevic 2005) Although not particularly defined, performative architecture takes many aspects of context into consideration, varying through projects. Referring to spatial, social, cultural or technical, his philosophies essentially are summarized by the relationship of geometry (form) and contextual analysis. (Kalorevic 2005) Many contemporary projects have used performative techniques in sculpting designs with contextual data, extracting different benefits for different design strategies.

Projects such as Foster and Partners City Hall design in London England, used performative techniques to formally sculpt the buildings exterior with objectives of avoiding direct solar penetration into the interior environment. This method of design will reduce cooling loads throughout the warmer months and in turn will emit less pollution. (Fig. 39) In contrast, the FabLab Solar House by IAAC (Fig. 42), has used digital performative techniques to script a language which determines the most efficient form for solar gain (Fig. 40) Their concept was to use a universal digital language that adapted to any global location. When the location input is changed, the form changes based on solar angles and accumulation for that particular global region. Therefore efficient solar reliant buildings can be generated

Fig. 39: London City Hall, Foster and Partners

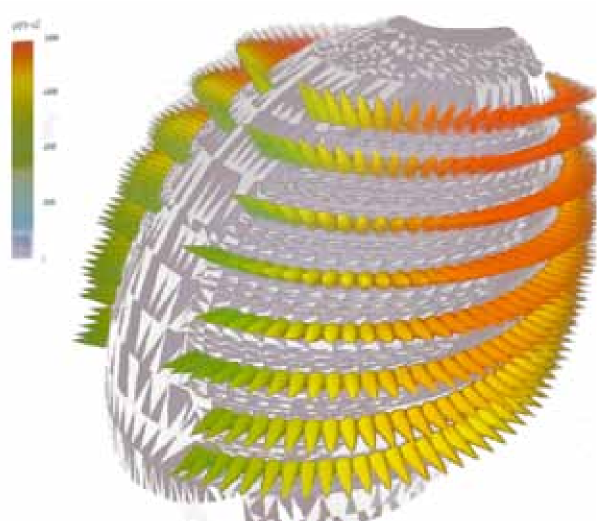


Fig. 40: London City Hall Solar Study

for many different global locations using one script. (Fig. 41)

While both of these examples are positive progressions towards responsible design strategies, both are lacking in real-time responsiveness (continuous conversation with context) such as the work by D'Estree Sterk. Once their sites are analyzed and relationships to context are extracted, buildings are modelled, fabricated and built, however still remaining as static entities, only being able to respond to one particular stimuli/factor for which it was designed. Though these methods of performative design are successful in determining proper orientation, angle, locations of fenestrations or perforations, the concept needs to be integrated with responsive technology to generate real-time conversation for maximum efficiency.

Another method of performative design can be understood as biotechnical, as defined by William Bahan, (elaborating on the work in 1939 of Frederick Kiesler), understanding buildings as participants and ' living ' systems of the biosphere. (Kolarevic, p. 58) In order to understand a building as a living system, one must understand the composition of a living system and how it communicates with its environment. For example, leaves are structurally composed of networks of cells. These cells individually respond at the micro scale, absorbing C02 and sunlight, processing and expelling oxygen and complex sugar, all while maintaining a constant real-time communication with its external context. Architecturally speaking, this method of cellular networks applied to buildings can perhaps generate a more productive and efficient system. The project Adaptive

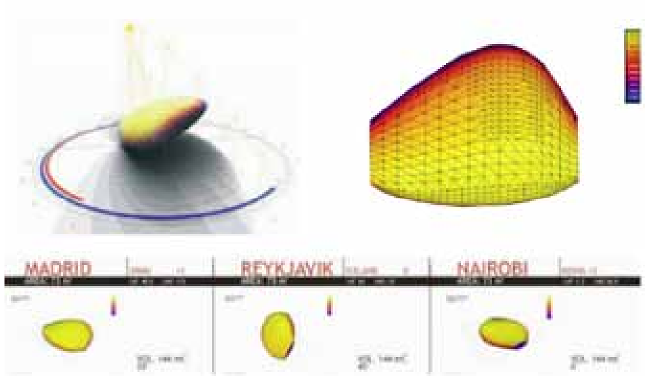


Fig. 41: Fablab House Solar Study, IAAC

Fig. 42: Fablab House, IAAC

Pneus by Mehran Gharleghi & Amin Sadeghy from the Architectural Association, attempts to incorporate this similar strategy using real-time behavior, through a component based system which responds to wind and sun (stimuli). The design of the components have resulted in generating a porous structure with operable flaps integrated within it.(Fig. 43) This system was generated by digitally analyzing wind flows (Fig. 44) and solar exposure resulting in a populated surface of responsive components (membrane) which open when exposed to direct sunlight. The pressure from the solar radiation on this membrane is detected by valves (sensors), which then activate air compressors, pumping air through the pneumatic membrane opening the flaps, allowing natural ventilation to occur. This example uses technology and environmental processes (sun and wind) to stimulate the dialogue between space and atmosphere. This exploration can be a catalyst for future building skin explorations, seeking permeability.

By using basic principals of perfomative design, as illustrated from precedent the studies (specifically referring to wind and solar studies) and combining this with materials which can communicate with the local atmosphere, a breathing apparatus can begin to be defined.

The studies on the following pages explore atmospheric analysis' of an example of an urban site with a high exposure to pollution. To develop a language of communication between interior and exterior of a building, the environmental parameters must first be defined. The exploration on the following pages assist in a further understanding of what this downtown Toronto site perhaps could benefit from.

We need to redefine the threshold of modernistic architecture and begin to generate a dialogue between inside and out. This redefinition could potentially turn these static, unresponsive, hermetically sealed buildings into vehicles for creating the relationship between breather and atmosphere.

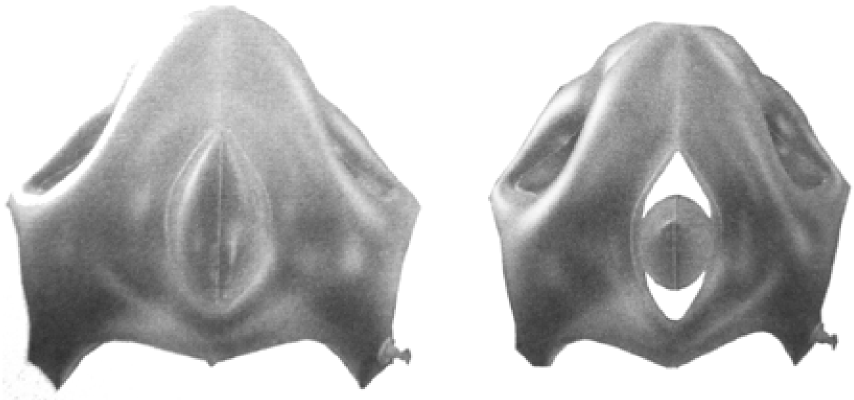


Fig. 43: Component Prototype

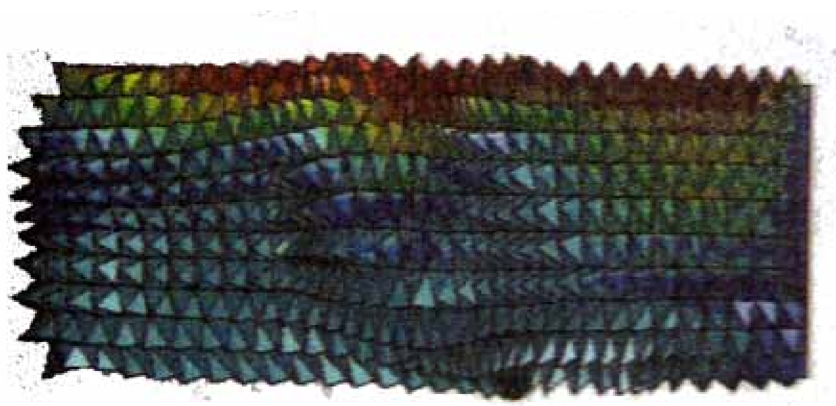


Fig. 44: CFD Analysis

Fig. 45: Potential Use As Climatic Skin

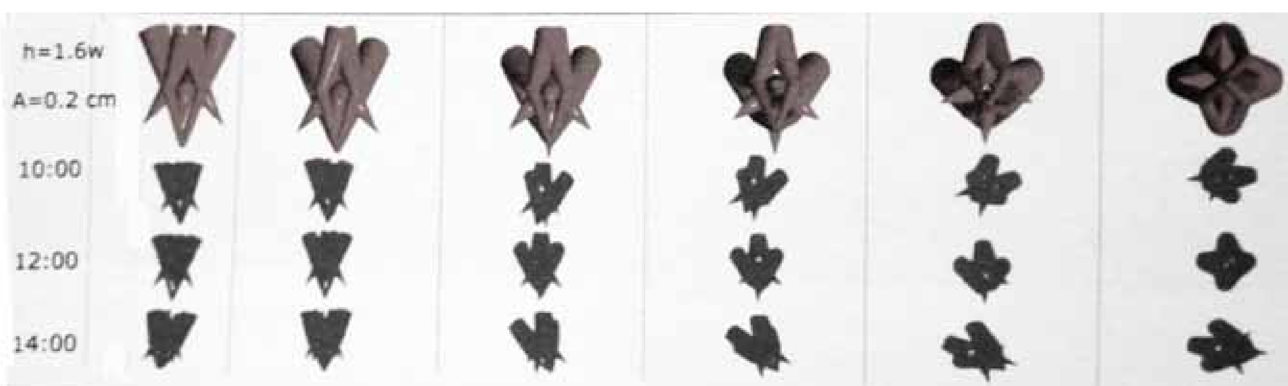
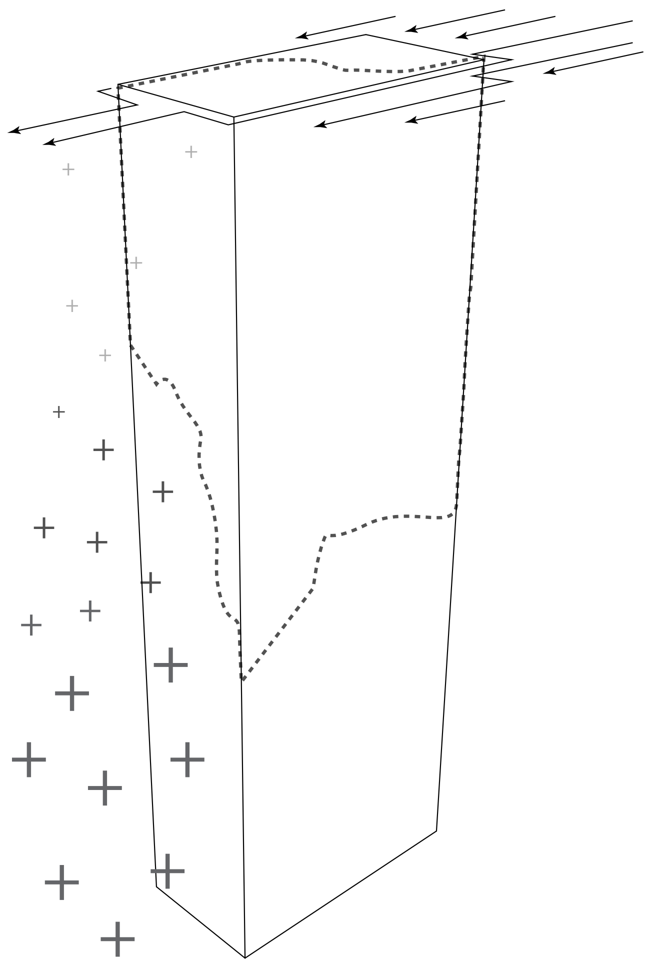


Fig. 46: Geometrical Manipulation of Components

Fig. 47: Atmosphere Accumulation Diagram



05

Defining the Local Atmosphere

To understand how to materialize the air, one must be able to understand its parameters. To design for example a pollution sink in the context of downtown Toronto, a site must first be selected. Previously mentioned, Toronto Dominion Tower by Mies Van Der Rohe is chosen due to the building's symbolic representation of the modern era.

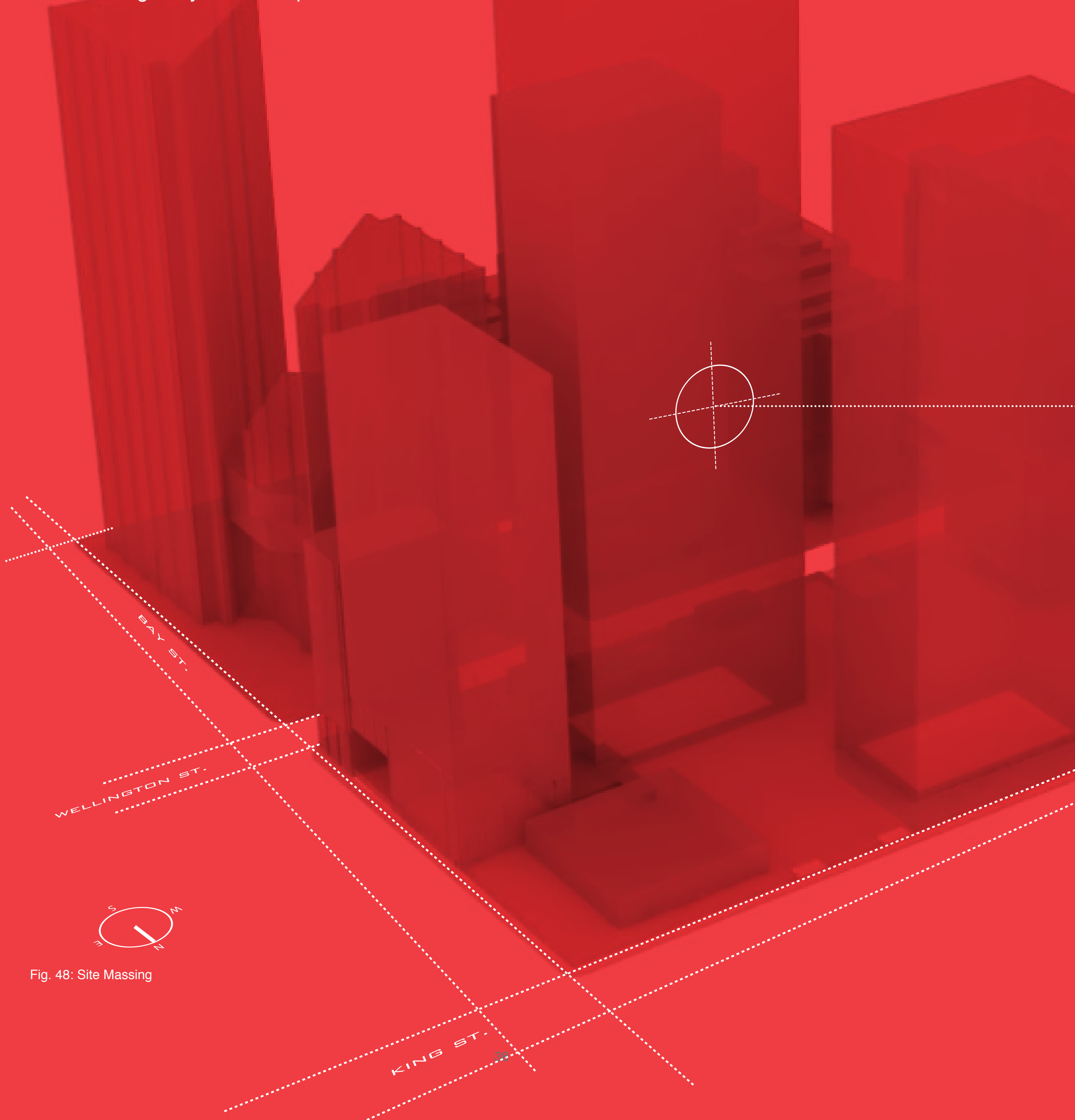


Fig. 48: Site Massing

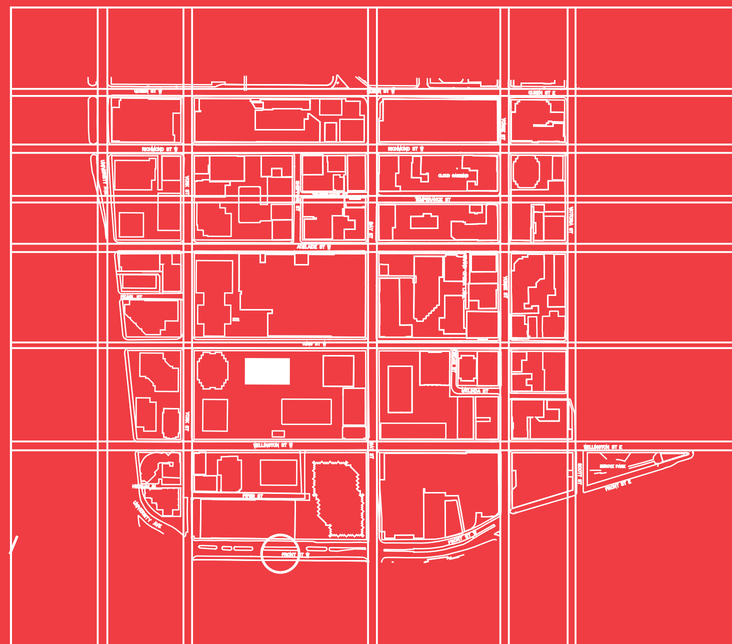
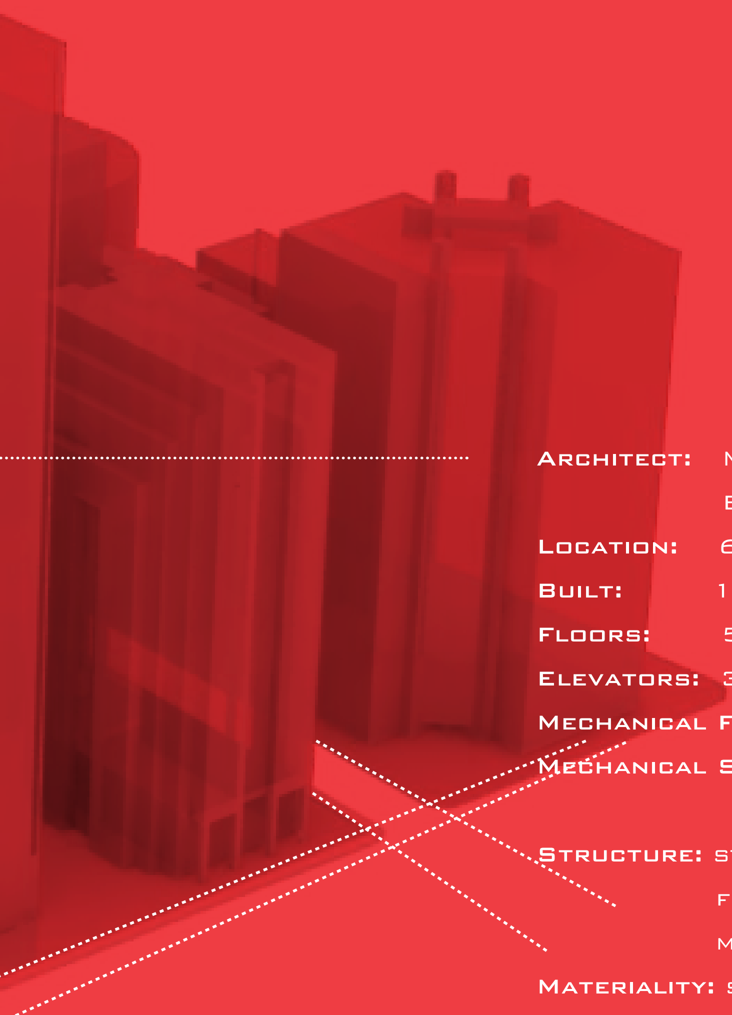


Fig. 49: Map of Downtown Toronto



Architect: Meis Van Der Rohe (design consultant)
B & H and John B. Parkin

Location: 66 Wellington Street W

Built: 1969

Floors: 56 above, 3 below grade

Elevators: 32, 2 freight and 3 shuttle

Mechanical Floors: 3

Mechanical System: force fed air, 4 intake shafts and perimeter induction heating

Structure: structural steel core and exterior framing, 140 mm concrete composite floor (64 mm topping on 76 mm corrugated decking)

Materiality: steel and glass curtain wall, single glazed, matte black finish. Glass has a solar bronze finish

5.1 Wind Analysis

The study begins by exploring the immediate impacts of atmosphere on the building. Previously mentioned, the pollution levels for Toronto are most significant in the proximity of this site. Observing typical wind patterns will assist in depicting how to make use of the wind flow for possible filtering or to depict the possible form.

Illustrated in Figure 50, predominant wind patterns are shown coming from the east, south east for approximately 7 months of the year. (remaining studies located in Appendix B). Figure 52 and 53 are summary diagrams from digital wind simulation tests (Fig. 51) which schematically illustrate two major conditions to be taken into consideration for the design of a breathing apparatus. First, there is a direct flow of wind through the center of the roof (possible filtering path) and secondly, a gradation of wind eddies occur on the western facade as the elevation decreases due to friction of wind on surrounding buildings.

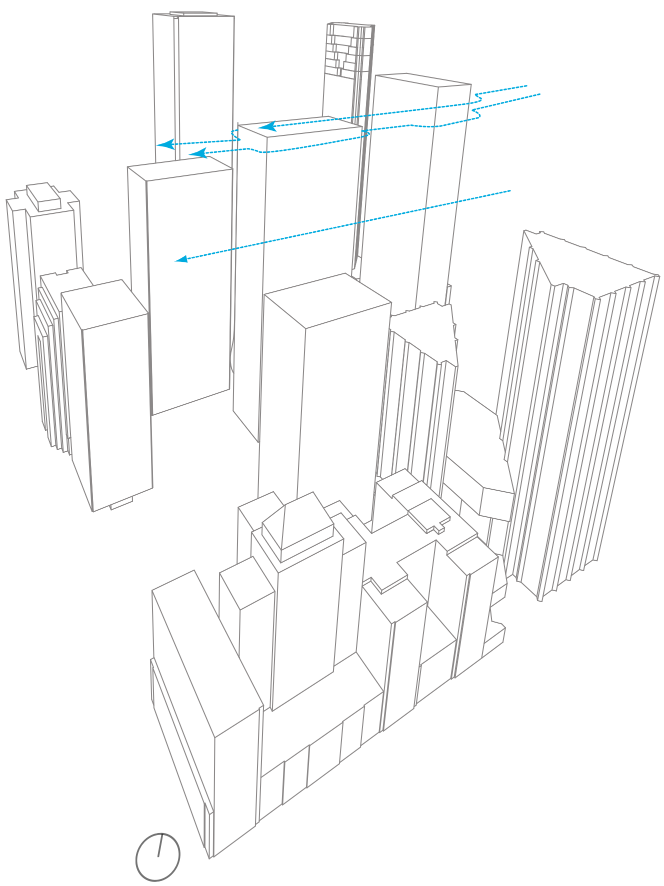


Fig. 50: Predominant wind direction, east, south east.

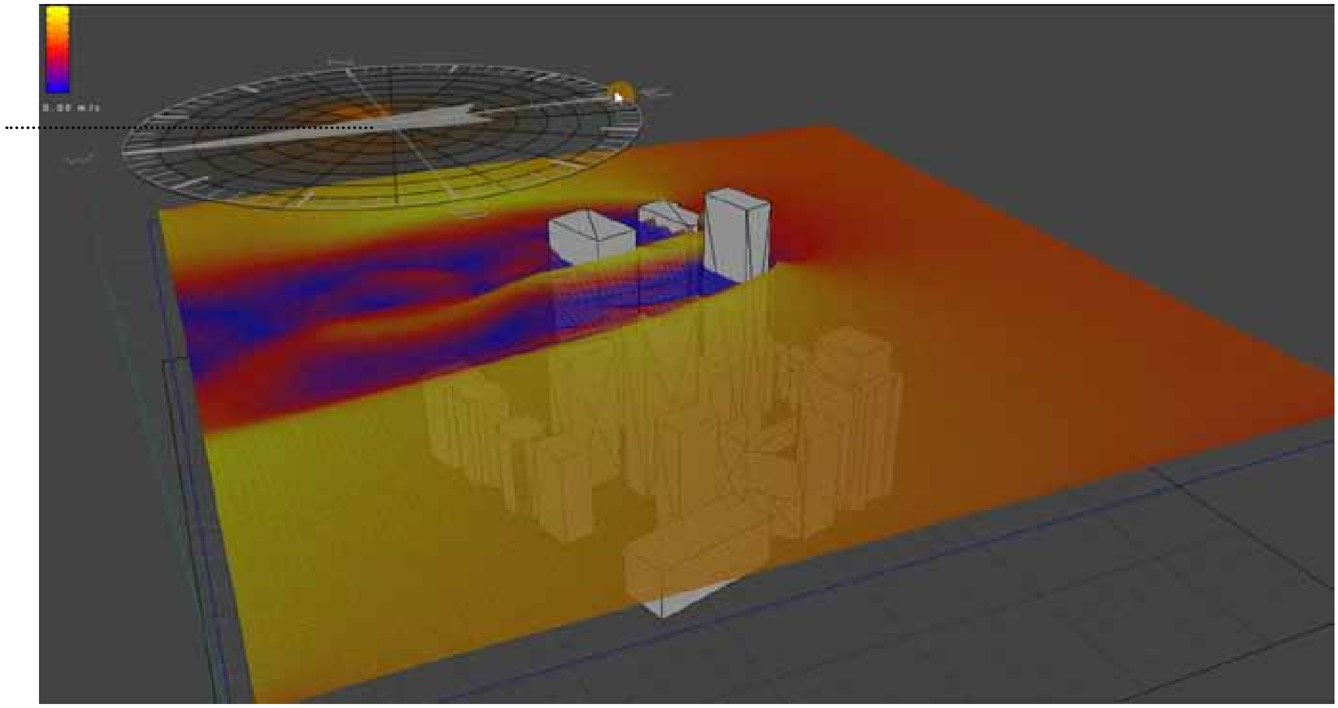


Fig. 51: Easterly Wind Flow Simulations at 220m

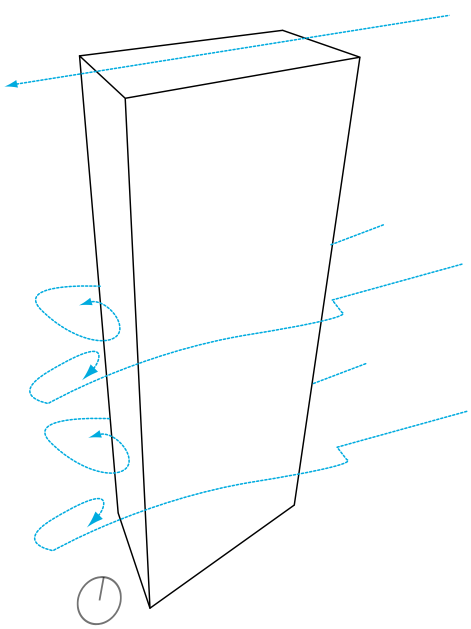


Fig. 52: Eddies caused by friction due to buildings closely placed together.

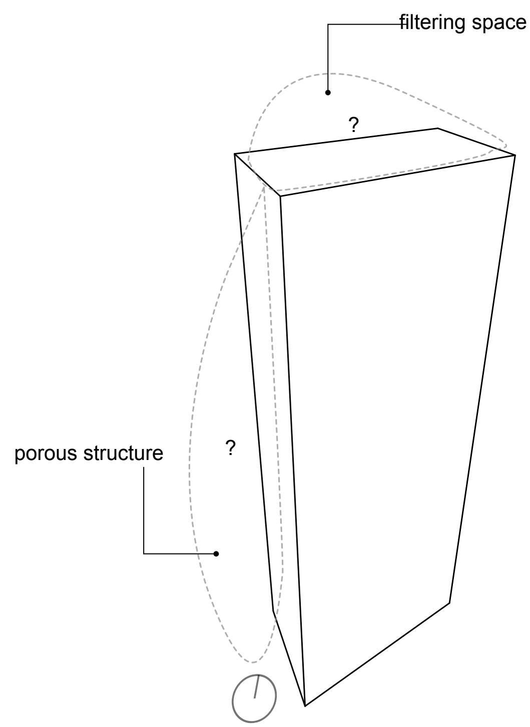


Fig. 53: Possible location for structure.

5.2 Solar Analysis

The solar analysis for the tower illustrate that the most efficient faces for possible solar use are the top, southern and western faces. Figure 54 shows the studies accumulated on a volume which begin to suggest a location for a solar-communicator. A grid was overlaid on the volume and insolar radiation was calculated using a digital solar analysis program (Autodesk Project Vasari). This grid can be seen as a series of vectors communicating with the building (Fig. 55). In order to generate a responsive language, a stimuli, user and object need to be defined. In this scenario, the building is the object, solar radiation the stimuli and the user will be the vehicle which manifests the communication. To make this happen, an exploration of materials which can mediate this communication must to occur.

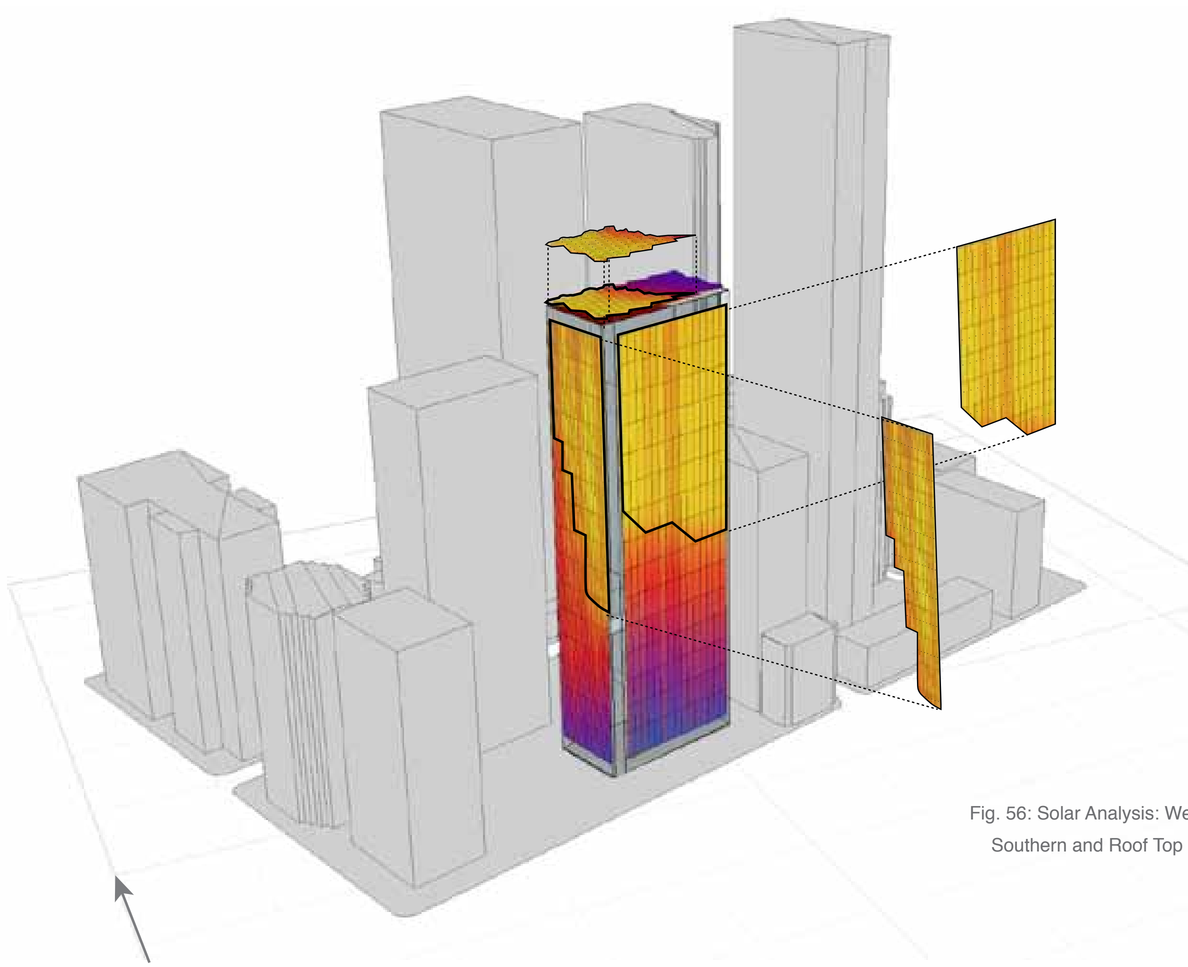


Fig. 56: Solar Analysis: Western, Southern and Roof Top Faces

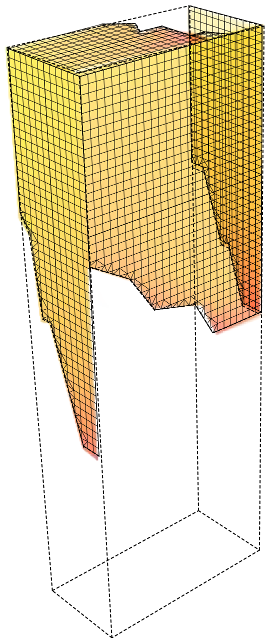


Fig. 54: Cummulative Solar Analysis

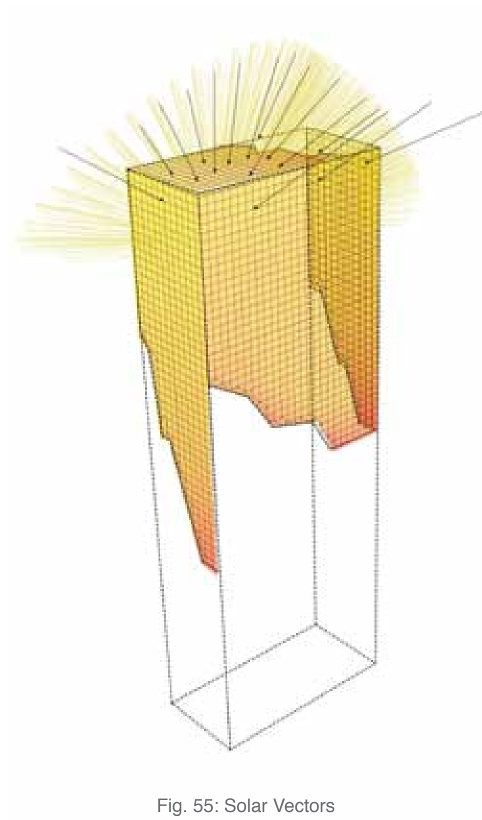


Fig. 55: Solar Vectors

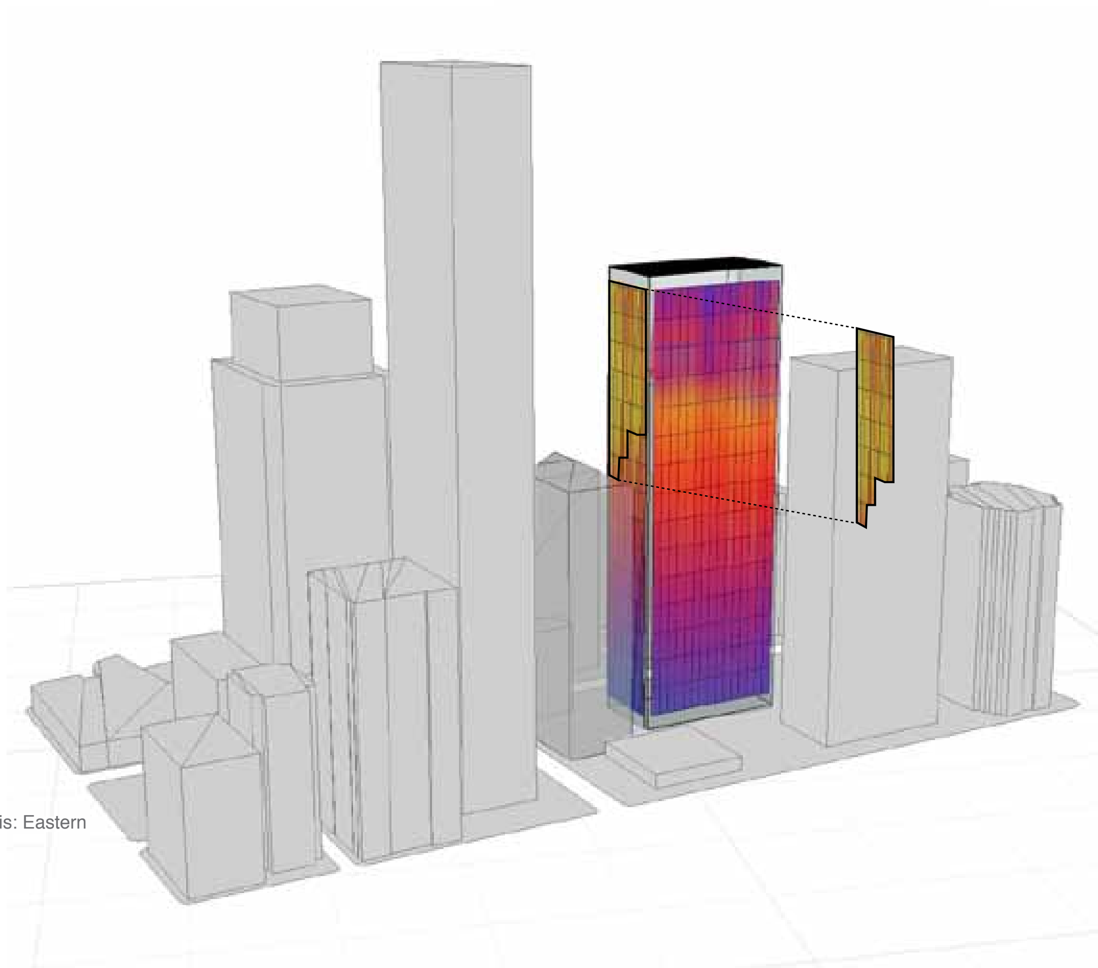


Fig. 57: Solar Analysis: Eastern Faces

5.3 Pollution Analysis

A pollution and air quality study is the final atmospheric parameter needed to define a breathing apparatus. The exterior air is a hybrid of toxins, gasses, vapors, dust and air. We are exposed to this residue on a daily basis, not realizing its hazardous effects. In order to understand how to materialize the air, one must be able to understand its parameters. To design for example a pollution sink in the context of downtown Toronto, a site (building) must first be selected. Previously mentioned, Toronto Dominion Tower by Mies Van Der Rohe is selected. An analysis of the typical atmospheric conditions are illustrated in figure 58, figure 59 and figure 60. The results dictate that the most polluted time of the day is approximately 1pm, which is when the sun is hot enough to stimulate the photochemical reaction with emissions produced during morning rush hour. (Tony Munor) When these chemicals are heated, they accelerate in toxicity, generating a 'ground ozone' condition which is tested at approximately between 7M and 15M above ground level (in the downtown location)(Tony Munor). At this level, air mixing by wind flow is not as regular which causes the air to become stagnant and extremely toxic for the street realm, which is why readings are not taken at higher altitudes. The pollutants become heavy when heated and hover due to inversion of air temperatures. (Fig. 23)

Data states that the main threat to Torontonians (and other cities) from emissions is O3 (ground-level ozone). This colorless composition of toxins includes Nitrous Oxide (No4), Carbon Dioxide (Co2), VOC's and

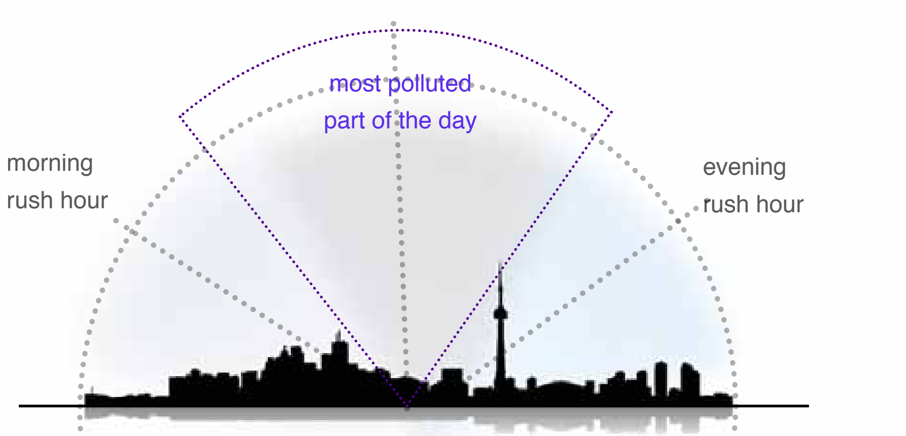


Fig. 58: Time Line of Photochemical Processing

fine particulate matter which are the key components of smog. (http://www.airqualityontario.com) In Ontario, smog is present typically on hot, sunny days from May to September between noon and early evening. (http://www.airqualityontario.com) When ground ozone levels have settled (at night), fine particulate matter remains present in the air throughout the year. Although Toronto is not as large of producer a producer of pollution as other major cities, Figure 60 illustrates that urban atmospheres are being affected by neighboring polluted cities. Air Quality Ontario states that 50% of Ontario's ground ozone and fine particulate matter are blown in from the United States.

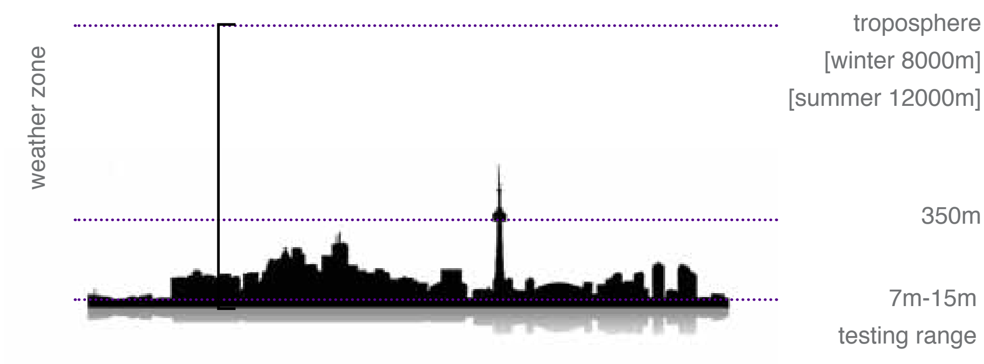


Fig. 59 Atmospheric Layers

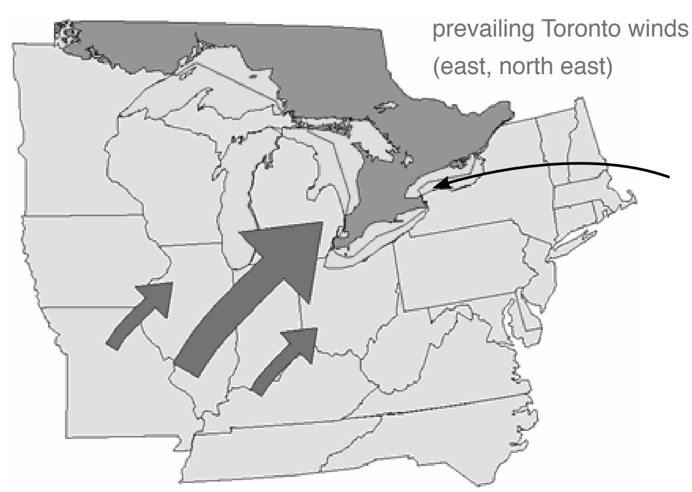


Fig. 60: Generation of Ground Ozone In Ontario, Air Quality Ontario

Figure 62 illustrates a massing diagram of the Toronto Dominion Tower, encompassed by a pollution density gradient conceptually formulated from the atmospheric research. Exact locations of density change have not yet been tested for, due to priorities of focusing on the realm of current habitation (ground level). However, it is generally understood that the higher the altitude, the less dense the particles, vapors and gasses are due to mixing from winds, flowing around neighboring buildings. This diagram therefore exemplifies the zones in which a design can address the atmosphere. It has dictated that the ground ozone level (dark purple) is the primary area for a possible carbon sink, or a pollution removal system.

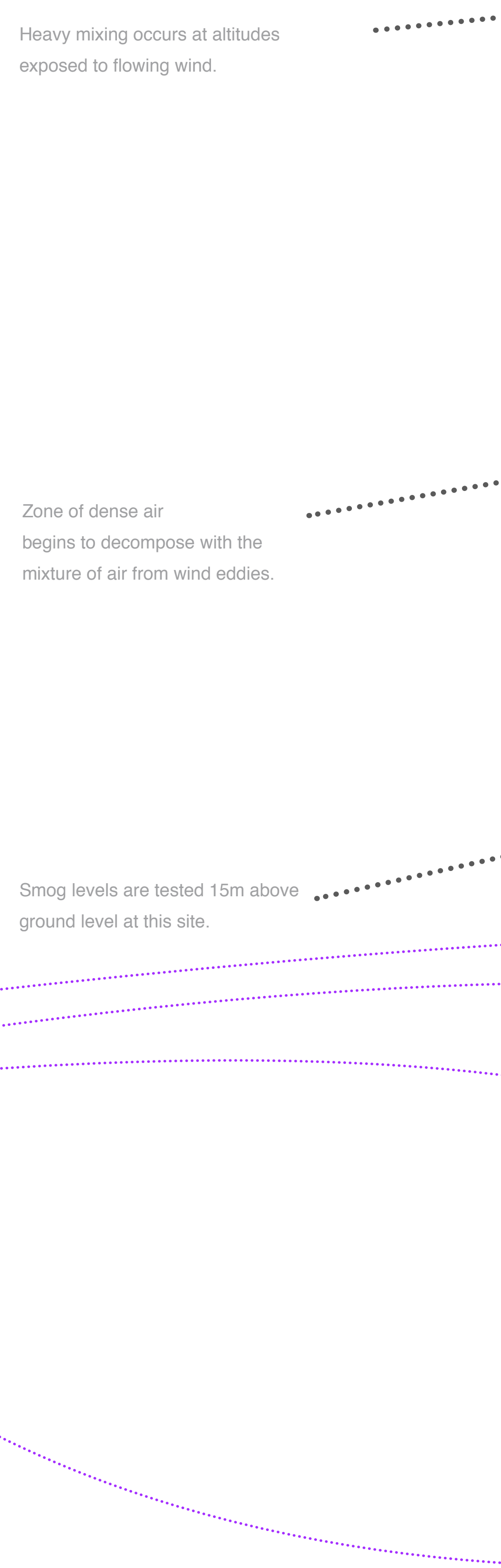


Fig. 61: Cancerous Lung

Fig. 62 Pollution Gradient Diagram

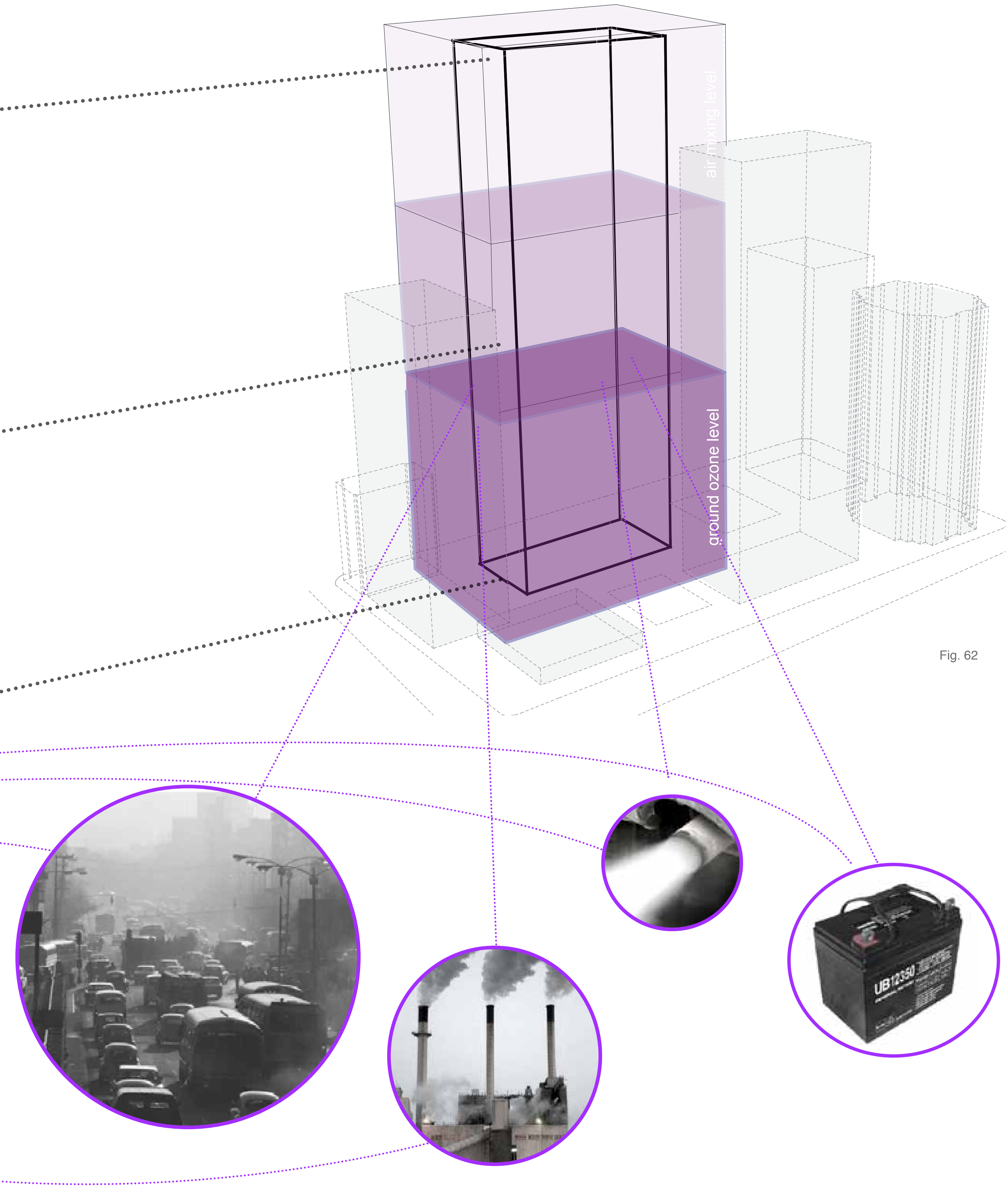


Fig. 62

06 Learning from Nature

6.1 Biomimicry

Nature has been the inspiration for technological and architectural solutions for many years. Nature has proved its survival in many different conditions (nature's extremes) due to evolutionary biological programming, such as the transformation of plant cells in response to the increasing rate of carbon dioxide (Wagner 1996). Both nature and the built environment will keep evolving, but there needs to be a conscious awareness of how the two are affecting each other. Two important concepts can be extracted from nature, that of metabolism (chemical processes) and symbiosis (fusion of two unlike organisms) which can be applied to the fabric of the urban environment. (Kurokawa 1994)

6.2 Metabolism

Metabolism, speaking architecturally, refers to a type of chemical process which results in a 'closed loop' cycle. This idea, strongly written about by William Mcdonough refers more specifically to 'eliminating the concept of waste through design'. (McDonough 2002, p. 15). He encourages designers to be aware of the larger scope of the individual product, where its inputs originate and what its outputs effect. If looking to nature for examples of metabolism, all living organisms process matter, whereby the outputs are used in other natural processes.

Architecture has evolved from relying solely on nature for energy; to buildings dependent on grid systems; to modern buildings dependent on air conditioning systems; to contemporary buildings once again dependent on nature (partially). The role of the architect in the future will be shifting to focus on a future building typology which demonstrates continuous communication and measurement between the skin, systems and context. This conscious relationship needs to involve a metabolic loop whereby emissions are significantly reduced or eliminated entirely. Current technology and natural emission-absorbing materials must be explored in order to rejuvenate urban life and regenerate city breathing.

Fig. 63: Lungs of the Earth

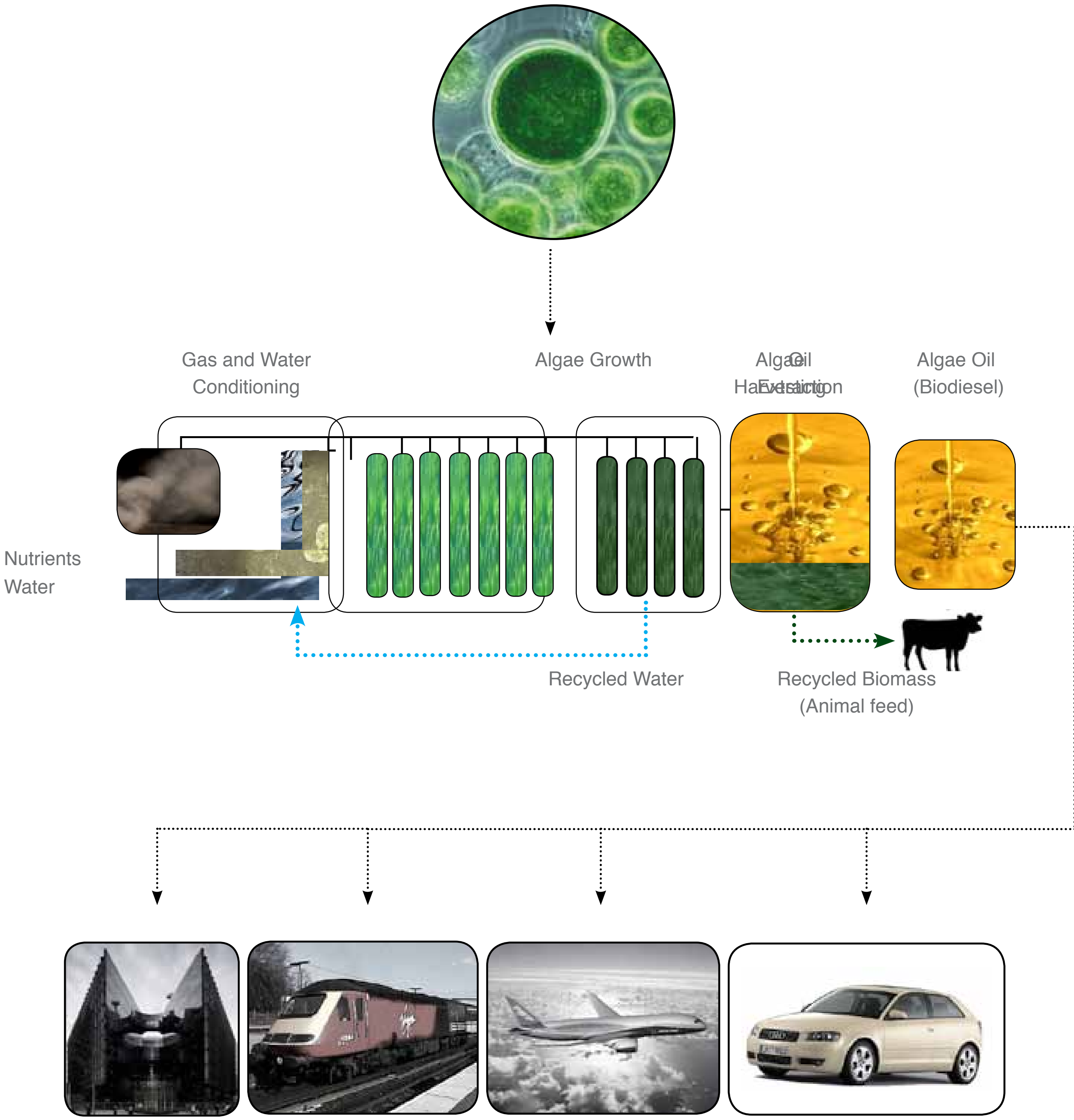


Fig. 64: Photobioreactor Cycle

6.3 Algae

Algae, a micro organism which survives on the process of photosynthesis is present in many forms in nature. Algae can be found in bodies of water in microscopic formations (as uni-cellular) organisms or larger forms such as kelp. (Science Daily 2007) Typically thriving in damp areas or bodies of water, algae converts inorganic substances such as nitrogens and phosphates into organic matter as well as non-toxic gases such as oxygen. Research has shown that algae is responsible for 73% to 87% of net global output of oxygen. (Science Daily 2007)

Algae as a metabolic material is a progressive topic in research for the future of combustible fuels. The benefits of the photobioreactor process (biodiesel fuel, oxygen and electricity) are becoming luring factors for architects and environmentalists. Although research is still in primary stages of application, many uses are being realized for buildings, planes, vehicles and power plants due to the massive amount of carbon absorption algae can withstand. (Science Daily 2007) Production of these positive outputs requires inputs of nutrients, sunlight, C02 and water, which are readily availably on most building surfaces. The system can be compact and applied to a facade, generating a new aesthetic as well as benefiting its context.

Many contemporary designs have integrated algae in a variety of scales, and reasons for use. The Flower Street Bioreactor, by Emergent Architects (Fig. 69) is an installation in a building facade where an aquarium-like condition contains an algae solution which photosynthesizes with natural light as well as with LEDs. Conceptually, they strived for a 'decontextualizing of the material and focused on the atmospheric and spatial qualities', while simultaneously harvesting biodiesel oil. (http://materialocean.com/sustainability/flower-street-bioreactor/) The Hydrogenase towers by architect Vincent Callebaut have designs stimulated by the reality of future fuel shortages. He emphasizes how algae can be used as a means of self sufficiency by powering a conceptual transport system (airships). Algae also has been found to provide electrical currents, having the ability to power lights (Fig. 66). Designed by Mike Thompson, based on research by scientists from Yanesi and Stanford University, a small electrical current is able to be drawn out during photosynthesis. (http://www.miket.co.uk/)

Fig. 65: Algae Green Loop,
Influx Studio

The mentioned algae applications resulted in a design study to explore how these methods could be combined into urban applications which not only metabolized urban exhaust (C02 in particular), but generated a dynamic outdoor urban space as well. In a sense, re-thinking the public green space.

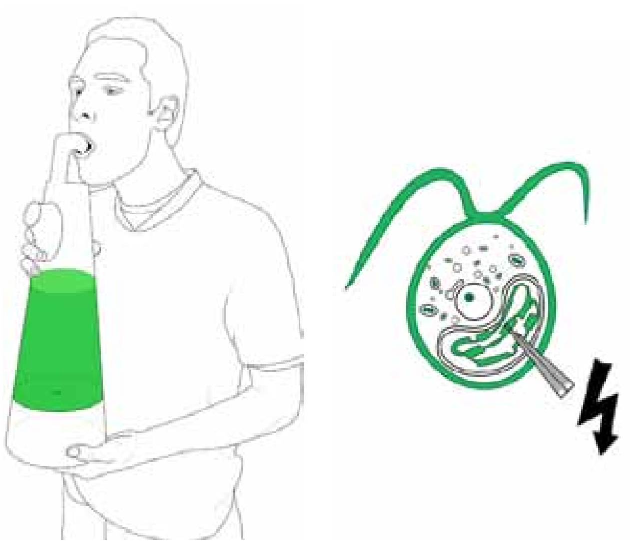


Fig. 66: Algae Lamp, Mike Thompson

Fig. 67: Algae Lamp, Mike Thompson

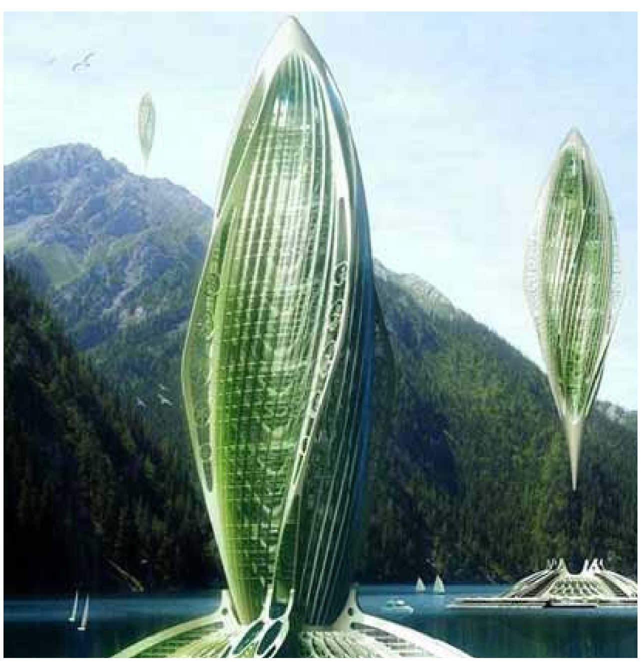
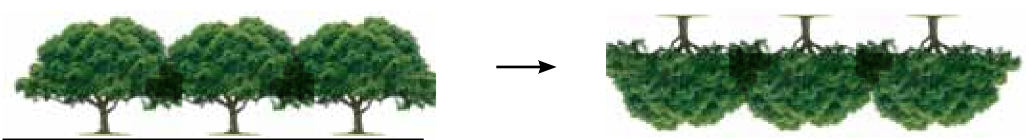


Fig. 68: Hydrogenase Tower, Vicente Callebaut

Fig. 69: Flower Street Bioreactor, by

5.3.1 Design Study: Urban Algae Ceiling

The mentioned algae applications resulted in an exploration through a design study to observe how these techniques can be applied in a polluted urban setting with minimal land availability. The outcome was a design which re-conceptualized a green space, and generated an urban carbon sink while simultaneously defining a new typology of urban space. This exercise conceptually took the idea of a forest (carbon sink) and turned it upside down, allowing the ground to be free for urban programming, ultimately generating a green ceiling.



The design was comprised of a series of expanding and contracting tubes of liquid algae solution which appeared undulated at certain points of the day, depending on harvesting rates. Each tube would respond to the sunlight and C02 exposure, and expand as the algae reproduced. The caps on top of each tube allowed for C02 absorption, and the membrane of tubes was integrated in a cable meshwork suspended between two buildings (Fig. 70). The underside of the ceiling contains LEDS imbedded in the base of each tube, generating light for evening events. The electrical current produced by the algae will power the system.

Once the tubes reach full potential (full expansion of the tube), the algae is harvested and by products (biodiesel fuel and pulp) are extracted and implemented in other city buildings and infrastructure.

The light that filters through in the daytime creates a green glow below, a space that is filtered from the sun, which creates a gathering place on hot summer days and becomes animated at night as a performance space (Fig. 75).

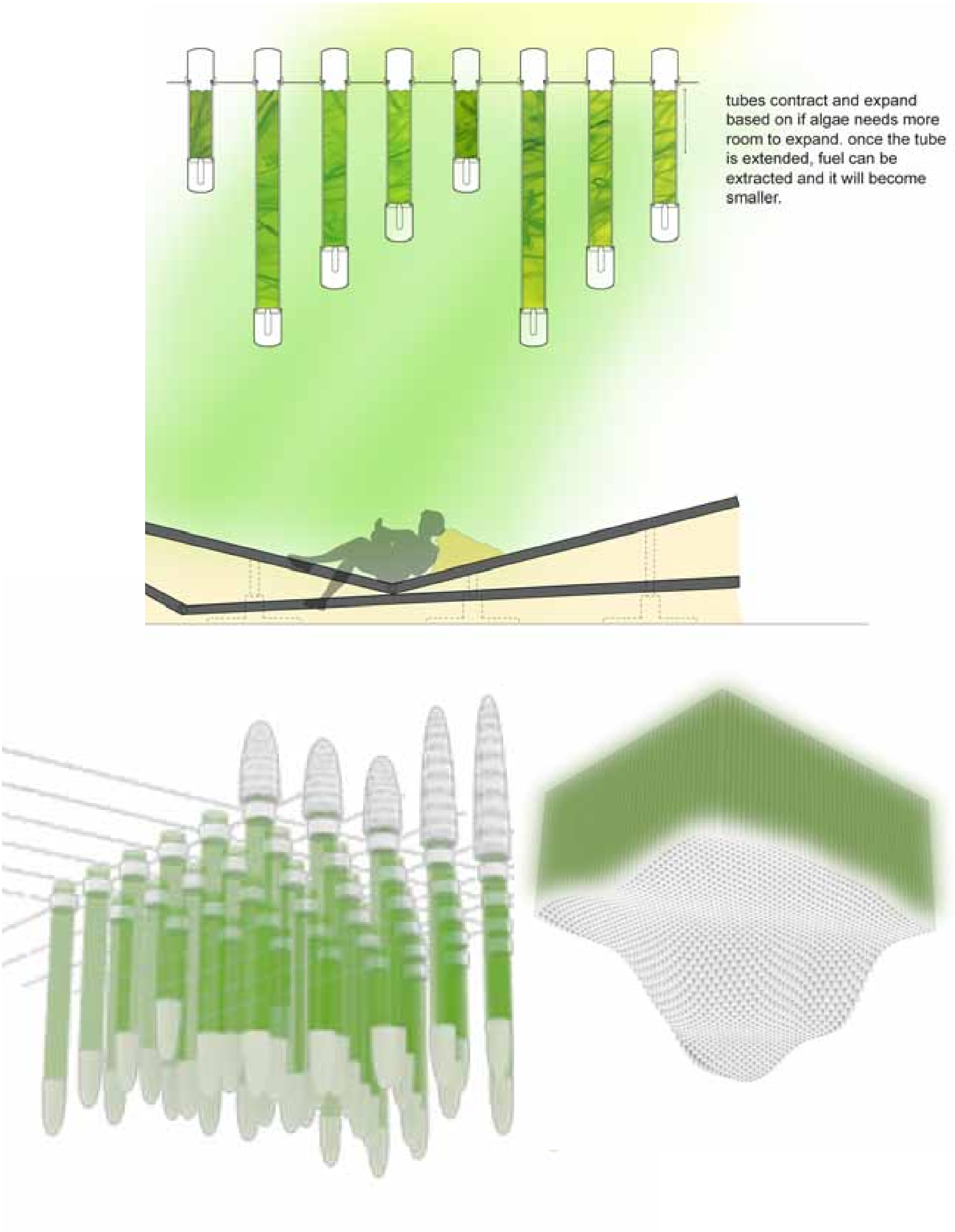


Fig. 70: Urban Algae Ceiling, Design Study

Fig. 71

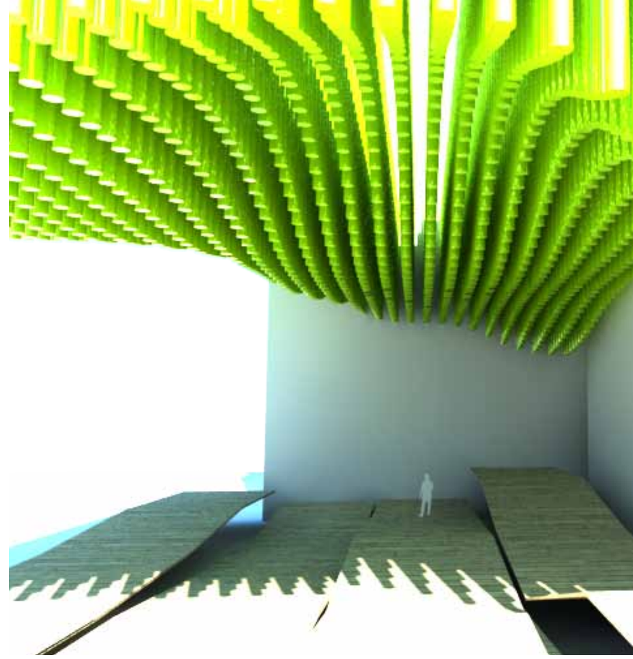


Fig. 72

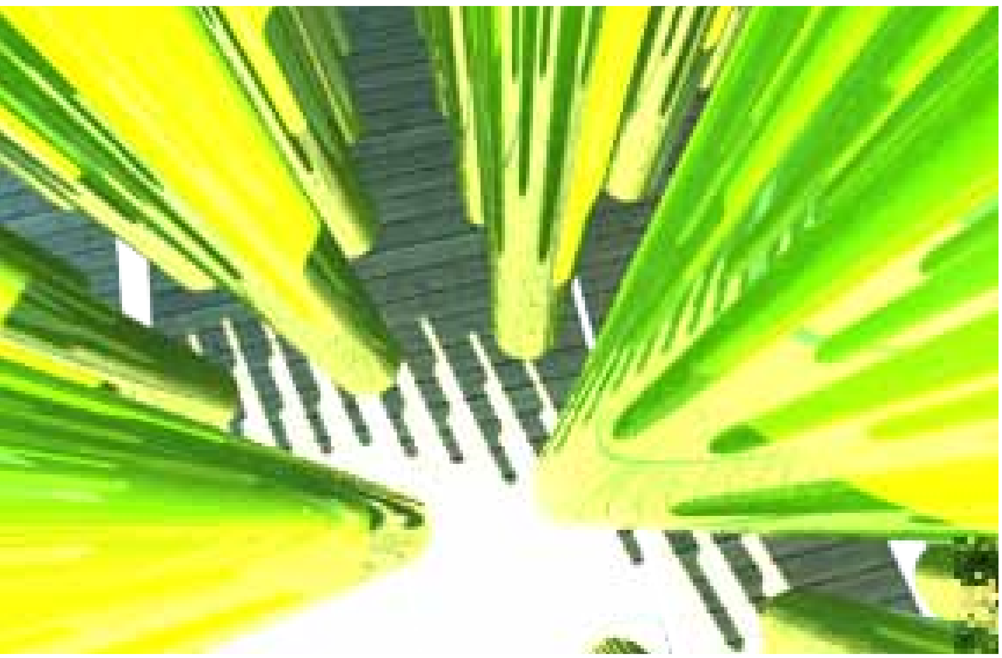


Fig. 73

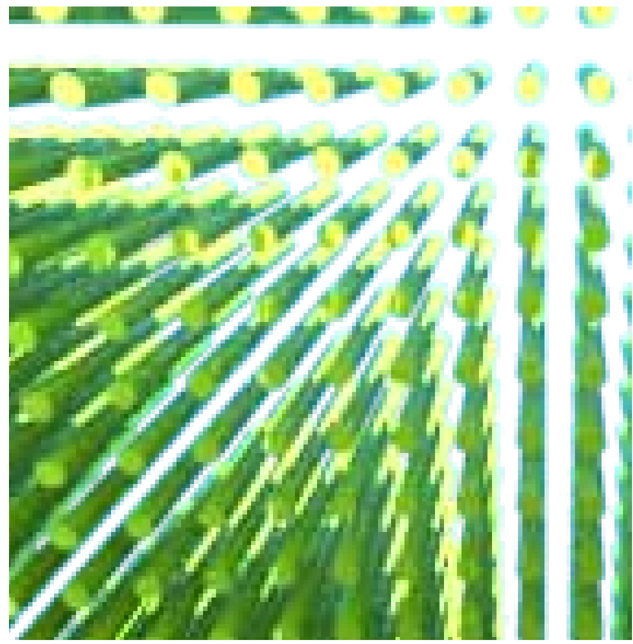


Fig. 74

Figure 71: Looking into the space from Gould Street.

Figure 72: Looking into the space from Yonge Street.

Figure 73: View looking down into the space.

Figure 74: View looking up into the sky.

Figure 75: At night, the ceiling glows and creates a dynamic performance space.

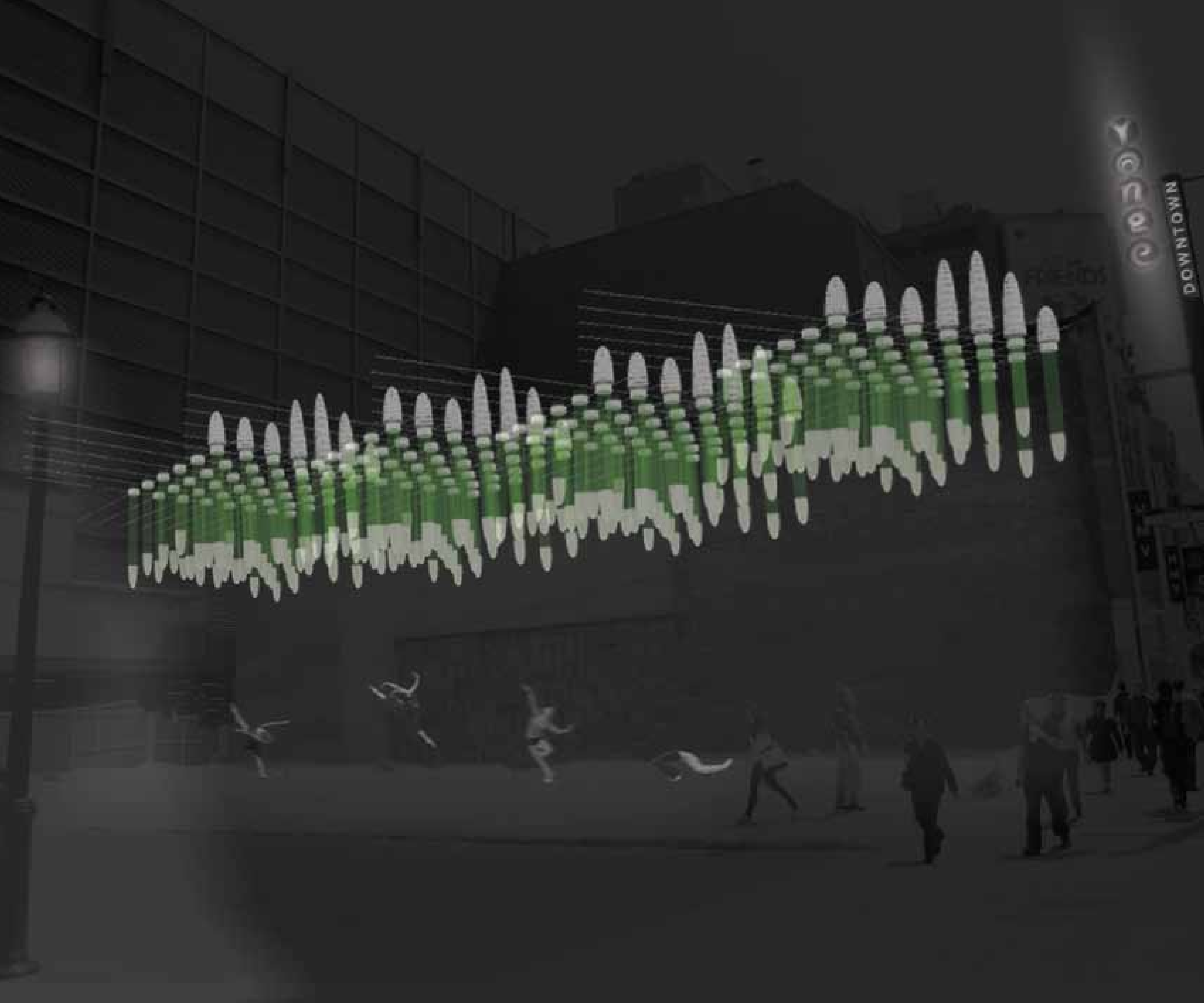


Fig. 75

6.4 Plants

Vegetation is commonly known as the most natural form of pollution absorption, providing earth with oxygen, while absorbing carbon and natures' by products (compost from the earth). Stomata are the breathing pores in plant leaves, which when opened expel moisture, oxygen and intake C02. (Wagner 1996) (Fig. 76) Research has shown that since the industrial revolution, atmospheric concentrations of C02 have been increasing at a rate which has physically impacted the evolution of the cellular formation of stomata, in a decrease in cell growth. (Science Daily 2007) When the pores are exposed in excess, the cells suffocate and shrink, causing a deformation in the next generation of species. (GENI 2007)

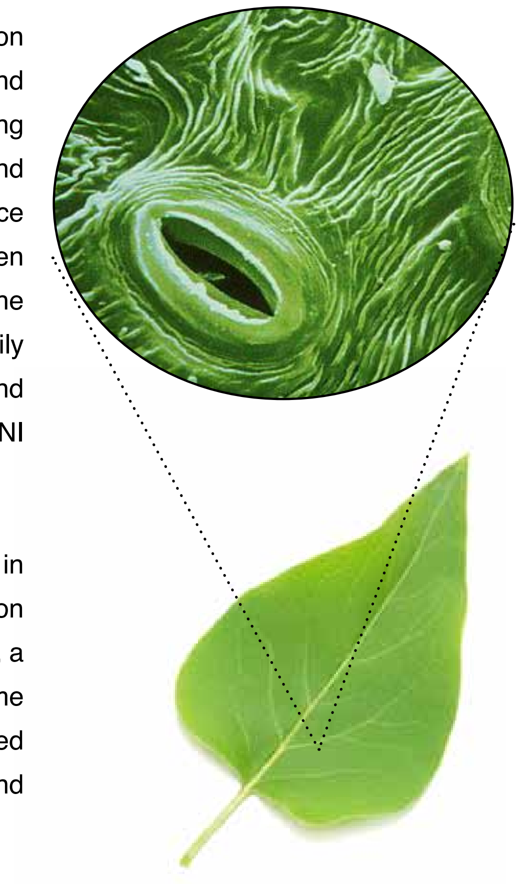


Fig. 76

Designers tend to use the concept of coating objects/buildings in vegetation, however understanding how plants are effected by pollution is important as well. It appears in some cases to be a band-aid solution, a topical layer perhaps sufficient enough for current pollution levels in some cities. For an impact in future urban life, plants will have to be integrated with other carbon-metabolizing materials in order to function properly and prosper in a toxic environment.

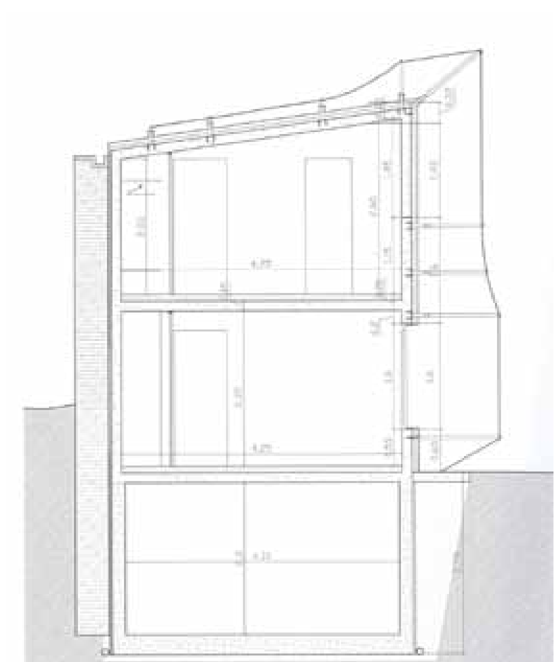


Fig. 78

Fig. 76 Stomata of a Leaf

Fig. 77 Caixa Forum Green Wall, Patrick Blanc

Fig. 78: I'mlostinparis: Section, R & Sie

Fig. 79: I'mlostinparis: Interior view, R & Sie.

Fig 80: I'mlostinparis: In between facade, R & Sie

Fig. 77

Fig. 79

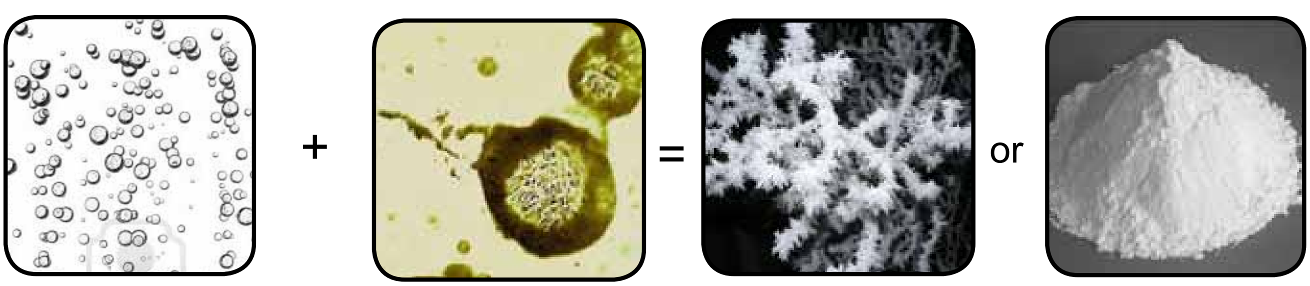
Fig. 80

6.5 Protocell

A revolutionary metabolic material that has potential to become a 21st century phenomenon as a building material, has been discovered in collaboration by Dr. Rachel Armstrong and scientists. Looking to nature for inspiration to generate an artificial process of limestone growth, protocell technology was developed, speculating that (at the nano-architecture scale) a solution of engine grease and chlorides (salts) would metabolically form into solid calcium carbonate (limestone) when exposed to C02 in a matter of days. (Devlin 2009) Although still in infant stages of development, the cells are being genetically programmed to solidify, forming a crystalized snowy coating on the surface it is applied to. This utopian idea of removing C02 is rapidly developing, or at least concepts of its use, with objectives of having the cells regenerate themselves in the near future. (Devlin 2009) Currently outputs of this material is calcium carbonate which can be ground up into a dust and re-used in other applications such as chalk, paper, and other construction materials. (Devlin 2009)

The GEOtube project, by Faulders Studio, has conceptualized a proposal for Dubai using salt as a medium for the generation of the building facade. Using similar concepts as protocell technology (solids forming from liquids), whereby the skin is composed of a hollow 'vascular system' which is gravity fed with salt water extracted from the neighboring Persian Gulf waters. Within a span of 15-30 years, the salt will crystalize on the lattice and generate a facade. (Fig. 82) The Persian Gulf has the world's highest oceanic salt content, which Faulders speculate that when the facade is in its mature state (Fig. 83) the salt could be harvested for commercial use. (http://faulders-studio.com/)

Fig. 81: Protocell Metabolizing Process (Below)



C02 | Protocell Oil | Protocell Crystals | By-Product, Calcium Carbonate

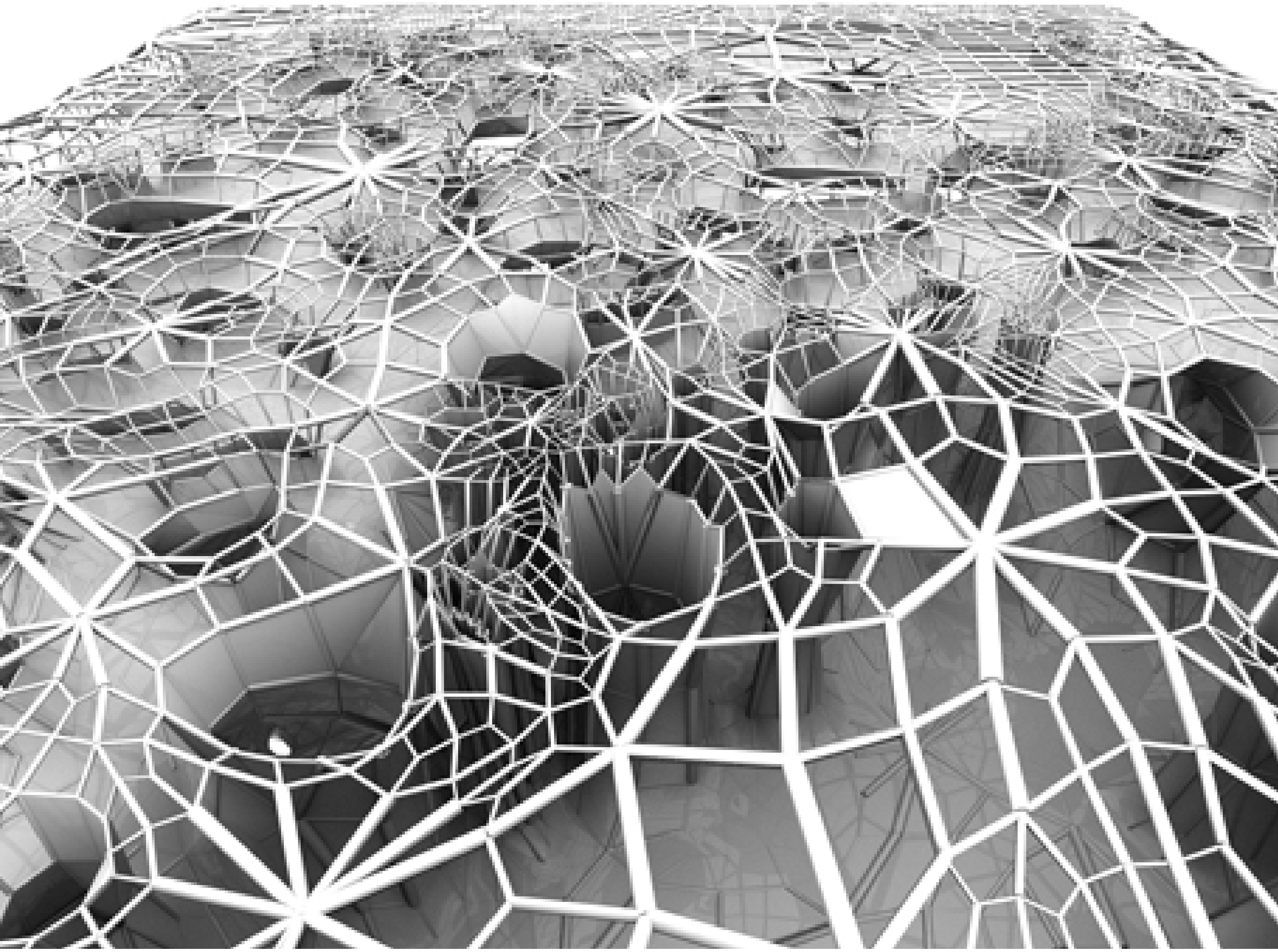


Fig. 82

Fig. 82: Geotube: Facade Capillary System, Faulders Studio

Fig. 83: Geotube: Evolution of Salt Crystallization on Facade, Faulders Studio

6.6 Symbiosis

An ecosystem is a tight web of organism interaction and dependence, which in some cases involves life-sustaining relationships between two different species. (Kurokawa) Many symbiotic relationships in nature have developed over time with a dependence on other species for survival in mutual relationships. Algae, for example is an incredible micro organism which is symbiotic with many tissue bearing organisms. Lichen, are able to occupy places of extreme drought, moisture, heat and cold due to their ability to re-synthesize themselves on other nutrient-rich surfaces (Fig. 86). (Kurokawa 1994 p. 49) Many species of coral and the tridacna (large sea clam) (Fig. 85) also benefit from algae's ability to provide food for its symbiont via photosynthesis. (Kurokawa 1994 p. 31)

While many instances of symbiosis occur in nature the idea of combining two separate species to generate a 'better' one can be translated into the language of urban architecture.

6.7 Architectural Symbiosis

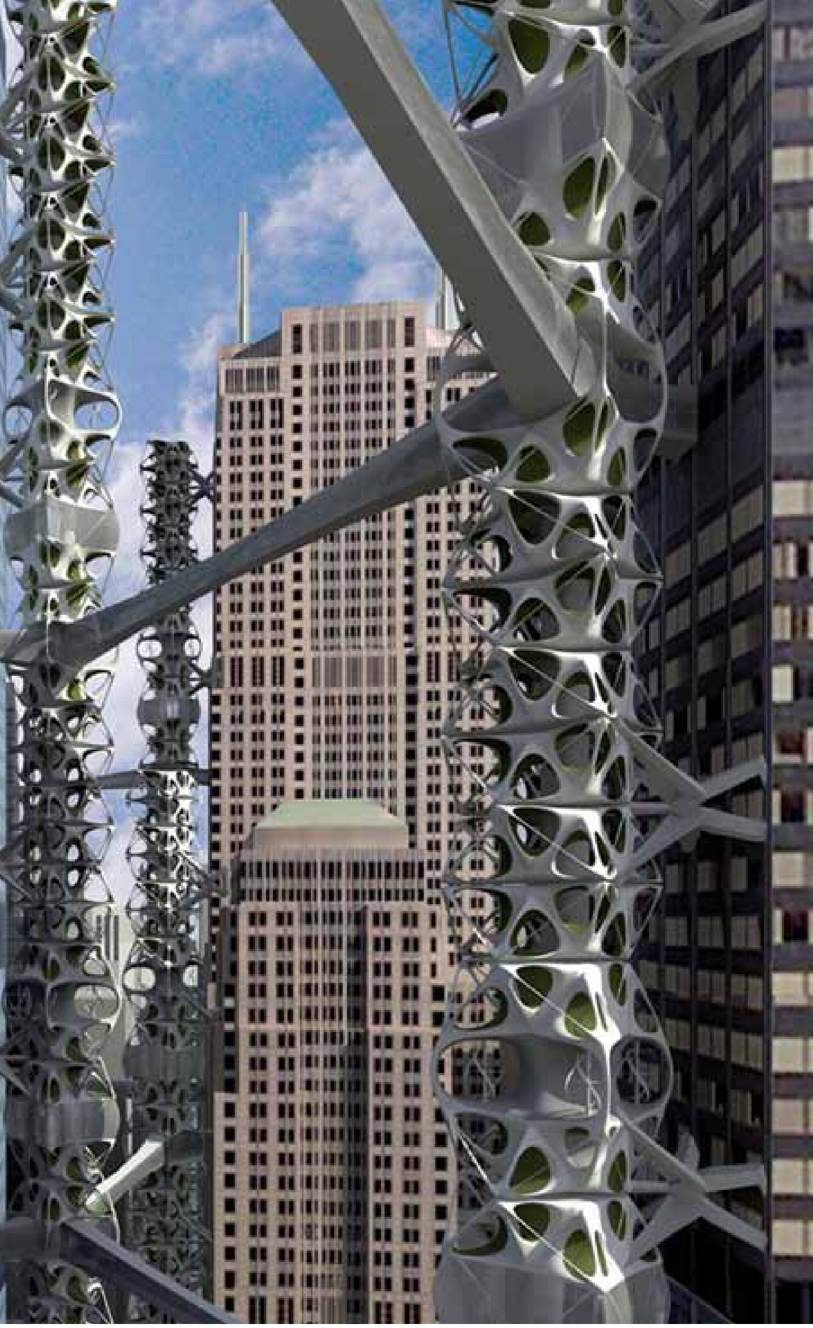
The 21st century is a time of extreme density in metropolitan cities around the world. The design of new skyscrapers in these cities are in fact becoming more sustainable, directed by new green guidelines and mass consumerism of healthier building materials. However, creating new buildings, creates new waste. The objective of new urban architecture is indeed a topic to be questioned. There already exists a dense, eclectic fabric, that of which has been designed to withstand up to 100 years in some cases. The demolition of these buildings to generate healthier ones is not an efficient approach, resulting in thousands of tons of landfill waste and debris to add to our junk-space. New approaches should be explored, to view the city as not a clean slate (because it cannot be) but as a series of opportunities in unique locations. Locations such as existing buildings; the roofs, the edges, the voids. There are many visionary proposals of such thinking, who are starting to generate a new language of possibility for the future of the urban fabric.

The project, Symbiotic Interlock by Daekwon Park (Fig. 84), is a visionary intervention, critiquing the diminishing public space on ground level, due

(Top) Fig 84: Daekwon Park

(Right) Fig. 85: Tridacna Clam

(Far Right) Fig. 86: Lichen



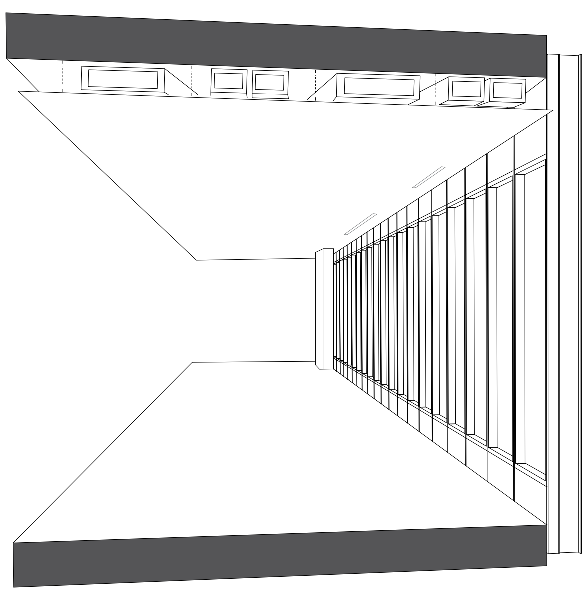
to the eruption of office towers in dense cities. This project provides a new insight to the idea of bringing park space upwards and drawing a new language of green space and energy generation to the vertical realm. Composed of programmed components, it affixes itself to the sides of towers and creates an interconnected link between each intervention.

On the other hand, there is an imperceptible symbiotic relationship in the work of R & Sie. Andreas Ruby, speaks about the future visions of the built urban environment as being a 'hyper-local architecture'. He refers to hyper-locality in terms of extracting the physical reality of a place, removing all previous layers of architectural representation and exposing its true nature, physically and environmentally. (Ruby p. 64) Expressed in terms of materializing the local material (pollution) of place, its now genius (spirit of place), and manifesting these realities to define languages of eco-machines, performing ecological functions while still maintaining user relationships. (Corbellini 2009, p. 5) These principles can help shape the future of architecture as being the process instead of being a result of the process.

Fig 87: Biomorphic Robot for Biomass Collection, R & Sie

07 Architecture *as* Process

This collective research has informed a visionary design proposal which integrates biological and technological principles through the understanding of responsive and performative techniques. Rethinking materiality, such as those which encompass metabolic processes, understanding new architectures symbiotically and the generation of new part-to-whole relationship are qualities which can lead to the redefinition of the future of architecture. The following design stresses on the concept of breathing and metabolizing negative outputs of the urban environment. It strategizes to process and utilize outputs in a positive way by exploring methods of assisting modern architecture to communicate with its exterior through biotic thresholds.



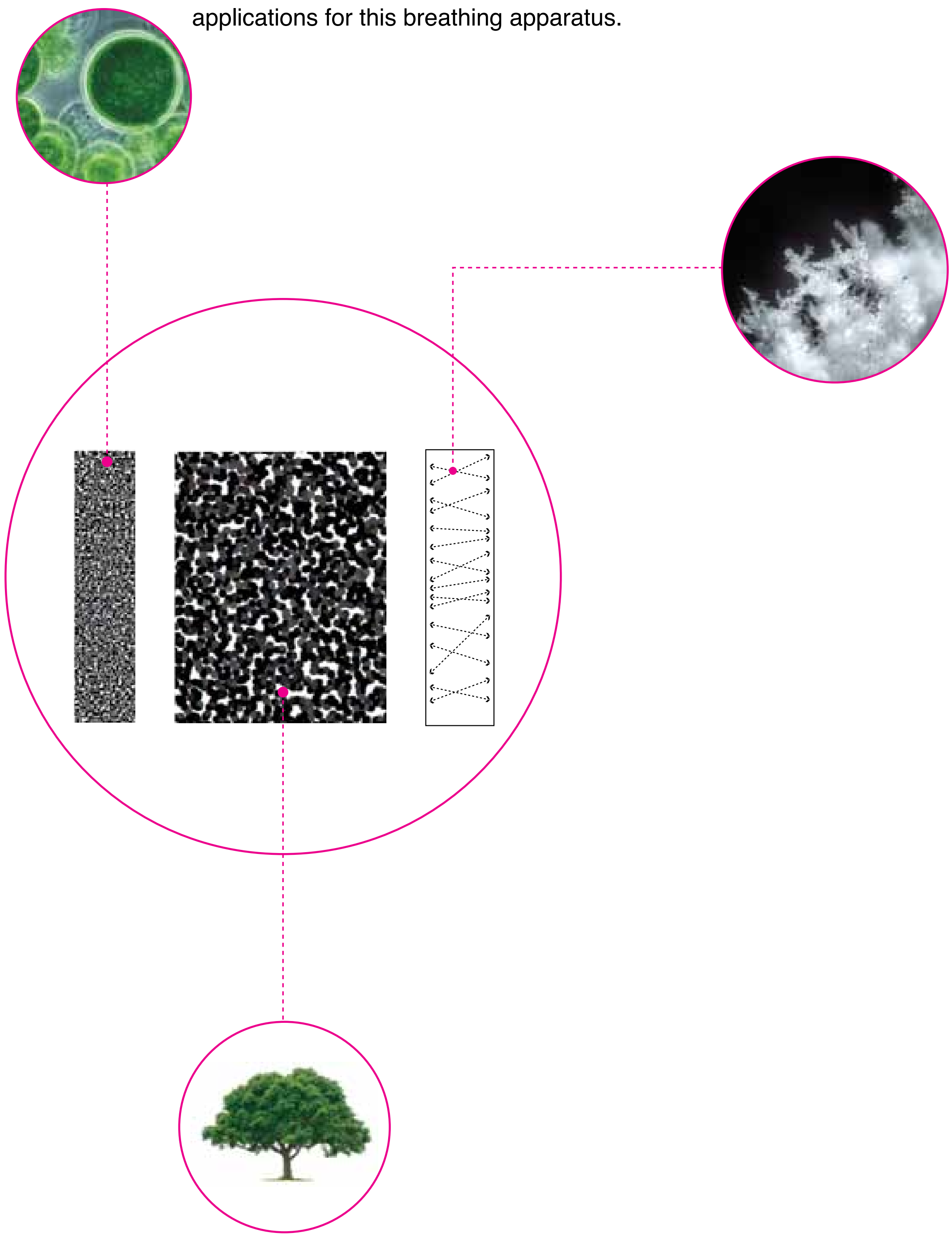
hermetic seal

filter

Fig 88: Re-thinking the hermetic seal as a series of filtering layers

With the analysis of immediate impacts on the building and site, parameters of the design have been defined (in the previous studies) and can be applied to the selected building.

We can begin by taking the current state of the hermetic seal and re-conceptualize the threshold as a filter. The filter will be understood on 3 levels of intervention by absorbing, filtering and chemically breaking down pollution by use of biological principles and natural metabolizing materials. Algae, protocells and plants will be further explored as possible applications for this breathing apparatus.



5.3.2 Reinterpretation of Building as Carbon Sink Filtering Layer 1: Algae

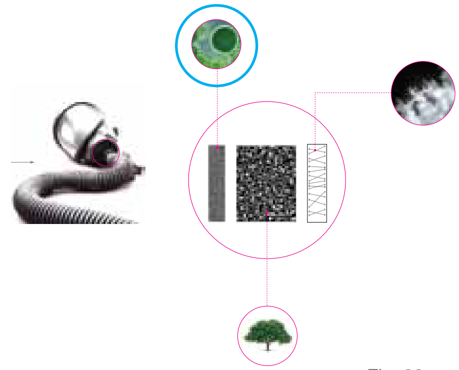


Fig. 88

The design begins by taking the skin of the existing building and peeling it back, exposing interior and exterior atmospheres to each other. This will allow for a new threshold to be defined, acting as a mediator between inside and out.

As the research has shown, algae is the most efficient metabolic material for carbon absorption. With its incredible abilities to reproduce at a rapid rate through photosynthesis, this material is the primary choice for the breathing apparatus. With the Toronto Dominion tower's large exposure to sunlight, this material can absorb the solar energy (which is currently penetrating the glazed surface) and convert it into positives for the immediate atmosphere. Algae will be the primary layer for absorption and chemical breakdown of toxins.

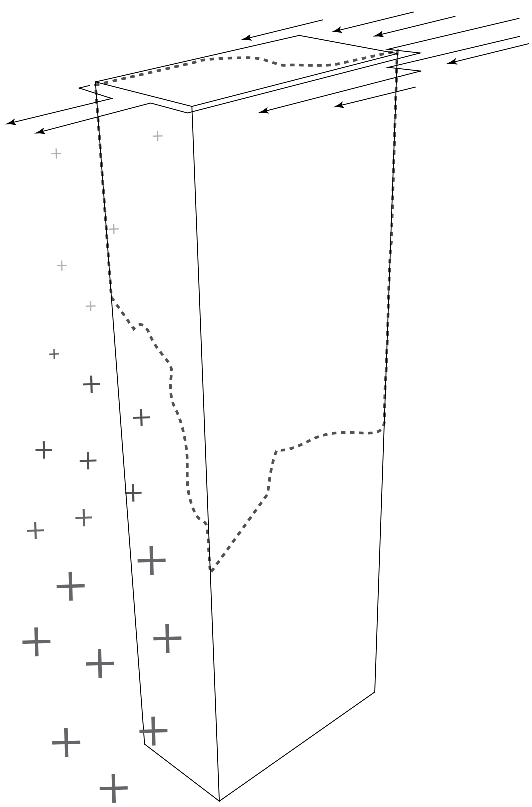


Fig 89: Environmental Analysis

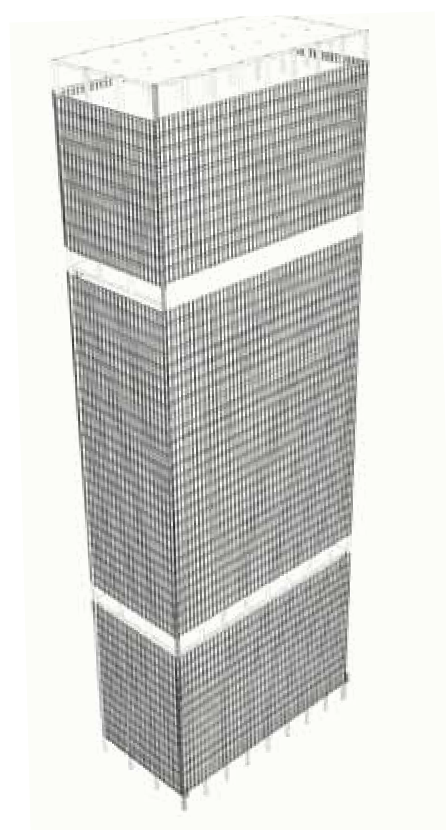


Fig 90: TD Tower Massing

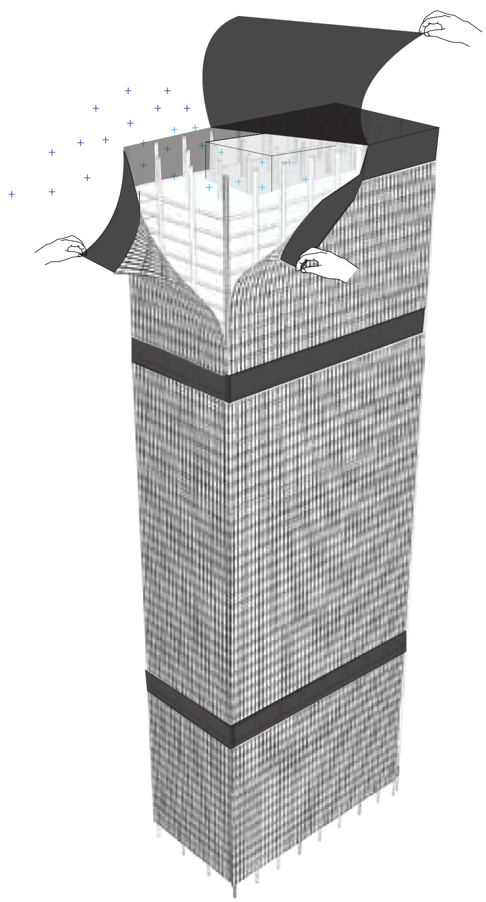


Fig. 91: Peeling Skin Back and Exposing Atmospheres

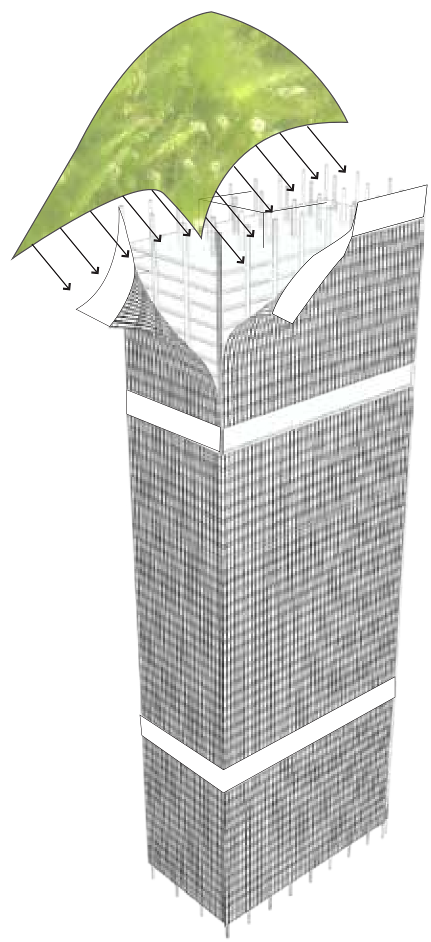


Fig. 92: Insert Algae Threshold

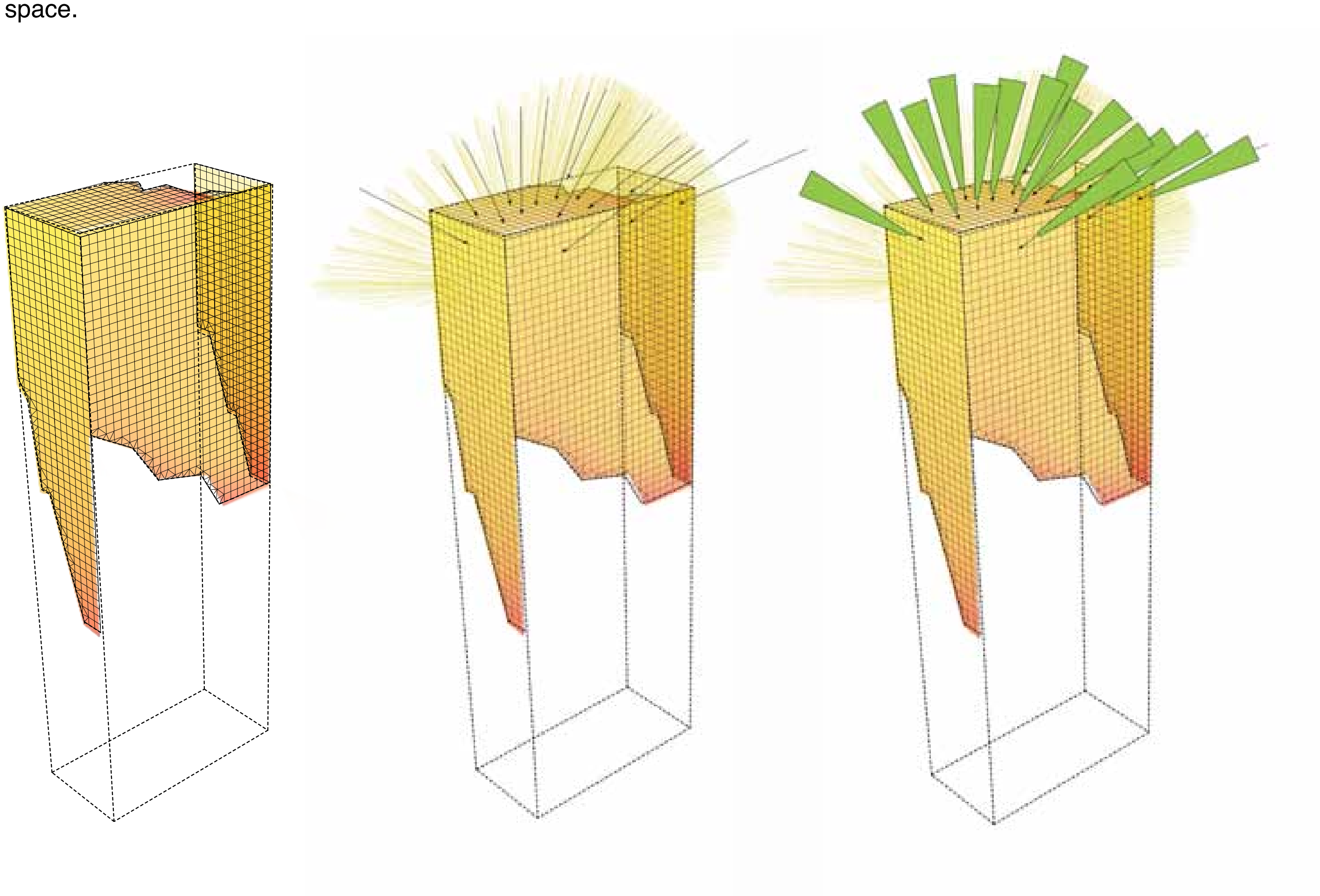
The previous solar study (Fig. 93) illustrates the area which has the greatest potential for a for an algae system. If we understand the sun contacting the building as a series of vectors (Fig. 93) and in place of those vectors, tubes of liquid algae solution (Fig. 93), the current solar energy draping the tower could be absorbed by the algae which will begin a process of oxygen production.

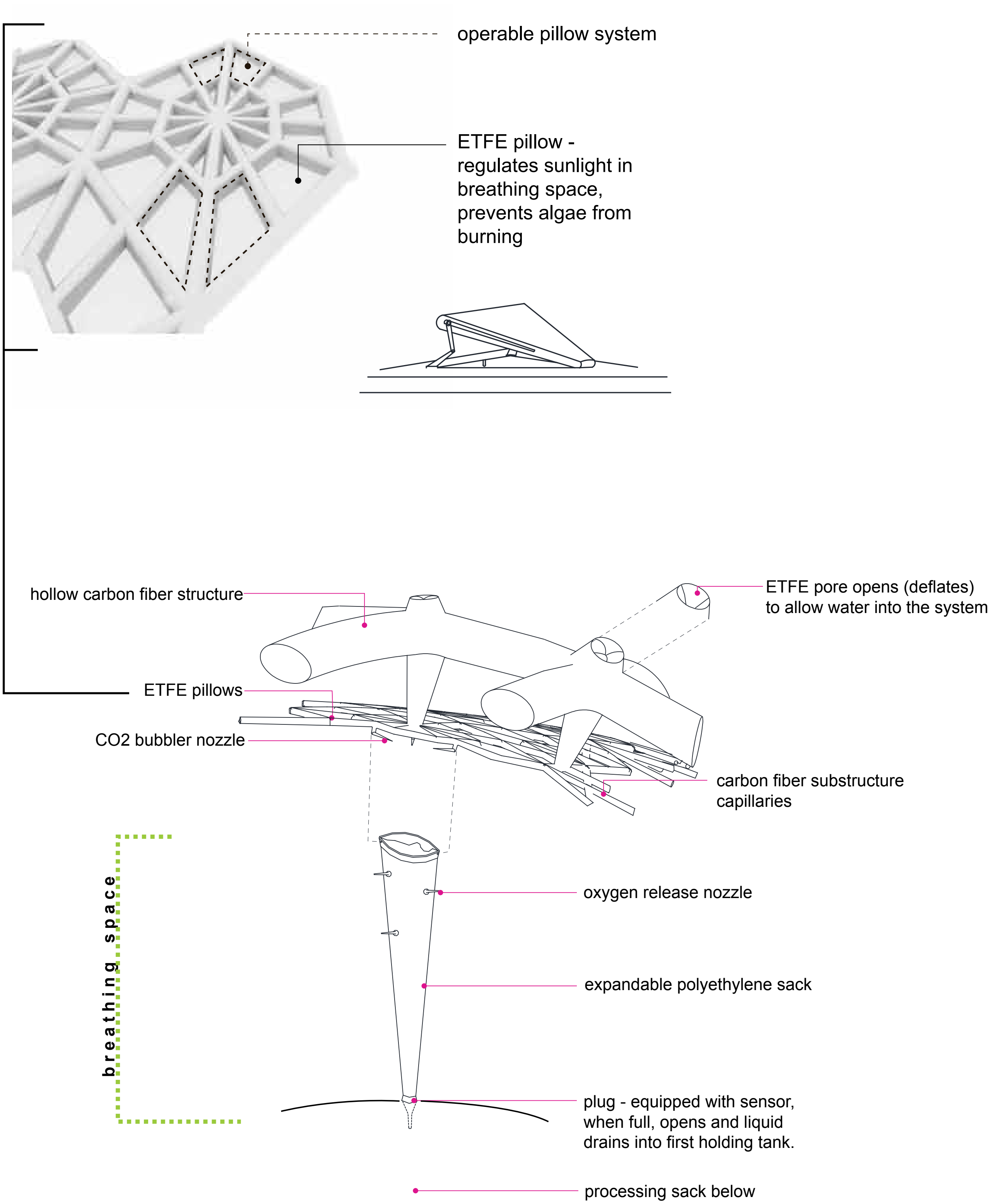
The algae component is broken up into 3 distinct parts as illustrated in Figure 94. The main habitable space (breathing space), the lower portion which processes the algae once the sack has reached full potential and the upper portion, the protective breathing shell.

The protective shell is a secondary structure which provides support for the sacks as well as supplies them with CO2 and water supply. It is a lattice of hollow carbon fiber capillaries which contain ETFE pillows (pneumatic, light-weight plastic pillow) which have the ability to regulate the amount of sunlight in the space by injecting gas into the plastic cavity. Selected pillows are also operable for fresh air supply into breathing space.

(Below) Fig. 93: Algae Placement Diagrams Based on Solar Accumulation

(Right) Fig. 94: Algae Sack Component Breakdown




operable pillow system
ETFE pillow -
regulates sunlight in
breathing space,
prevents algae from
burning
hollow carbon fiber structure
ETFE pore opens (deflates)
to allow water into the system
ETFE pillows
CO2 bubbler nozzle
carbon fiber substructure
capillaries
breathing space
oxygen release nozzle
expandable polyethylene sack
plug - equipped with sensor,
when full, opens and liquid
drains into first holding tank.
processing sack below

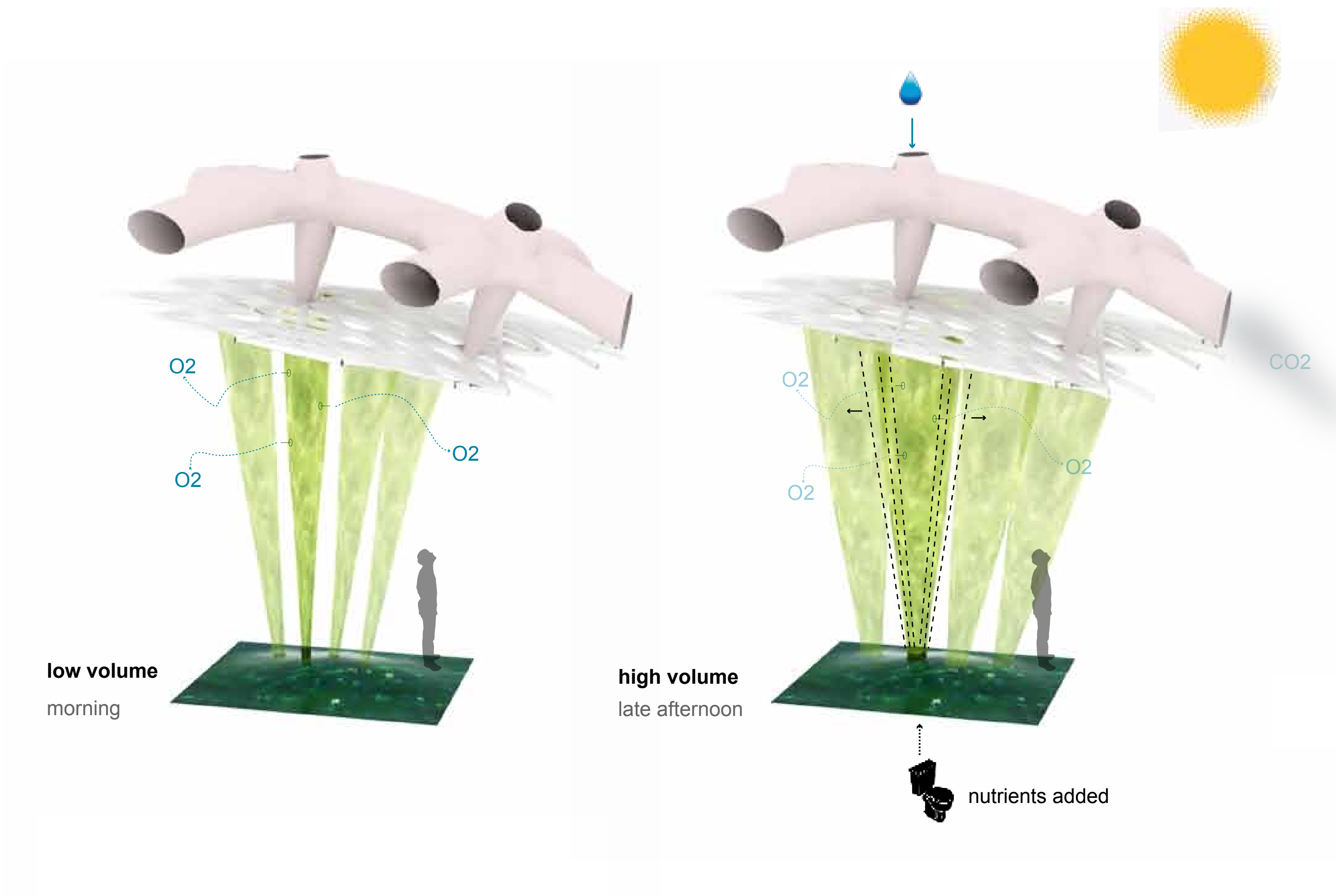
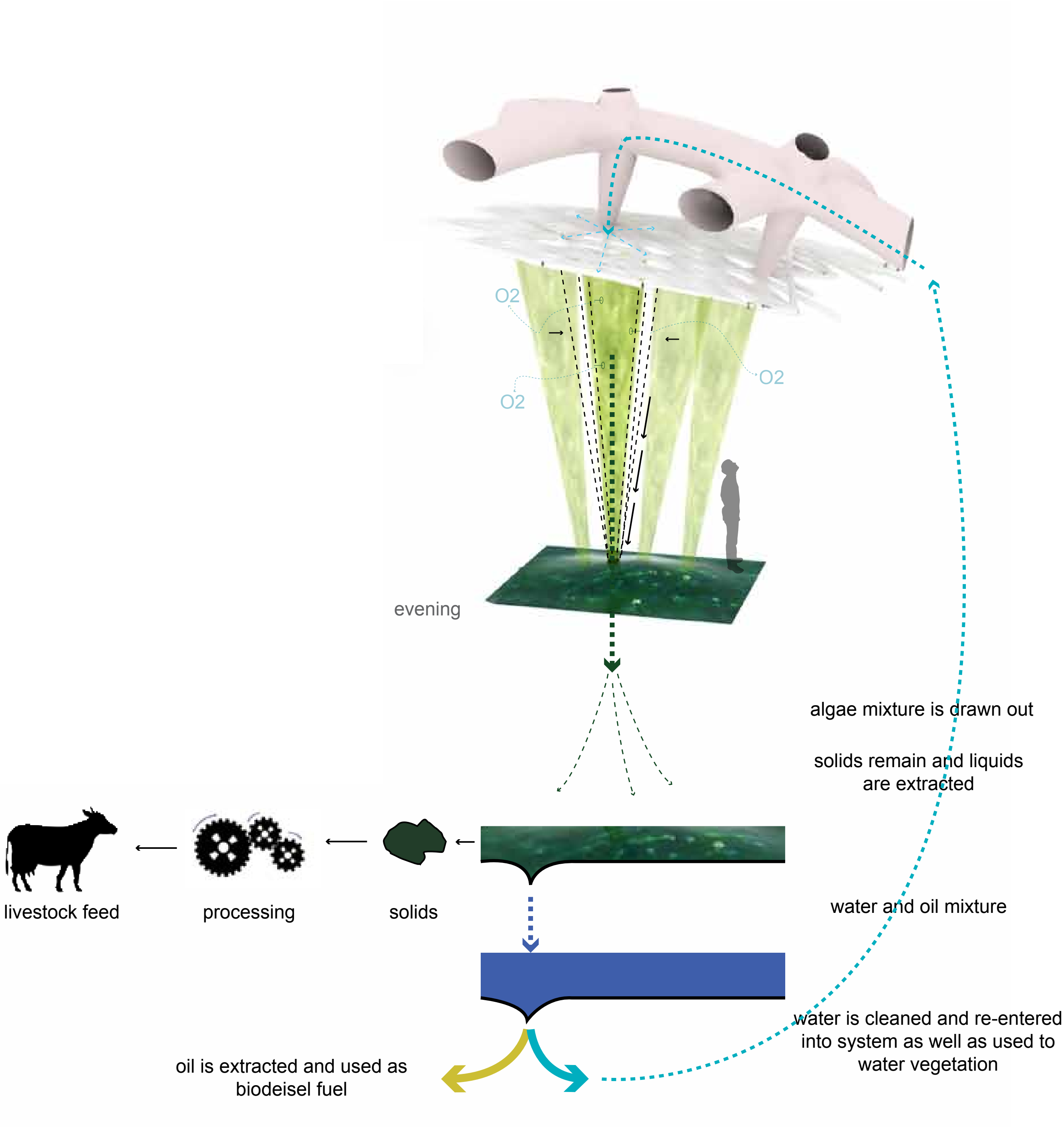


Figure 95 illustrates the algae growth process in the public breathing space (located on the roof). The algae harvesting cycle occurs on a daily basis with low volume in the morning and high volume in the evening. The polyethelene sacks of algae solution expand and contract throughout the day releasing oxygen into the space at a continuous rate. At the end of the day the sacks must be drained for a new harvest. The solution is extracted and separated into solids and liquids. The solids are treated and processed into animal feed which are then shipped to local farms. The liquids (oil and water solution) are then treated and separated, the water is put back into the system while the oil is used as biodiesel fuel for either the Toronto Dominion tower or for other local buildings. The images on the following pages illustrate the spatial qualities of the algae breathing space (Fig. 96 and Fig. 97).

(Above) Fig. 95: Algae Harvesting Cycle Diagram


O2
O2
O2
evening
algae mixture is drawn out
solids remain and liquids are extracted
livestock feed
processing
solids
water and oil mixture
water is cleaned and re-entered into system as well as used to water vegetation
oil is extracted and used as biodeisel fuel

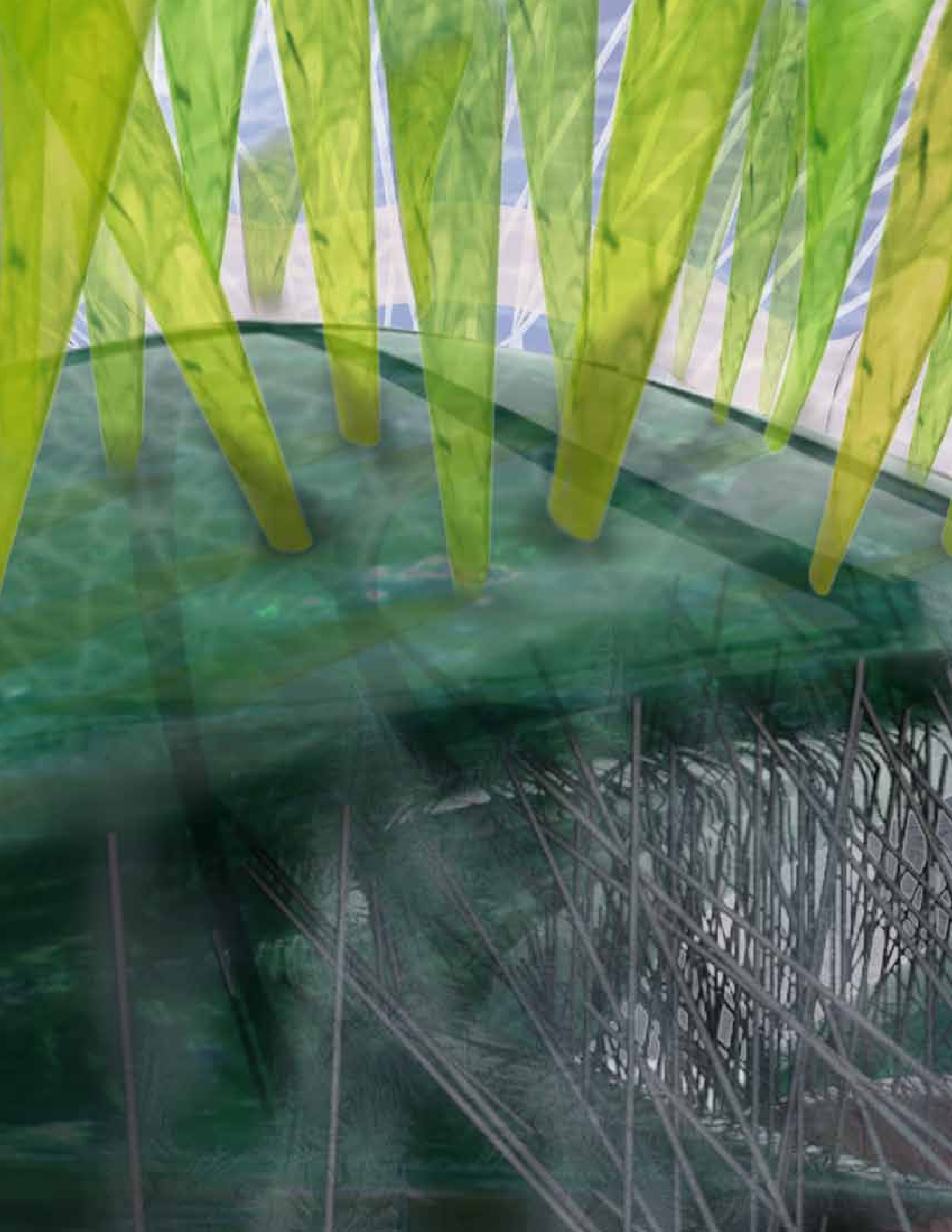


Fig. 96: View from interior of central breathing space (on roof).

Fig. 97: View of breathing space at dusk.

Fig. 98

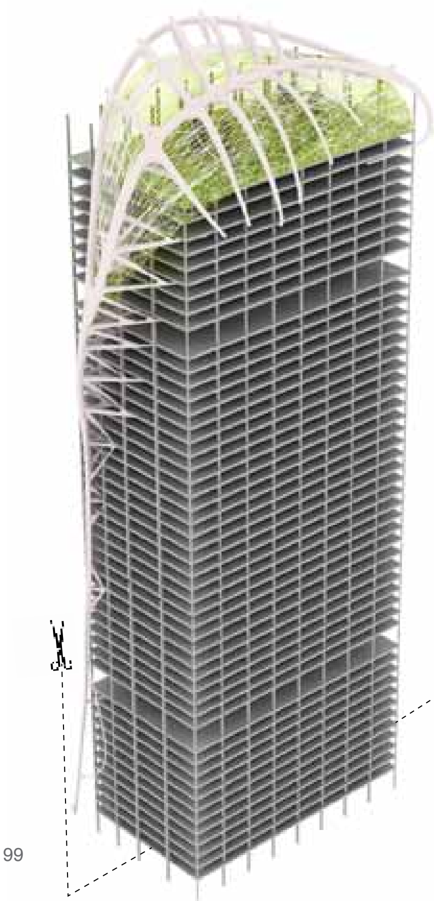


Fig. 99

To hold this algae system up, an exoskeleton was designed, conceptually mimicking a rib cage. It protects the delicate interior while being a porous light-weight addition to the existing structure, to allow the wind eddies to circulate around itself. The hollow carbon fibre skeleton connects to the existing exhaust shafts (Fig. 100) by penetrating though the exterior spandrel and continuing through the drop ceiling. Illustrated in Figure 101, the skeleton is the primary structural and feeding system to the algae membrane while the ETFE/capillary system below acts as the secondary structure directly connected to the sacks. The secondary structure distributes the CO2 and water supply to the algae below.

In Figure 104 on the page 82, the design of the exoskeleton was determined by not only the wind path consideration but the pollution gradient level. Here, it is illustrated that the skeleton filters differently taking into consideration the different densities of pollution and using different layers of filtering as the elevation changes.

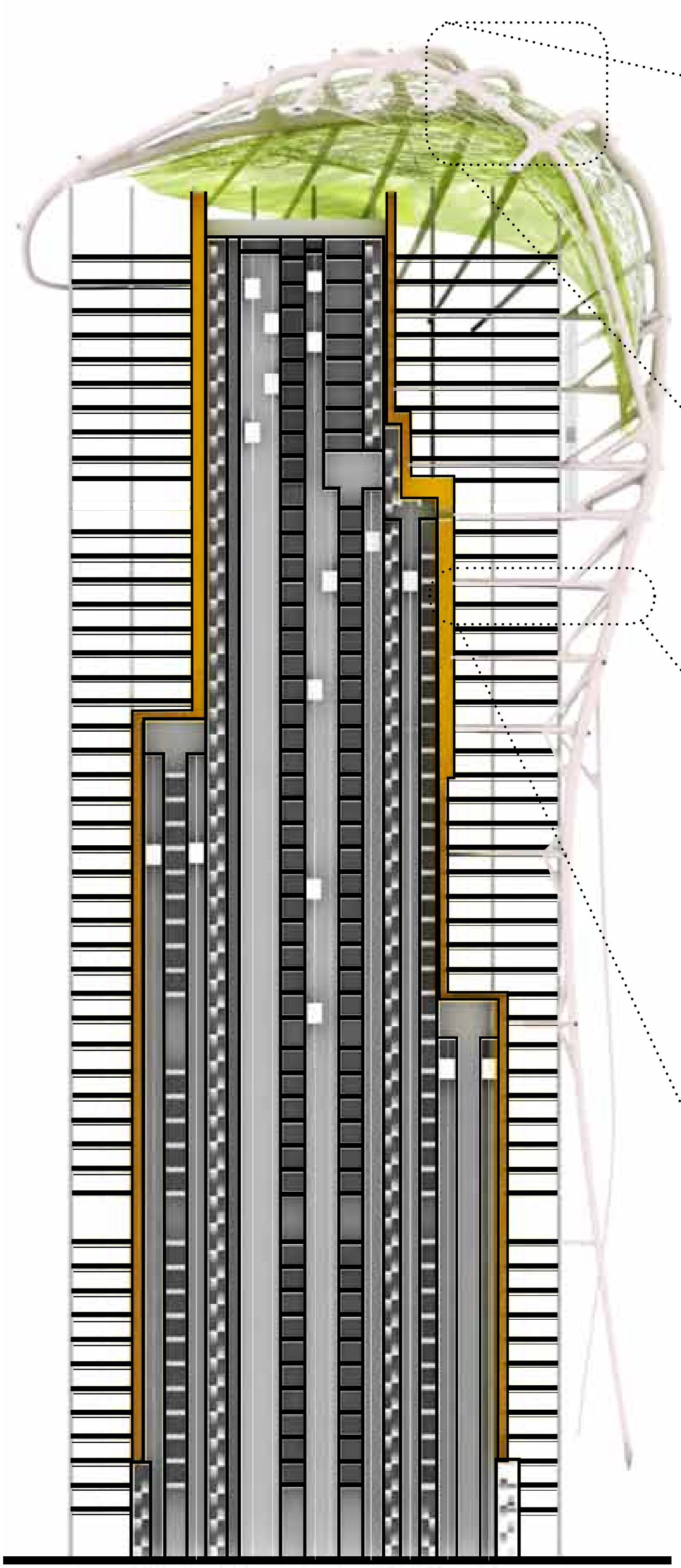


Fig. 100

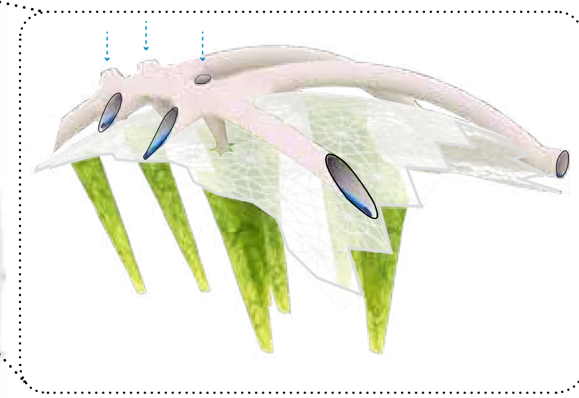


Fig. 101

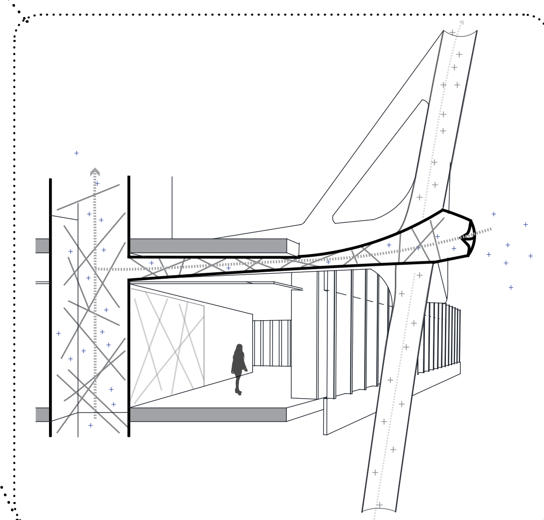
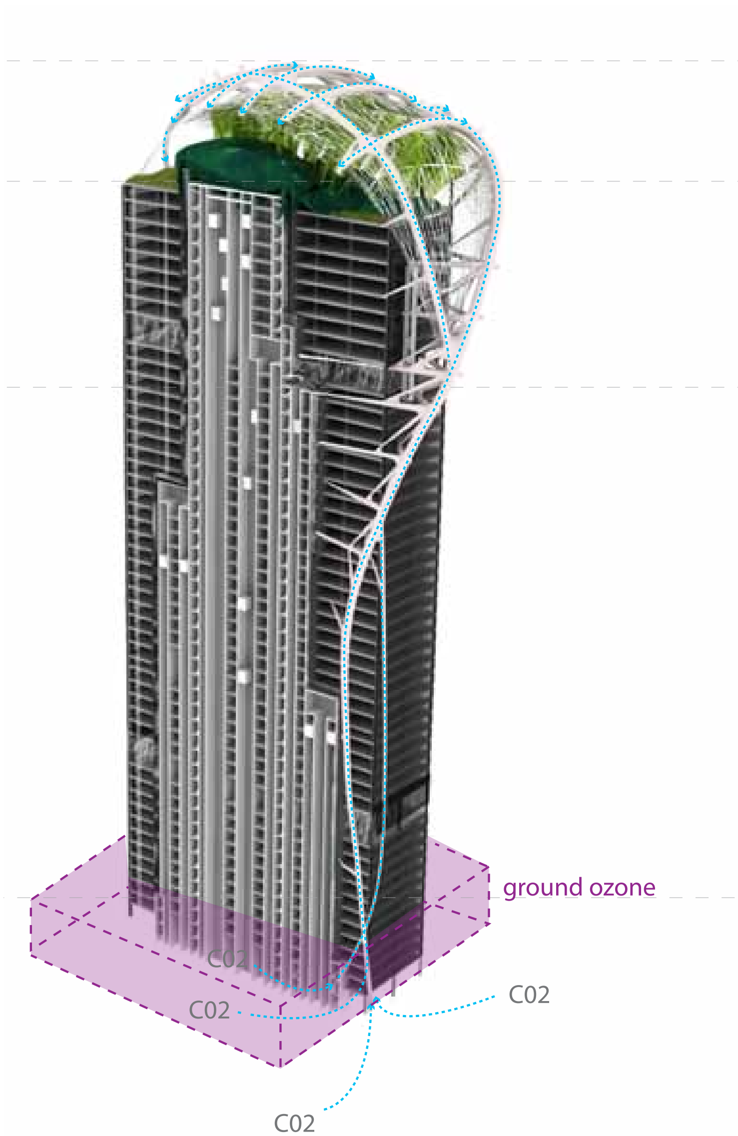


Fig. 102

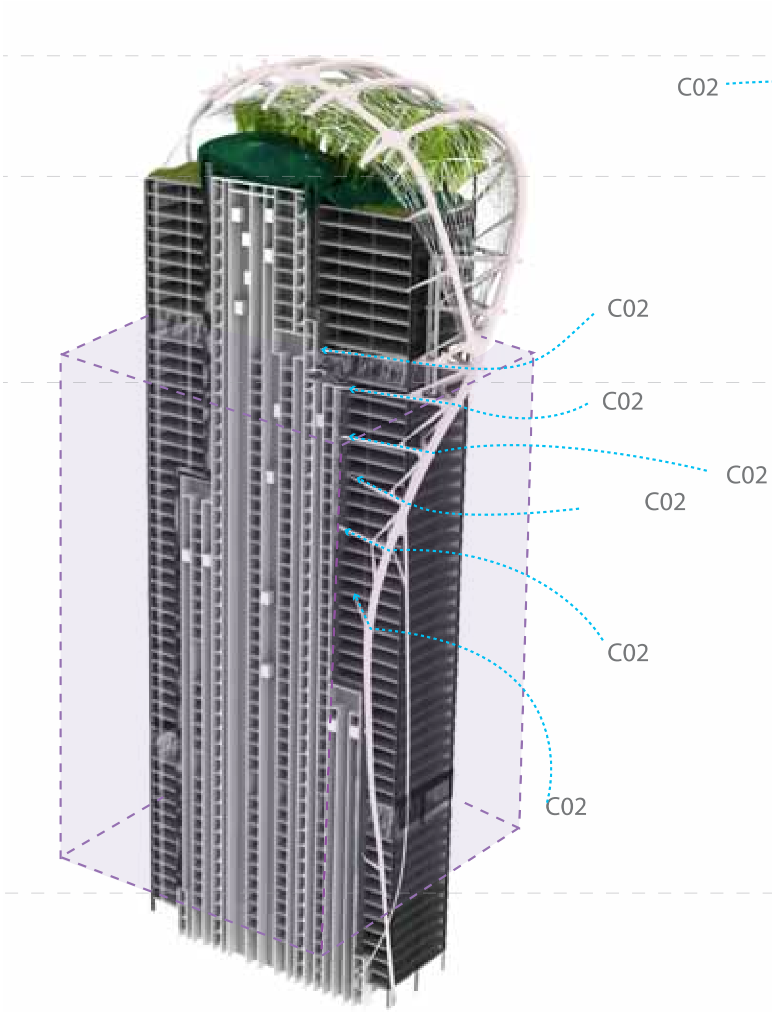
Fig. 98: Base Structure
Fig. 99: New Structure Symbiotically Attaching to Existing Structure
Fig. 100: Building Section
Fig. 101: Structure Detail
Fig. 102: Systems Integration Diagram

Fig. 103: View of structure on building.

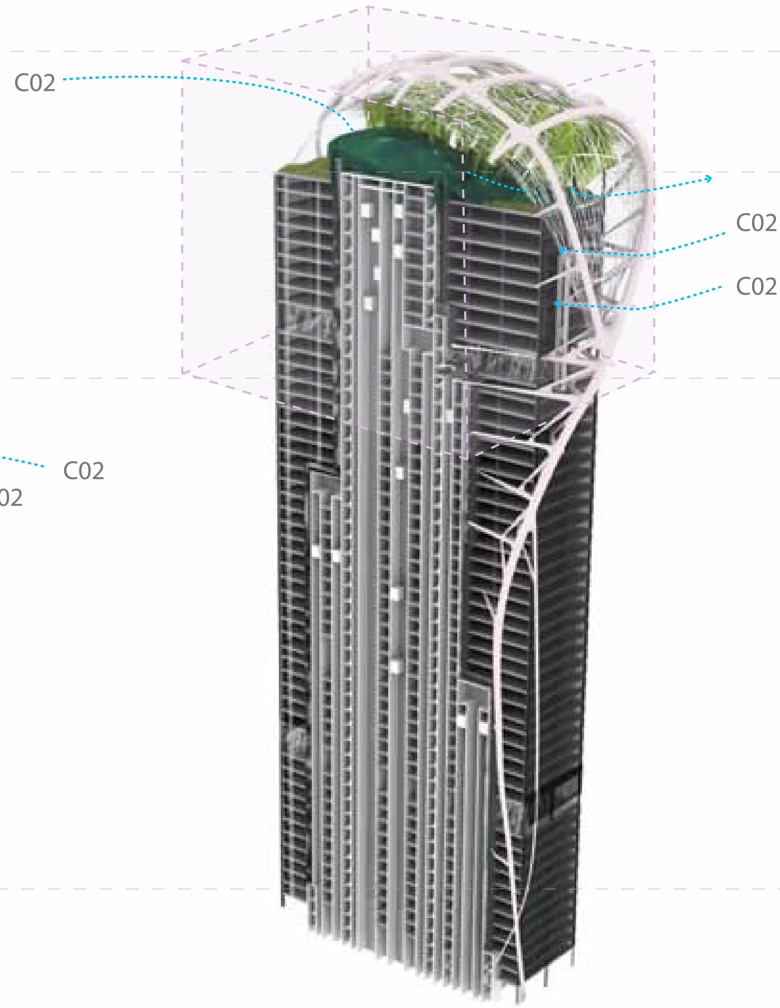


Highest Pollution Density

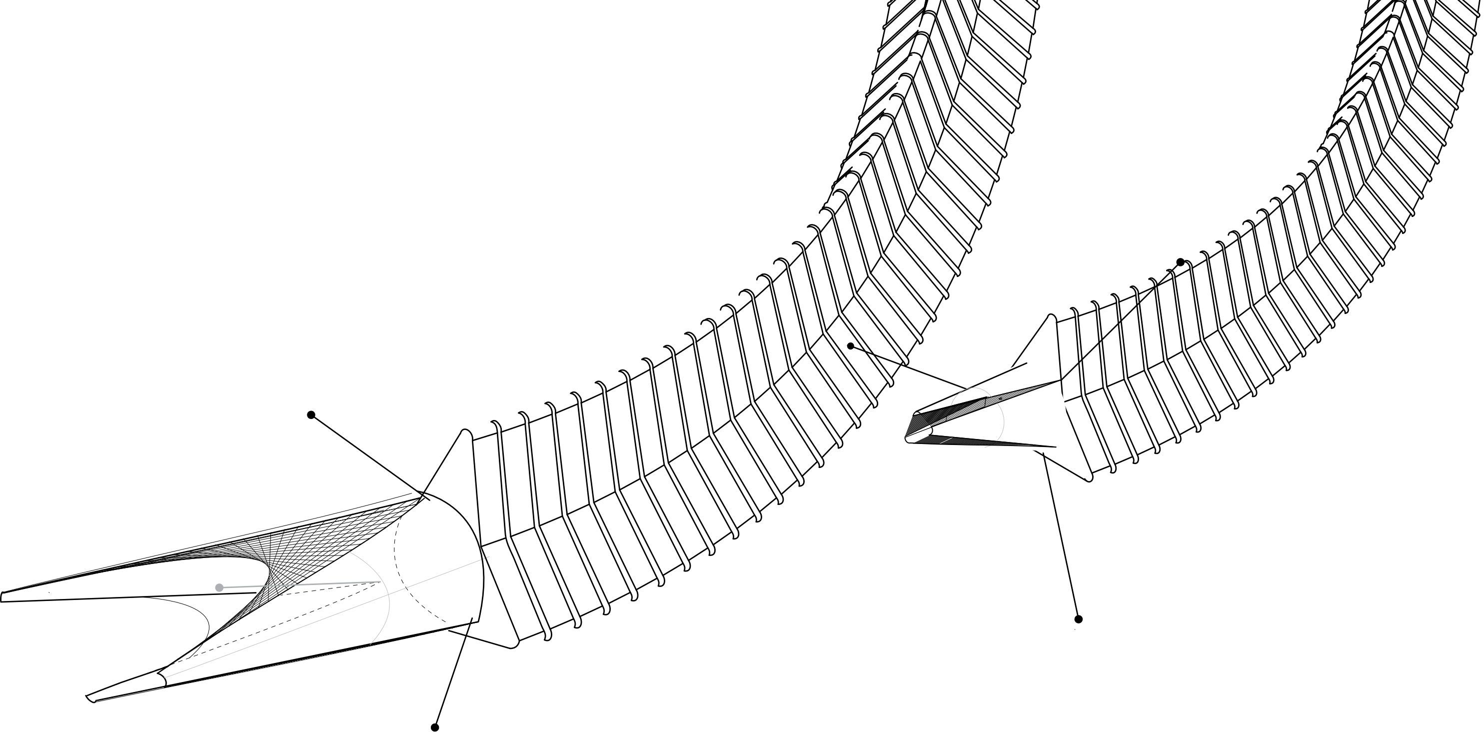
Fig. 104: Structure Design Relative to Pollution Gradient.



Moderate Pollution Density



Less Densely Polluted



Ground level ozone, the most toxic and dense level of pollution inhabits the main pedestrian realm. The algae, located 220m above this level needs the C02 supply for survival, so an element from the exoskeleton must touch down in this realm and provide an intake. The intake, illustrated in Figure 105, is equipped with sensors and actuators and communicates with the algae sacks above. When the algae is in need of more supply, the intakes open and inhale the contaminated air which is then drawn upwards to feed the algae.

(Above) Fig. 105: Pollution Intake Detail At Ground Level

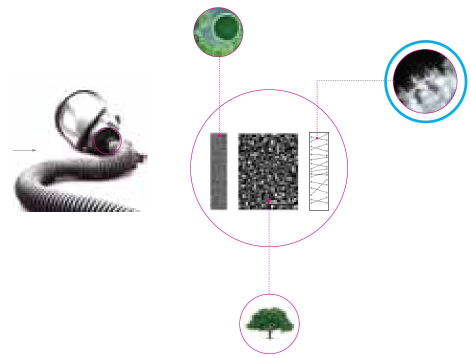
(Right) Fig. 106: Image of Breathing Apparatus on TD Tower

5.3.2 Filtering Layer 2: Protocells

The next layer of filtration are the protocells. As mentioned, they can be applied to surfaces where contaminated air is present and will begin to react immediately. In this design, the cells are applied to carbon fiber rods populating areas where high concentrations of C02 occur. Figure 107 illustrated where the coated rods will be placed. Since protocells, like algae, have a rapid metabolic rate, a system will be implemented to remove the by-product (calcium carbonate) and be able to replenish itself with cells for the following day.

The 4 exhaust shafts, 2 mechanical floors and rooftop wind filter are all equipped with a vacuum system (Fig. 107) which will remove the by product at night and send it out for use in local construction material.

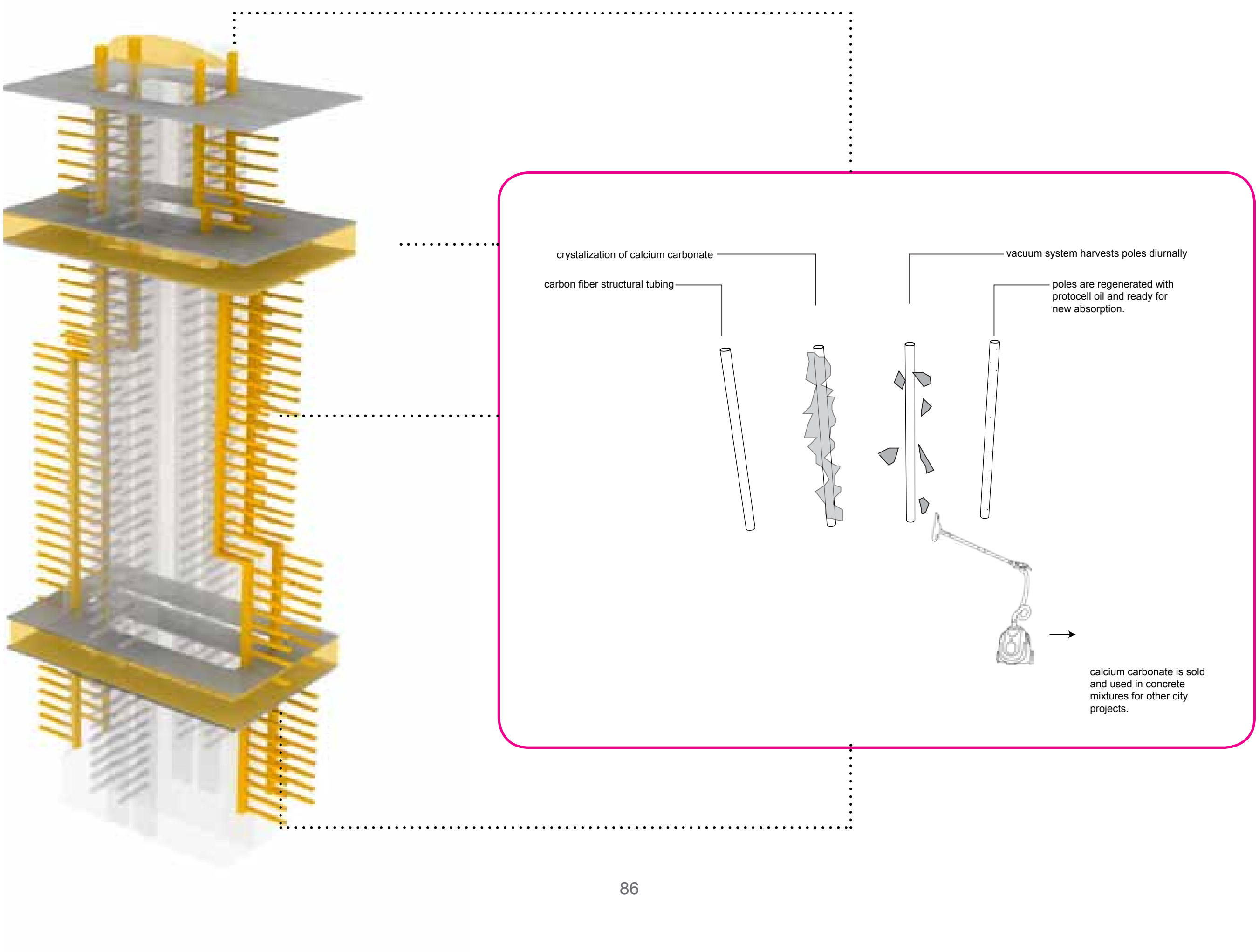
Figure 108 illustrates the core of the processing sack on the rooftop as a wind filter for the direct wind flow coming off of the building to the east (refer to wind analysis page 41).

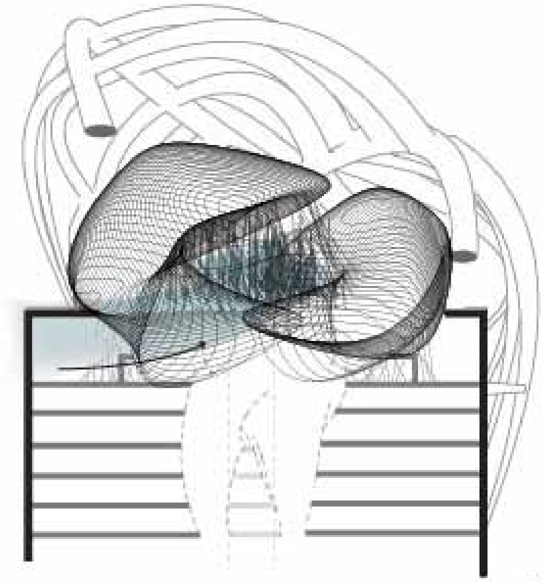


(Above) Fig. 88

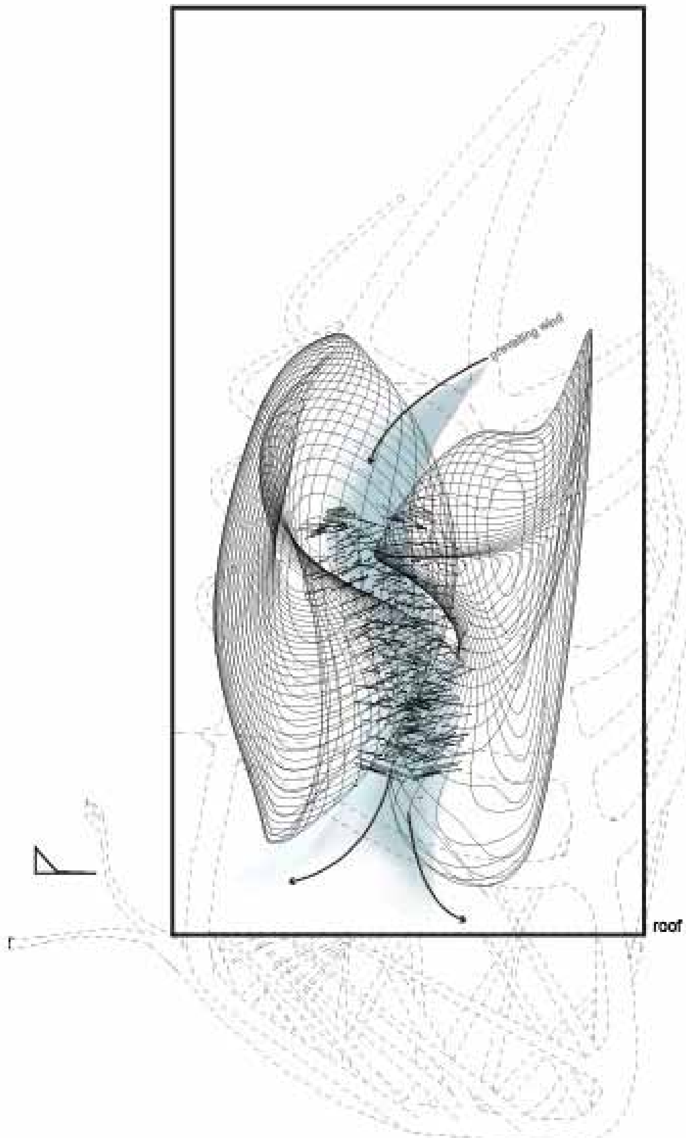
(Below) Fig. 107: Location of Protocells in TD Tower and Extraction Method

(Right) Fig. 108: Wind Flow Diagram Through Processing Sack





section



roof plan

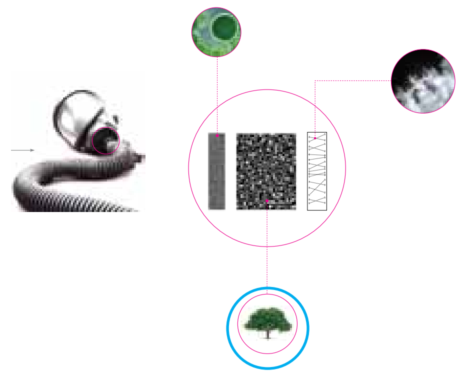
n

Fig. 109: Access hallway to breathing space on 43rd floor

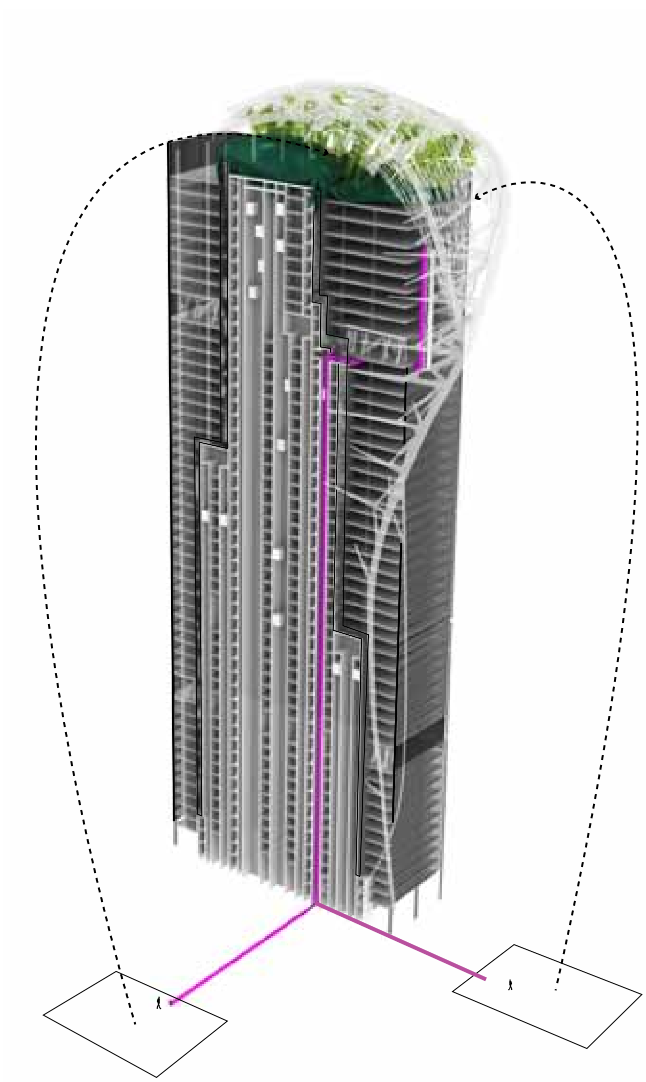
Fig. 110: Interior view of typical office space. Protocell lined rods inhabit the shafts behind glass walls. There is a visual connection between breather and contaminated air coming into the building.

5.3.2 Filtering Layer 3: Vegetation

The final filtering layer of the apparatus is vegetation. Currently two green/open public spaces exist at ground level. The concept of the breathing space is to draw this park space upwards and provide a healthy outdoor space, away from the dense pollution. One with not only views, but which provides fresh air as well. The vegetation in this design works in conjunction with the two other levels because on its own may not be sufficient enough to absorb all of the C02 it is exposed to. In this suspended park scheme, the vegetation is able to absorb what it needs to and is able to rely on the other filtering layers to capture the rest. The suspended vegetation is the transition space before the algae breathing space above. A ramp weaves the visitor through a meshwork of oversized hanging planters before arriving at the top (Fig. 112).



(Above) Fig. 88



(Left) Fig. 111: Pedestrian Access Diagram

(Right) Fig. 112: Detail of Suspended Park

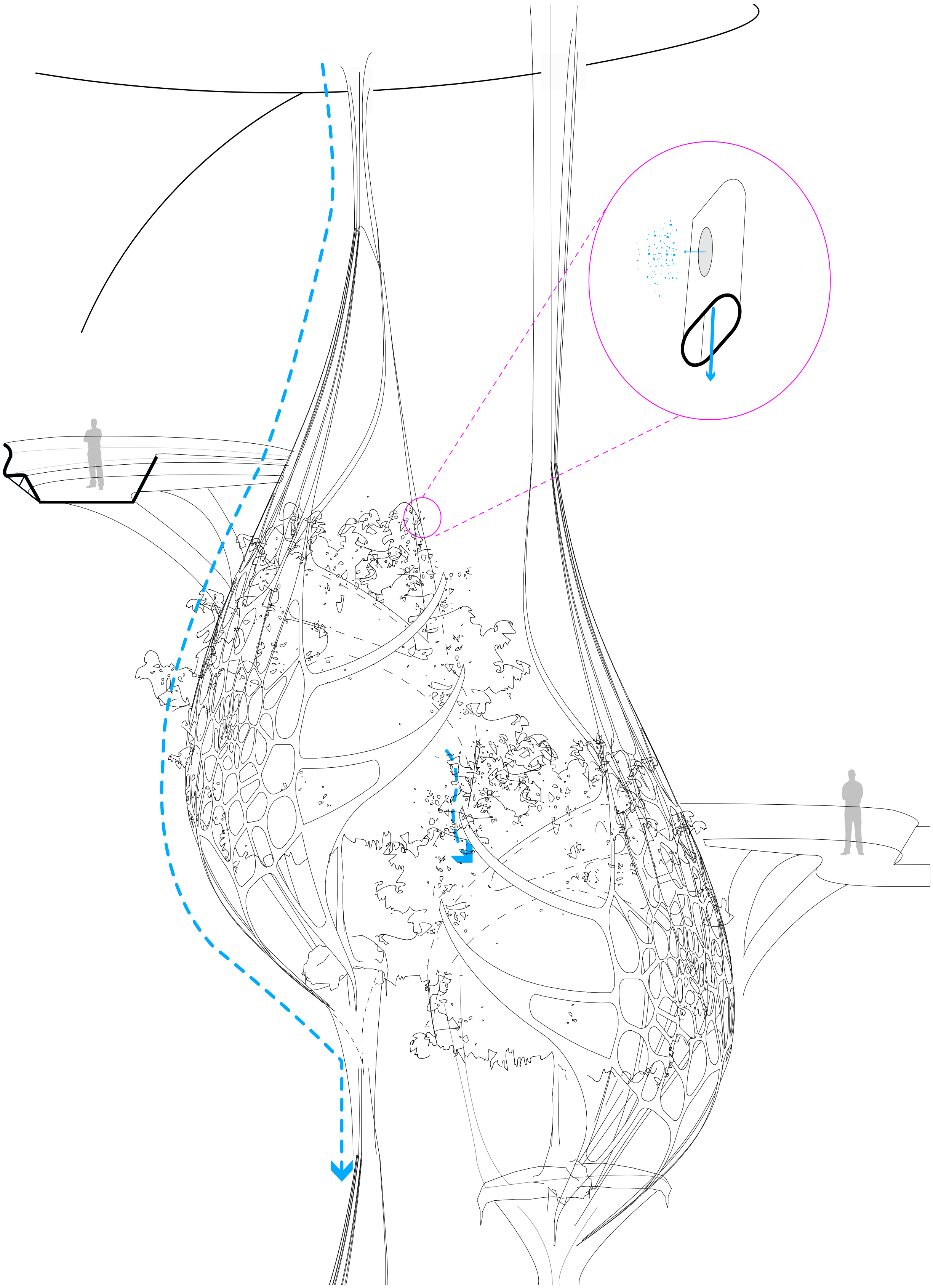


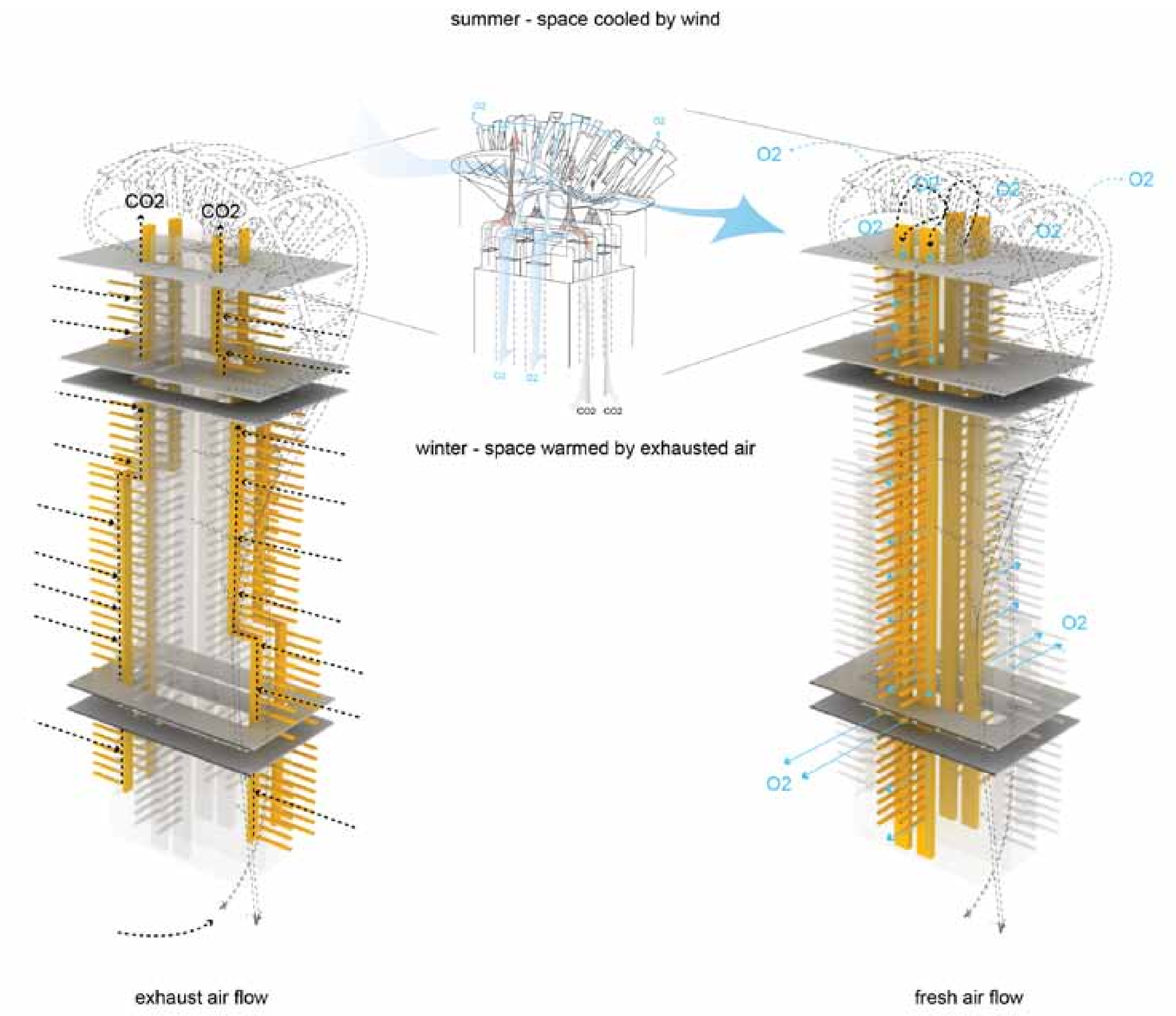
Fig. 113: View inside suspended park

5.3.2 Air Flow

The overall airflow throughout the building has been altered in such a way that along with the building's exhaust blowing upwards the breathing apparatus is drawing the contaminated exterior air up the same shafts, allowing both to be filtered. When the combined semi-filtered air reaches the top, more protocell-lined rods filter the air and before it is pumped back into the building, oxygen produced from the algae in the breathing space is drawn out and circulated back into office spaces as fresh air.

The breathing space produces large amounts of oxygen throughout the day and is distributed not only to the interior of the building and breathing space but the exterior atmosphere as well. The algae in the winter does not freeze due to small valves which release the warm semi-contaminated air into the breathing space. In the summer, the space avoids humidity and heat by the cool exterior air that flows through the space, via the core of the processing sack (Fig. 114).

Fig. 114: Overall Airflow Diagram


summer - space cooled by wind
CO2
CO2
O2
O2
O2
O2
O2
O2
O2
O2
winter - space warmed by exhausted air
exhaust air flow
fresh air flow


08

Continuing the Dialogue

The research demonstrates that air must be explicit in the discourse of architecture. The solution for the survival of our air does not lie in the construction of new architectures and the consumerism of more ‘efficient’ products. Today’s society is becoming increasingly dependant on mechanical systems for the creation of cleaner artificial atmospheres, due to the rapid depletion of our natural air supply. A process we take for granted, this which sustains life, is becoming more difficult to bear, especially in the urban setting.

Currently, carbon dioxide is being produced at a higher rate than it can be absorbed by natural carbon sinks. Processes such as absorption and metabolism can be learned from natural principals in conjunction with the readily available technology to begin addressing this crucial issue.

The breathing mechanism, defined through research, demonstrates a biological and technological application which begins to create a dialogue between architecture and atmosphere. This real-time conversation can help eliminate the banality of the modern static shell and assigns the hard systems of the urban fabric (building skins and mechanical systems) a practical role in the context.

Breathing is an architectural issue. Air, a prominent, yet subconscious part of the architectural discourse must be brought to the forefront and be made explicit.

If the future of architecture lies in continuing to seal itself from the atmosphere, then we are destined for a future of junkspace, one of pure isolation from our natural environment. Architects should consider the immaterial substance of not only what architecture produces (emissions) but its materiality and its relationship to its atmosphere both internal and externally.

Fig. 115: Toronto Dominion Towers

Fig. 116: Forest Canopy

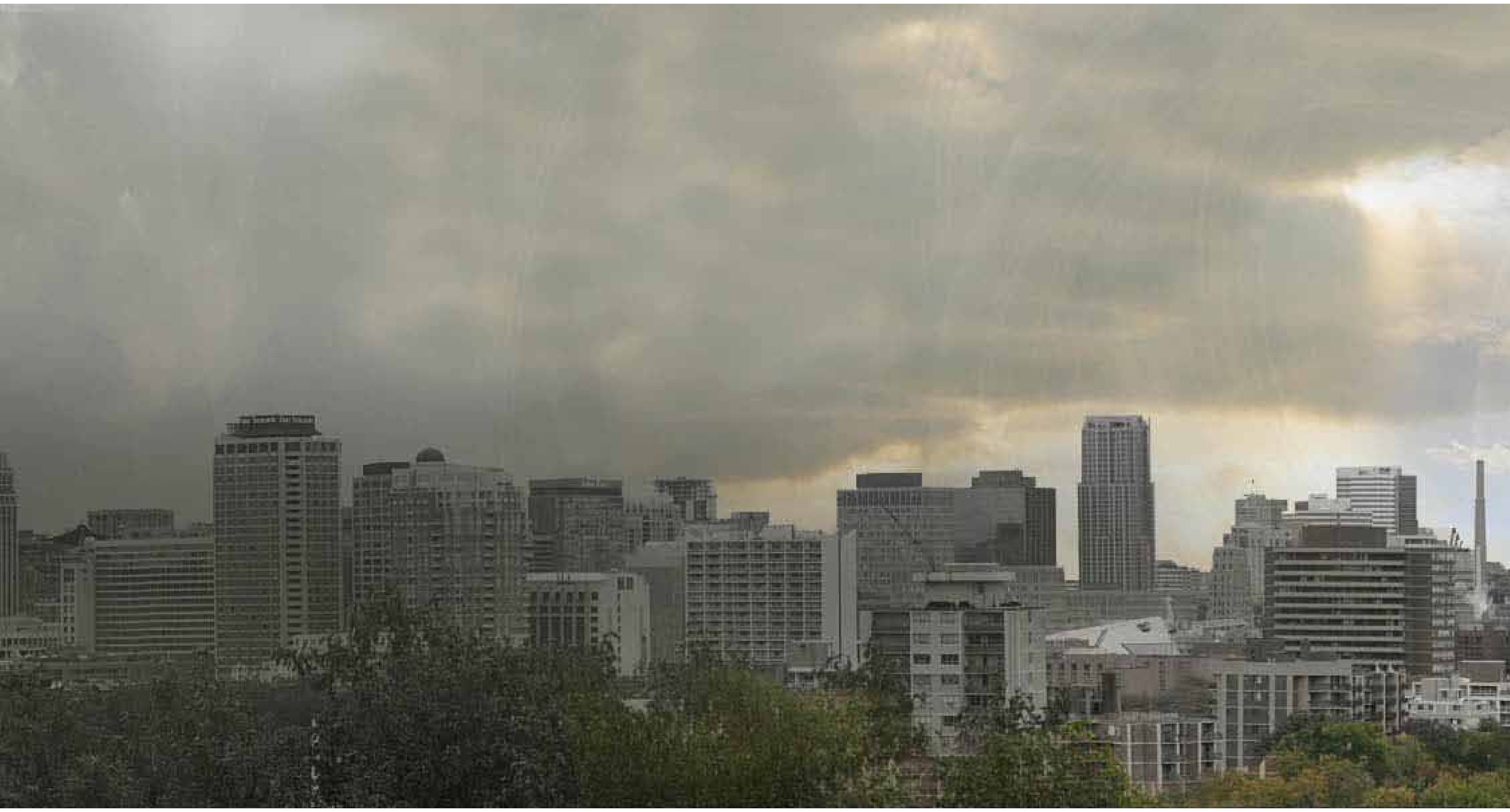


Fig. 117: Pollution gradient over time of the influence of the breathing apparatus on the city.

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Interview

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Appendix A
Reference Material

The following links contain further information on the topics discussed in this document.

Algae

http://www.sciencedaily.com/videos/2007/0407-possible_fix_for_global_warming.htm

<http://news.nationalgeographic.com/news/2004/07/0715_040715_oceancarbon.html>.

<http://www.geni.org/globalenergy/library/technical-articles/generation/climate-change/energy-central/climate-change-german-scientists-use-algae-to-absorb-carbon-dioxide/index.shtml>.

http://www.evolo.us/competition/bio-city/

http://www.algaeproductionsystems.com/equipment.html

http://www.popsci.com/technology/article/2009-10/bioplastics-could-replace-petroleum-algae

http://www.ewater.com.au/h2othinking/?q=2010/08/algae-source-

biofuel

http://algae.ucsd.edu/potential/why-algae.html

http://inhabitat.com/power-your-car-with-algae-algae-biocrude-by-livefuels/algae-biofuel-biocrude-livefuels-algae-based-fuel-bio-based-fuel-biodiesel-solix-greenfuels-nrel-us-doe-department-of-energy-2/

Plants

http://www.pnas.org/content/93/21/11705.abstract>.
Mazria, Edward. “Climate Change Data.” Architecture 2030. Architecture 2030, 2011. Web. 22 Oct. 2011. <http://architecture2030.org/the_problem/problem_climate_change>.

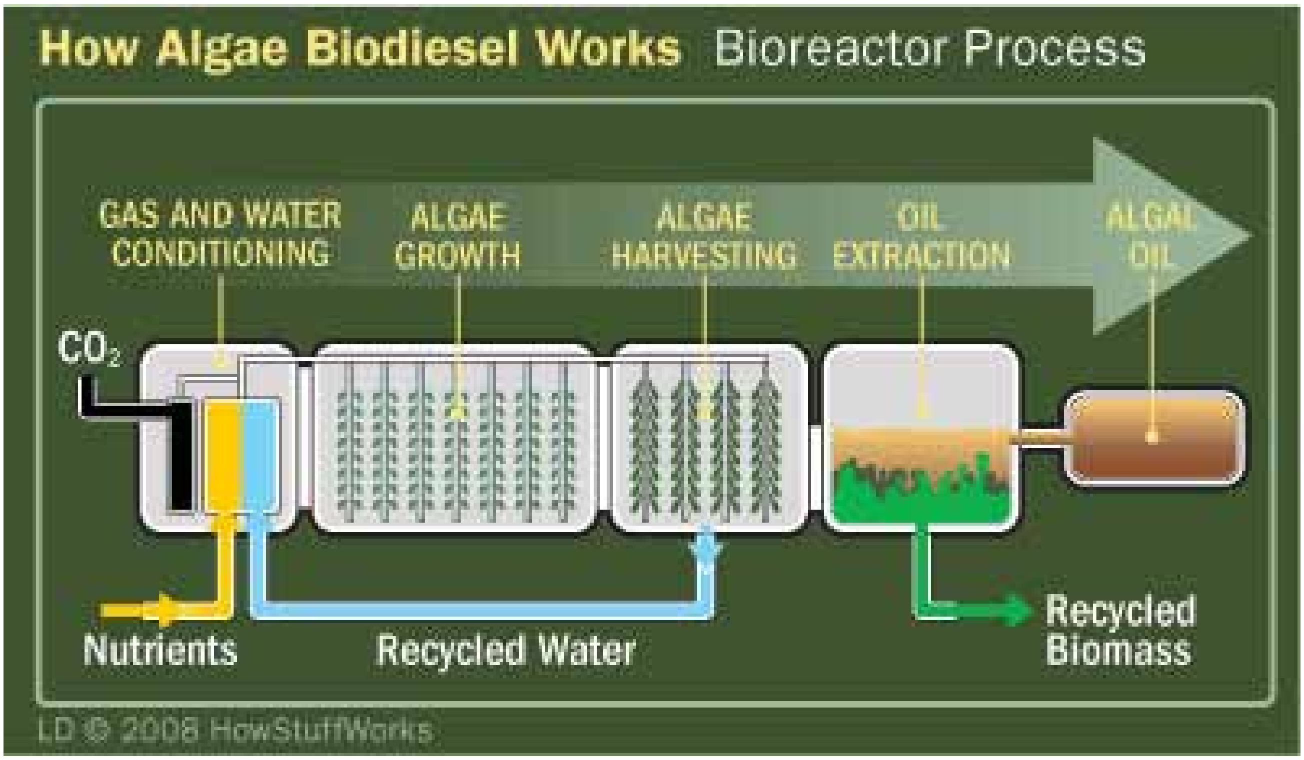
Protocells

http://magee-science.homestead.com/APES/APES_Articles/Article-Living_in_the_City.pdf

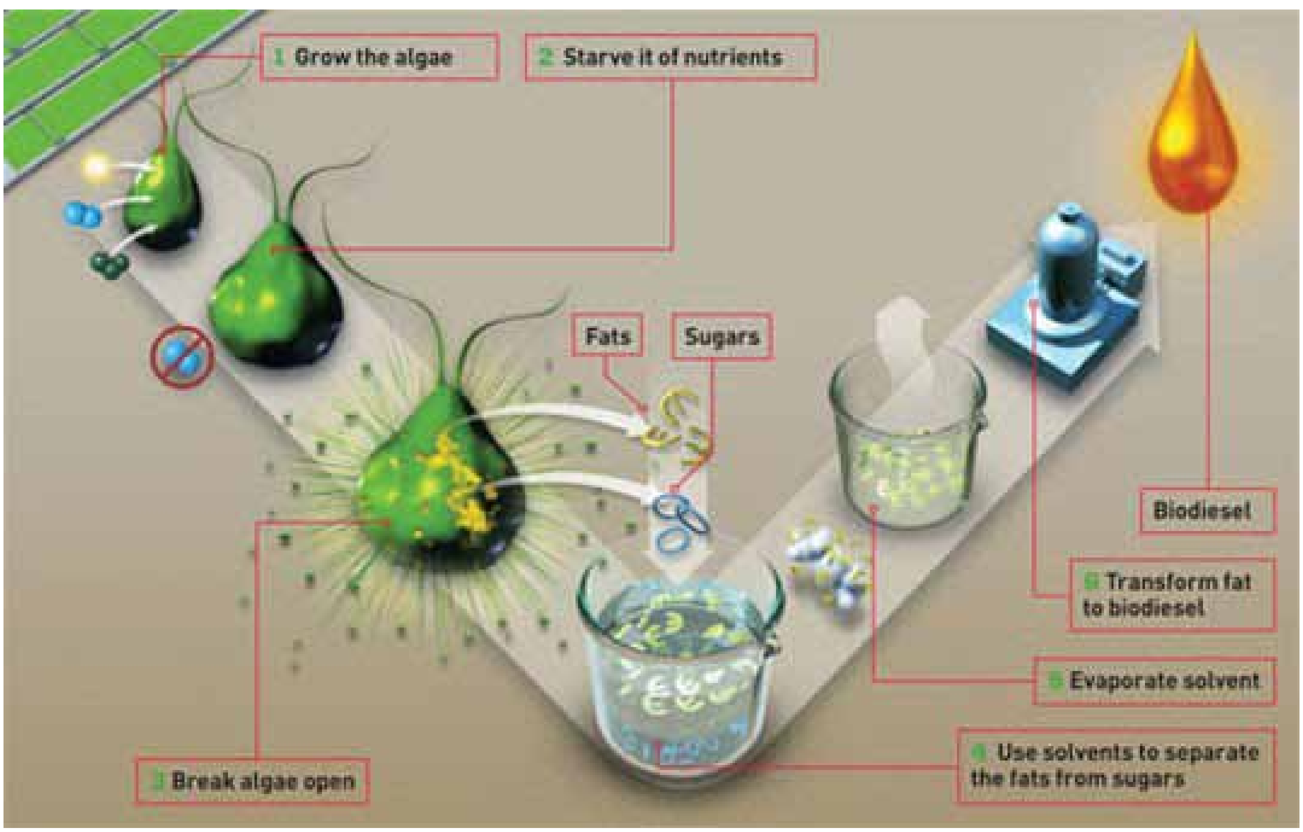
Air Quality

www.airqualityontario.com/

http://architecture2030.org/the_problem/buildings_problem_why



Biodiesel Cycle Diagram: http://science.howstuffworks.com/environmental/green-science/algae-biodiesel3.htm



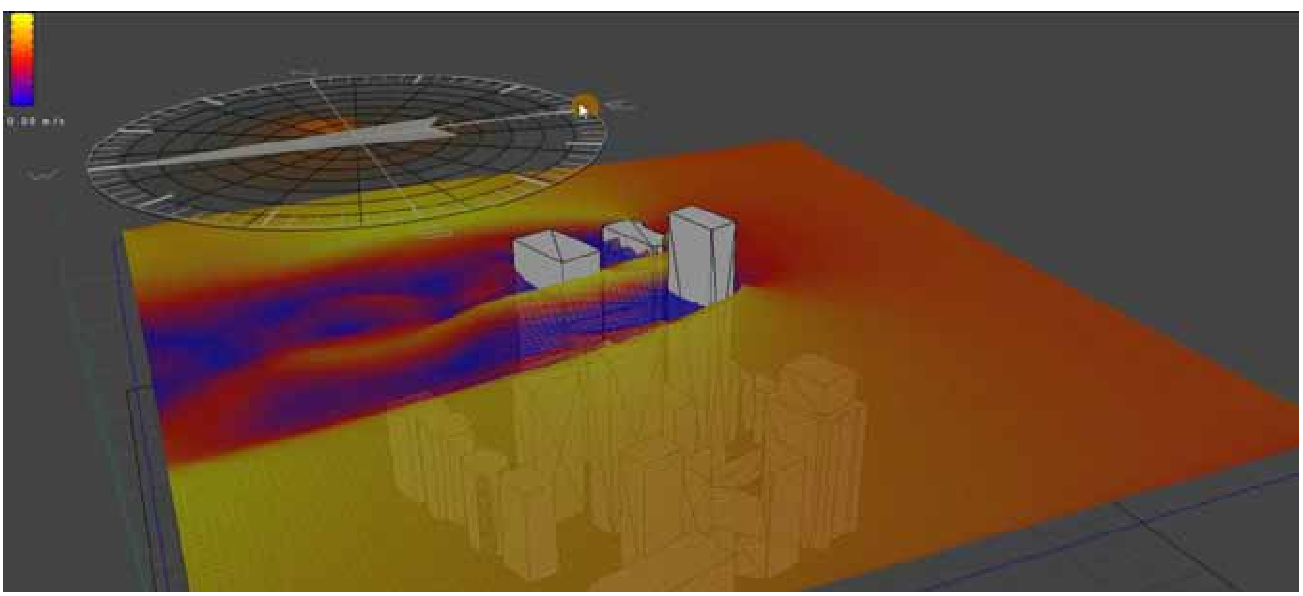
Biodiesel Cycle Diagram: http://www.usaei.us/The_Choice.html

Appendix B
Analysis Tests

Wind Studies
Source: Melissa Mazik

The first wind study was done using a 3D printed scale model, dry ice and a fan to demonstrate the pattern of wind flow around the buildings.





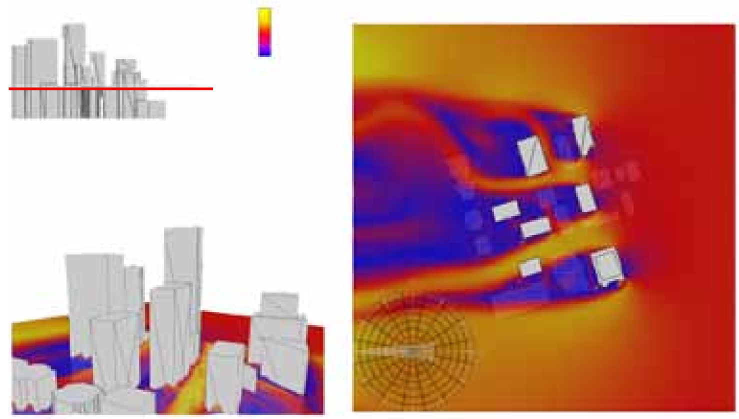
Easterly wind flow simulations at 240M +/-.

Appendix B
Analysis Tests

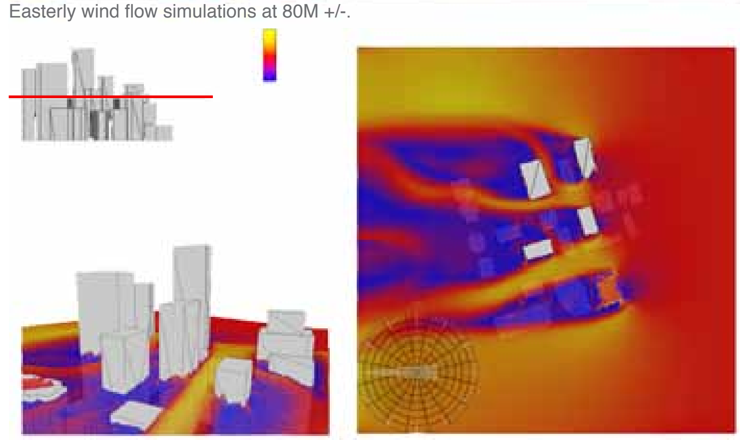
Wind Studies

Source: Melissa Mazik

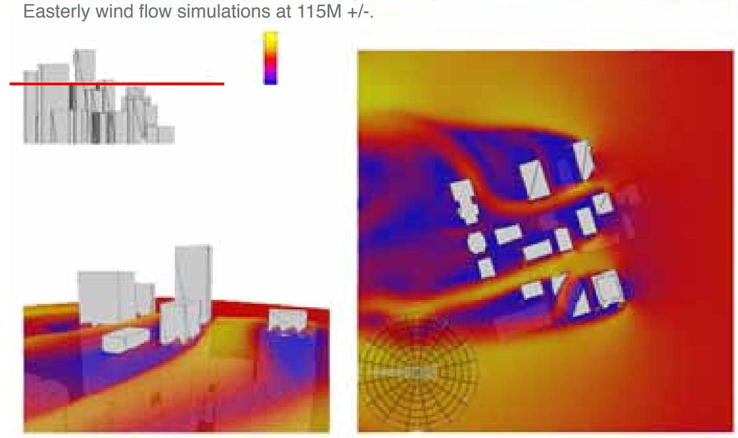
To confirm the physical study, a digital simulation was done using Autodesk Project Vasari. Below are still images captured at 4 different heights to illustrate the flow pattern. The eastern wind direction at 240m (bottom Left) high was the result that most influenced the design project.



Easterly wind flow simulations at 80M +/-.



Easterly wind flow simulations at 115M +/-.

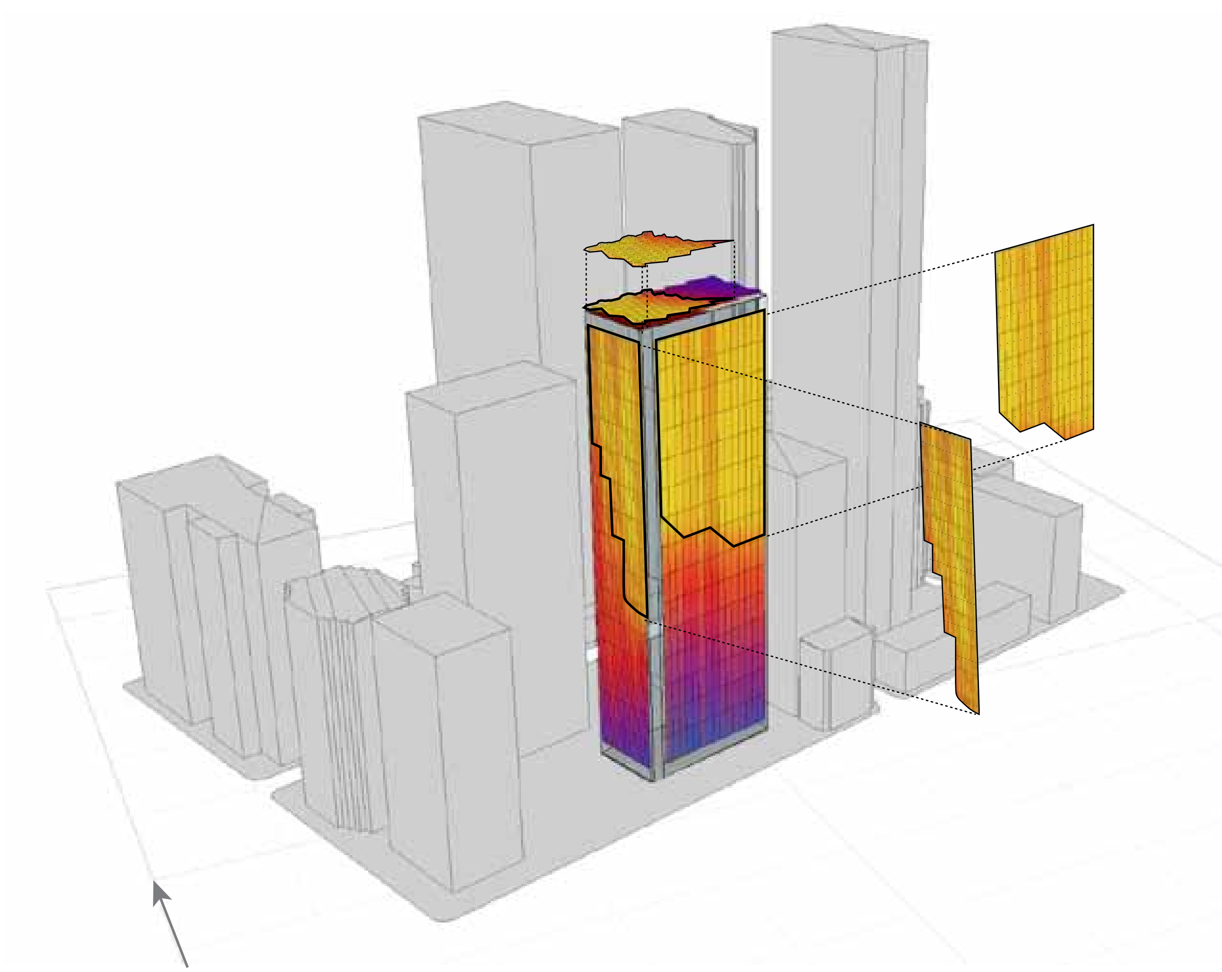


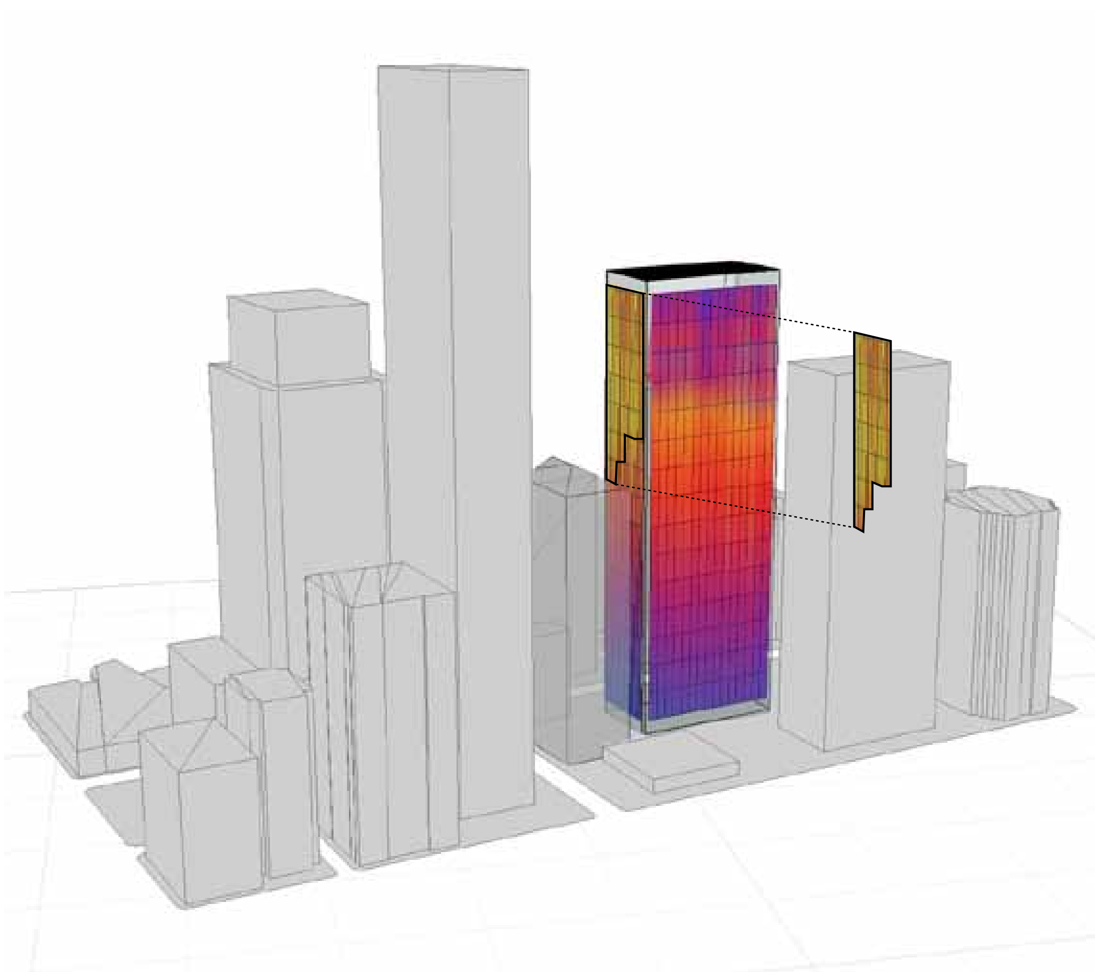
Easterly wind flow simulations at 200M +/-.

Appendix B
Analysis Tests

Solar Studies
Source: Melissa Mazik

The following solar accumulation simulation stills were produced using Autodesk Ecotect. The simulations were done to illustrate the average annual solar exposure to the exterior face of the building. The tests were used in determining the final form and function of the breathing apparatus.

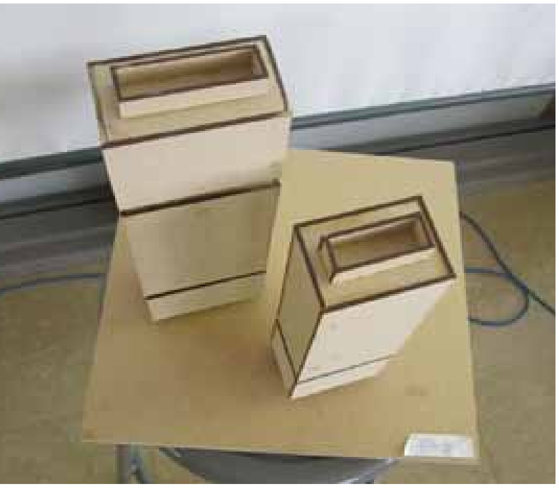


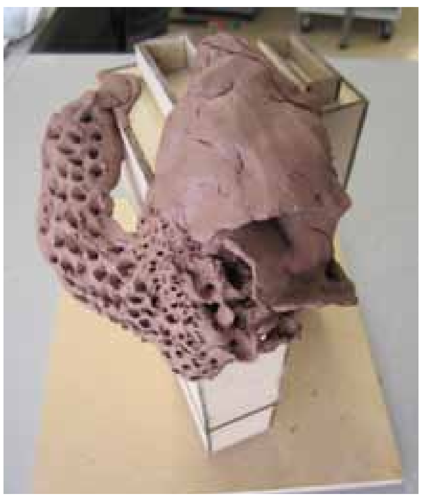


Appendix C
Scale Models

Symbiotic Iteration Study

Source: Melissa Mazik



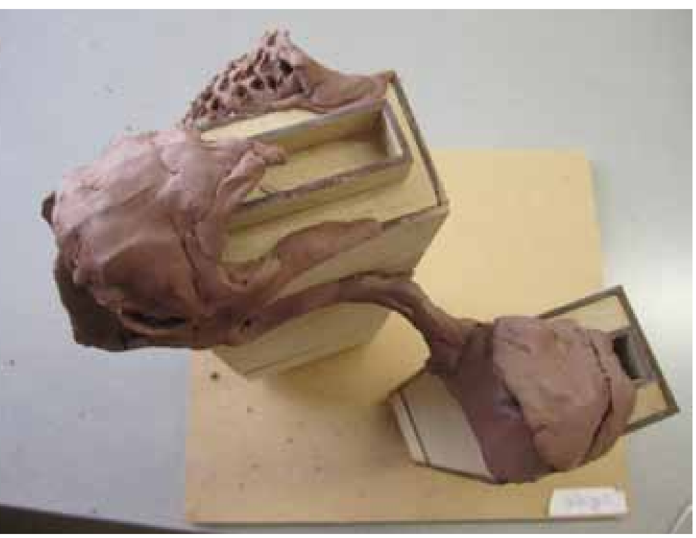





Appendix C
Scale Models

Symbiotic Iteration Study
Source: Melissa Mazik








Appendix C
Scale Models

Final Design Model
Source: Melissa Mazik