Title: **Condenser Typology: Open Envelope Vertical Farming, the Extremes of Tower Urbanism**

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Condenser Typology: open envelope vertical farming, the extremes of tower urbanism

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"In a hybrid vertical farm, harvests would inevitably cause 'delirium', as crops, people, and services would necessitate a 24-hour cycle of events"

Rem Koolhaas, (1994). Delirious New York

Can humidity-harvesting experiments inform tower urbanism in arid coastal environments? The finding of this study includes how the 'Condenser' tower typology deviates from other methods of vertical farming, climate control, and tower urbanism for the Dubai region. It includes an overview of the Condenser's rationale, precedence, technical workings, organization, incentives, and limitations.

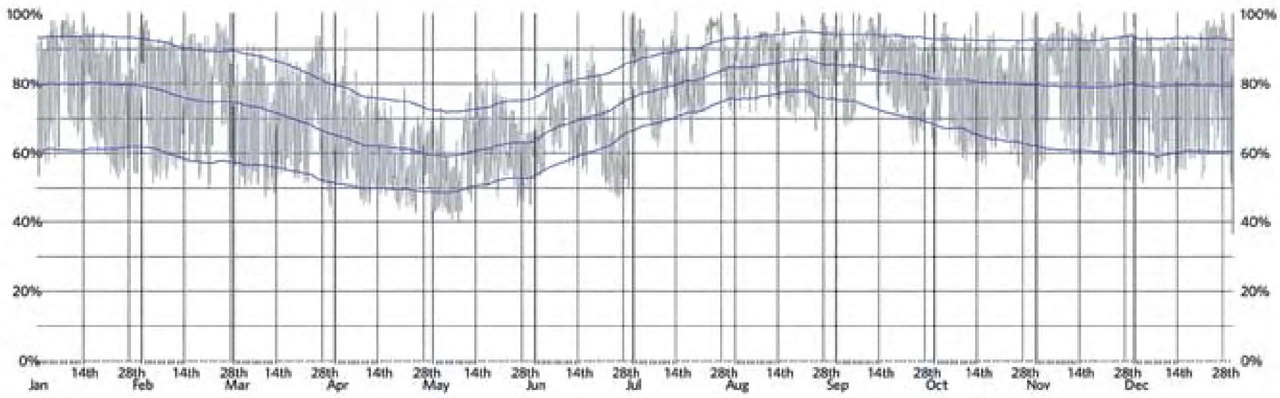
Foundations

Order, control, and purity are key attributes of the utopian socialist projects of the modern era. From within these modern visions, many academics have argued that 'high-technology' will conquer nature to save us from impending doom. These anthropomorphically centered desires have led us away from working with natural resources and into unfamiliar worlds (McHarg, 1992). The common side effects are feelings of alienation from the natural environment, and detachment from the city and the places we live. Our contemporaneous urban conditions are inspired in part by these visions, from the hinterlands, to the flat share (Pinder 2005). At the urban regional scale these ideologies are realized short of their social aspirations, leading to the erasure of local cultures, climatic ways of living, and the uniqueness of everyday life. Our modernized homes and workplaces are constructed as hermetic boxes of synthetic materials that are sealed and controlled by oversized ducts and advanced mechanical systems. To exacerbate the issue, some academics are promoting the use of hyper-elite and advanced mechanical technologies to germinate plants in closed-loop environments. Their manifestos depict towers as space ships that produce food for the entire city. Paradoxically, their proposals imply that humankind should seek subsistence in detached environments to deter an apocalyptic future. Preemptively, these vertical farm designers cite NASA-like, closed-ecological systems as the answer before considering contemporaneous bespoke solutions. Herein lies an opportunity to 're-territorialize', or open, the tower typology to dialectics with the city and its resources (Guattari, 1987). We could use our common hopes and desires for changing space in relation to life's fluxes. We could germinate plants in towers for climate control and food production and make towers that are responsive to the local culture, climate, and the urban fabric (Abalos, 2003) (Wood, 2008). In the following sections, I will speculate on the technological concepts of this 'open source' alternative, the Condenser tower typology. I will overview its precedence, technical application, and internal organization. Following these sketches is a discussion on the incentives, limitations, and implications of this and other methods of vertical farming.

...20 years to recover

"If a major project has not started in the city already, it is unlikely to start… I'm not thinking years, I'm thinking decades… After the Wall Street crash, it took 20 years to recover."

Peter Rees, the London city's planning officer, admitting that the gloom among developers and investors is so great it could be a generation before another tall building planning application is received by his department. From 'Decades till City's next tall building,' Building Design, March 6, 2009



Fog and humidity are prevalent sources of water, but a challenge to sequester.

In the MENA, agriculture accounts for 85-95% of water use.

Due to the unsuitable climate, limited water resources and poor soil conditions, the UAE imports 90% of its food and feed requirements.

Figure 1. Condensation Graph - Relative Humidity , Dubai, United Arab Emirates

Project Overview

This study introduces the Condenser tower typology and an uncommon vertical eco-tourism that is specific to Dubai's arid coastal environment. As one of Dubai's contemporary modes of urbanism, the ecologic tower could enhance the city's green credentials (Yeang 2008). The rationale for this project is that the tower's inherent nature is to 'condense' development. As it does so, it gains more access to greater amounts of sunlight and fresh air than any other building type. By reorganizing the tower, and exposing its inner core to Dubai's environment, we could collect or condense humidity to germinate plants for sustenance and climate control (see Figure 1). In this light, the Condenser situates itself as an alternative to many vertical farm proposals. On another front, the Condenser itself is a postmodern utopian project. It is situated to weave environmental, social cultural, and perceptive ecologies (Guattari, 2000). To foster these relations several of the Condenser's floors are designated for 'seasonal crop rotation', or 'flux-farming'. These are deceptive terms as these spaces are not dedicated to only growing crops. The function of these 'flux' spaces changes depending on seasonal natural resources, demand for crops, communal space, and finance. These variations create different social groupings within the tower. Together these space, seasonality, and communal living aspects introduce a rekindled 'keno-urban' tower typology (Dear, 2000). Its uncertainty of events derogates from modern aspirations and moves towards a postmodern utopianism.

Humidity Harvesting Precedence

Humidity harvesting can be traced into the depths of antiquity. Literature cites a wide, geographical gamut of these experiments, taking place in various regions of the world throughout time. This lineage ranges from the collection of dew in ancient Greece, taking the form of constructed dew ponds. It includes fog water collection from coastal mountain ridges in Hawaii and Chile, and extends to explorations on how to collect advection fog to settle nomadic tribes in Namibia (Beysens, 1998). The materials and methods that are employed to collect atmospheric vapors have varied in a manner that is significant to both time and region. This antiquated idea entered the modern era with the construction of an uninhabited masonry tower on a hill in rural France, called Knapen's air well (Nelson, 2003). Knapen built the large-scale masonry structure as a labyrinth of internalized cavities. He was keen on combining wind flows, diurnal temperature variations, and the structure's thermal mass to trap and condense atmospheric vapors (see Figure 2). Although he anticipated his air well to collect 90L (23.7 Gal) of water per meter of its surface per night, the well's 3.7m (12ft) height and 2.7m (9 ft) thick walls produced an average of 22L (5.8 Gal) of water by each sunrise.

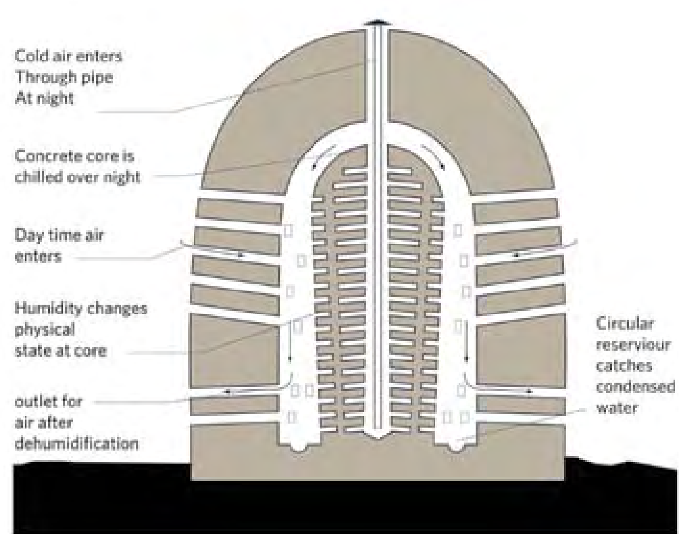


Figure 2. Knapen's Air well

FogQuest, the Canadian research organization, is widely regarded as one of the most prominent figures in modern day fog-water research. Their admirable interests lie in founding fog-water collection programs for villages struggling with water resource management. Today, FogQuest projects span across four continents in over twenty locations. Never the less, FogQuest meticulously considers the feasibility of each community project they undertake. Often, these communities share certain geographical, climatic, and social attributes. Many of the selected communities are located within arid coastal mountain regions that experience cyclic fog occurrences. A review of FogQuest's work also reveals that each community displays a commitment to a co-operative effort. Residents therefore choose to persevere with the trials and tribulations involved with establishing and maintaining a community fog water collection system (Edwards, 2001).

Mono-functionality is a common attribute to the humidity harvesting case studies cited thus far. Long treks through difficult terrain for establishment, maintenance, system malfunction, and abeyance are quite common. Communities that are isolated from these harvesting systems also carry the burden of transporting the collected water long distances before it can be put to use.

The Seawater Greenhouse breaks from this atomization and has implemented various working models throughout the Middle East and North Africa. It weaves local resources into an integral relationship that produces food and fresh water. (Paton, 2002) (Davies 2005)[1]. Sunlight, seawater, and airflow combine to form a greenhouse environment that prevents the leading causes of crop failure: evapotranspiration and excessive solar exposure (see Figure 3). Here, air circulation is the key. Mechanical fans play an important role in the process as they draw air into and through the greenhouse structure. As air passes into the greenhouse, it is drawn through seawater-saturated wall panels, creating a cool crop production area. Thus, the highly desirable environment enhances crop production while reducing evapotranspiration. Since the production areas are enveloped, the greenhouse becomes saturated with a surplus of humid air. To sequester this humidity the cool humidified greenhouse air is drawn through a wall of pipes circulating cool seawater (a condenser). Warm air from the greenhouses' roof cavity hits the pipes and mixes with this cool air. The exchange of humid airflows hitting the cool seawater pipes causes the humidity to change its physical state. It forms as fresh water condensation on the surface of the pipes and trickles into a reservoir for irrigating the crops (Davies, 2006). Producing a variety of food in extreme arid environments is therefore possible. Trucking desalinated water to rural farming areas or digging extraction wells is deemed unnecessary. Thus, the greenhouse overcomes the challenges of traditional farming in arid environments. However, the food produced in Seawater Greenhouse still requires transport to distribution centers and urban areas. If this technology were adapted to the tower typology, it may contribute to an integrated urbanization; condensing development, conserving natural habitats, and increasing the tower typologies emerging green credentials[2]. The following section contains a sketch of how the technology might form an integral relationship with the tower typology.

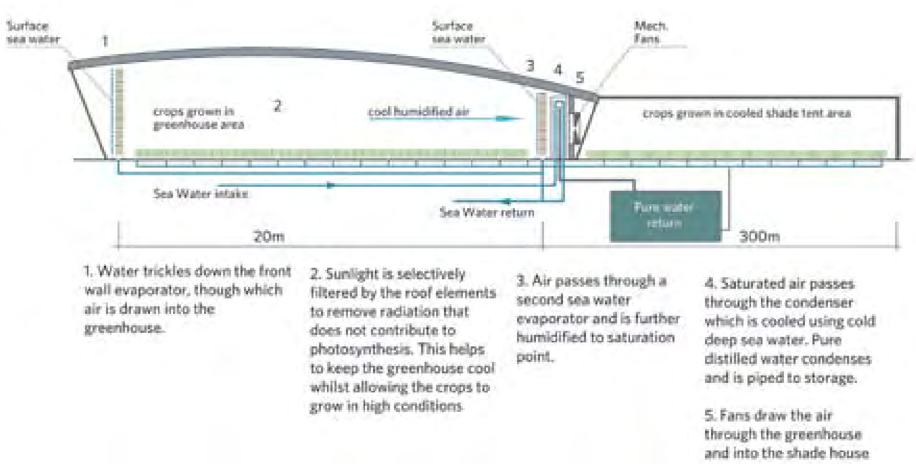


Figure 3. Paton Seawater Greenhouse

Typology Intervention

The tower typology, through its very nature, 'condenses' development and is exposed to greater amounts of sunlight and fresh air. Modifying and reconfiguring the 'flows' of the Seawater Greenhouse, and linking them to these tower 'byproducts' brings the potential to germinate plants within towers. Avoiding artificially controlled, sealed environments, this method also reduces resource redundancy. Substituting the mechanical fans, as employed by seawater greenhouse, with an atrium allows the towers internal organization to form a crucial role in climate control (see Figure 4). While the tower core is ventilated by these airflows, it draws air through the Flux Farming spaces. As you might suspect, these spaces are naturally cooled by airflows that pass through the outer wall. This permeable seawater saturated outer wall cools and humidifies the desert breeze as it passes into the cultivation areas. This cool air then escapes through the tower atrium. The mixture of air flows escaping through the tower atrium forces condensation to form on cool pipes distributing seawater from the gulf or the water table. A more detailed description of how this system could work is covered in the following section.

Sampling the environmental 'flows' of humidity-harvesting technologies has greatly informed the uncommon internal organizations, or interior urbanisms, of the Condenser. A survey of the working methods of commercial greenhouse farming also informed the rationale for the tower's stacking order. In one instance, crops could be

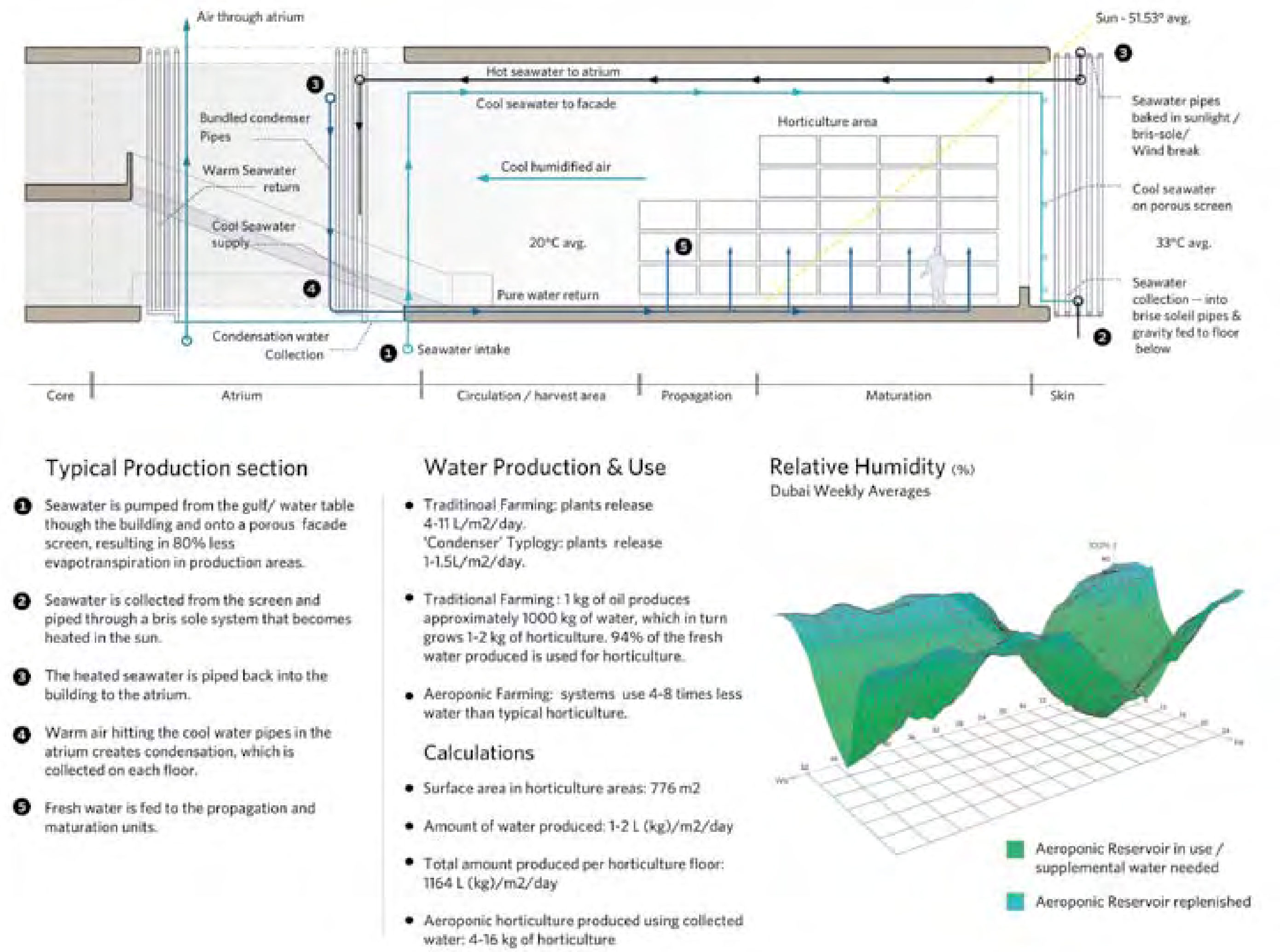


Figure 4. Typical Production Section

deployed in the tower's 'urban' areas, such as near, or within, the transfer lobbies. The benefit of this initial organization is that it enables a carbon dioxide (CO_2) and oxygen (O_2) exchange between the public and plant life. The proximity of mechanical equipment that expels CO_2 from the enclosed spaces of the tower is also beneficial to crop propagation. The exchange of these 'elements' forms a symbiotic relationship that eliminates the necessity of CO_2 generators. These wasteful devices are an ubiquitous solution to maximizing plant growth in commercial greenhouses. Thus, the concept of 'interior urbanism' becomes integral to reducing resource redundancy in crop production.

Responsive Spaces: From Outside to Atrium

Enveloping the garden lobbies, the 'seawater wall' system plays a major role in filtering Dubai's extremely arid environment. Consisting of two specialized panel types, the 'seawater wall' system sets the stage for climate control via its 'water wall' and 'filter wall' panels. Together, these panels envelope the production spaces as an integral facade system. The 'water wall' panels, made from durable porous materials, are whetted with naturally available seawater throughout their life. The timed release of seawater trickling onto these panels decreases the air temperature, while increasing the humidity levels of the production area. Over time the panels need to be replaced, as sea salt coagulates on the panel surface and constricts airflow. These salt-impregnated 'water wall' panels are removed and left to bake in the sun. This sets a hardened crystallized residue of sea salt, or magnesium chloride ($MgCl_2$), within its surface[3]. This process allows the panel to be converted into a dry 'filter wall' panel, as magnesium chloride is a low-grade desiccant. Therefore, the filter wall reduces the wet bulb temperature, increasing the rate at which the air is cooled (Paton, 2007).

Determining the 'choice' material for the 'water wall' panels could be determined by a series of material tests. Relatively inexpensive, the corrugated cardboard panels employed by the Seawater Greenhouse have the greatest utility. They provide permeability and just the right texture, allowing sea salt to impregnate it over time. Yet, the use of cardboard as a facade material is unlikely. Recalling other research experiments, brushed, perforated, or fibrous synthetics are alternatives worth considerable attention (see Figure 5)[4]. FogQuest uses fibrous synthetic materials for their fog collecting fences, such as polypropylene meshes, due to their record of resilience. They sequester fog while enduring intensive gusts of wind blowing between desolate mountain ridges. This type of panelized material may work just as well for towers, with little disruption to the structural system, all the while providing greater aesthetic value. Despite the panel material used, one should not lose sight of predictable results where the use of the water wall, in combination with the filter wall, drops the ambient room temperature to suit crop production.

Pumping seawater up through the atrium and allowing it to trickle down onto the 'water wall' facade panels enables the process of 'air conditioning' to begin. As the seawater percolates through the panels it is collected and circulated through a series of pipes along the perimeter of the building. These seawater pipes serve three main functions: a brise soleil, a windbreak, and a water heater. As a brise soleil or 'sun breaker', the set of pipes reduces excessive solar gains, allowing only diffuse light to pass into the production areas. Breaking down and redistributing forceful gusts of wind before they pass into the garden lobbies, the pipes concurrently work as a 'wind breaker'. As the seawater is piped around the perimeter of the production areas, it is heated before it is distributed back into the atrium. This seawater warms the atrium before it is piped away. To complete the circuit, cool seawater is pumped up into the atrium and onto the seawater panels to create the optimum growing environment. The surplus of cool air in the production area escapes through the warm tower atrium. The mixture of air currents causes condensation to form on the surface of the cool seawater pipes. This freshwater condensation is collected and fed into the reservoir of aeroponic modules, an adaptation of existing aeroponic kits for commercial crop production (see Figure 6a). Various factors determine the quantity of fresh water that can be collected[5]. A series of preliminary calculations (Calculations, see Figure 4), are based off of the ratios available in the seawater greenhouse literature. These ambitious figures listed, however, may vary greatly when the technology is adapted to tower development (Davies, 2005). From these statistics, it was determined that an 8-meter floor-to-floor horticultural space was highly advantageous. It allows larger quantities of air to encounter the water wall panels. This double height spacing also ensures that ample light enters the production areas.

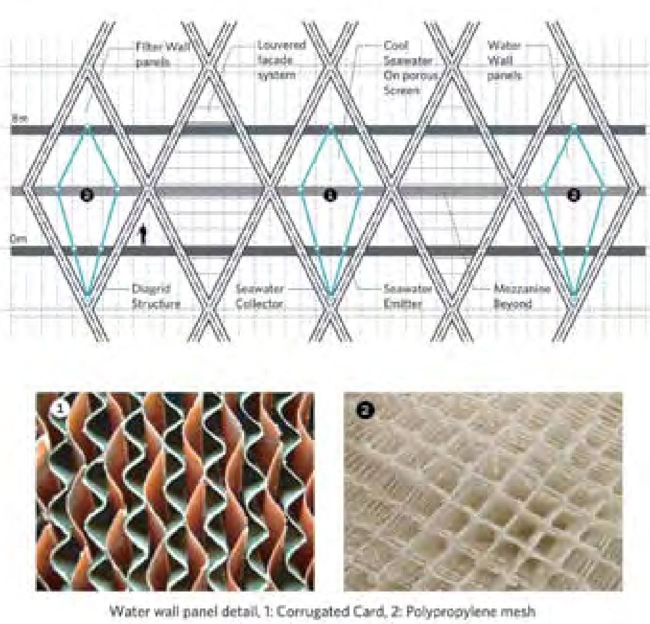


Figure 5. Seawater Wall

Other ambitious speculations can also be brought forward at this time. Condensing humidity to germinate plants, the Condenser typology lends its spaces to different types of crop forecasting. To illustrate this concept, humidity forecasting could depict the amount of water available for crops and the quantity of horticulture that could be produced before the system becomes dependant upon external water sources (Relative Humidity, see Figure 4).

Starting Small: For Flexibility, Hybridity, and Delirium

Developing a simple working model of a vertical farm will require an ambitious, if not heroic, effort. Moreover, the vertical farm's potential to feed an entire city is dubious. The vertical farm would have to enter a pedantic battle with worldwide food logistics networks to feed the city. Ominous climatic events, or social and financial upheavals leading to the next urban revolution are even less likely settings to witness the realization of high-tech vertical farming (Soja, 2001). Effectively, it seems ideal to focus on small interventions within the tower and other types of architecture. The following paragraphs will cover how starting small might work.

Introducing crops to mixed-use tower development could initiate capital gains while crop production systems are fine-tuned (Hani, 2005). This period of fine-tuning establishes the choice method of germinating plants. For the Condenser typology, a permutation of the traditional aeroponic farming system, among others, is proposed. In theory, the aeroponic module would allow the plants to be effortlessly repositioned. The lightweight modular system also minimizes water use and the tower's plumbing and structural loading (see Figure 6b). Thus, the size, location, organization, and purpose of the garden lobbies may change on demand. More importantly, crops could be situated to suit the availability of natural resources (see Figure 7) (Willis, 1995).

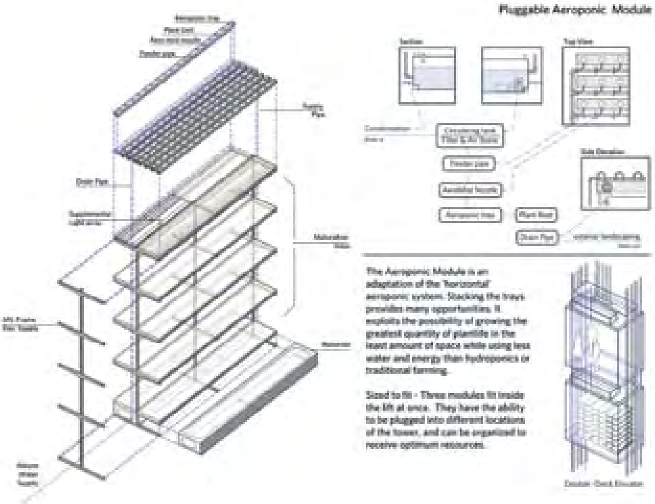


Figure 6a. Aeroponic module

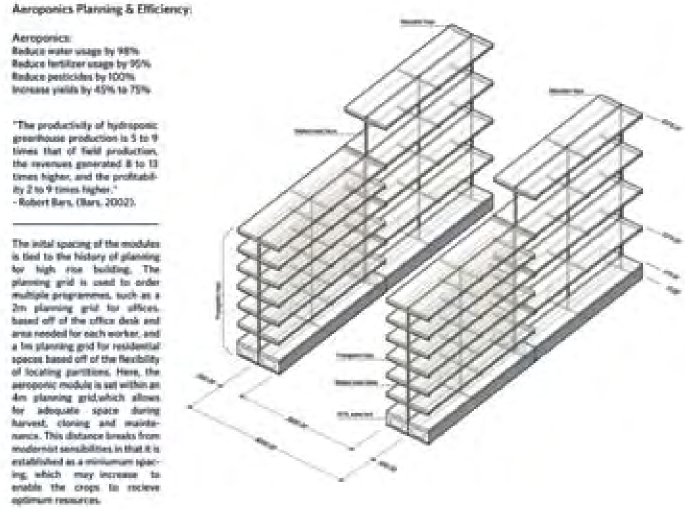
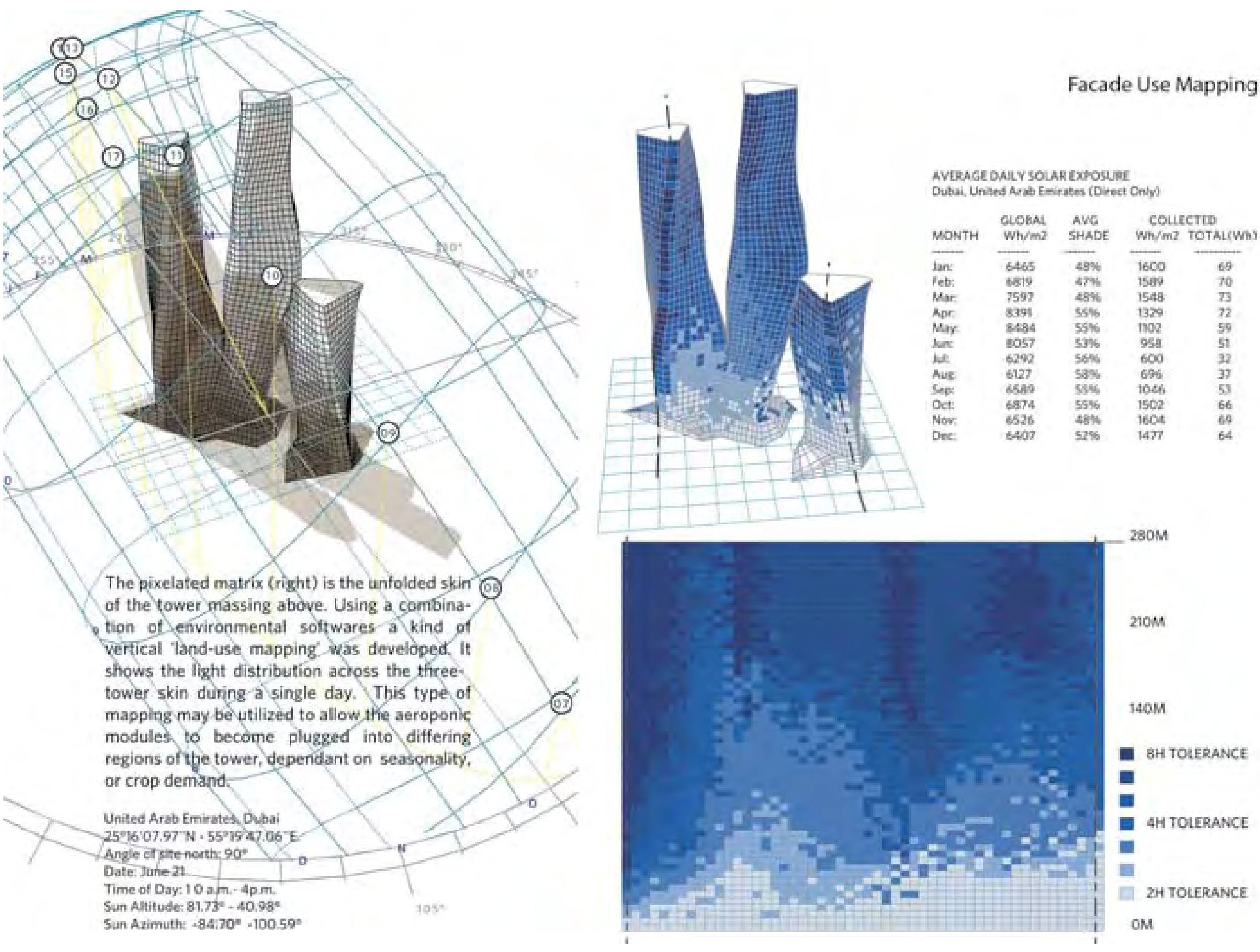


Figure 6b. Aeroponics spacing



MONTH	GLOBAL Wh/m2	AVG SHADE	COLLECTED Wh/m2	COLLECTED TOTAL(Wh)
Jan:	6465	48%	1600	69
Feb:	6819	47%	1589	70
Mar:	7597	48%	1548	73
Apr:	8391	55%	1329	72
May:	8484	55%	1102	59
Jun:	8057	53%	958	51
Jul:	6292	56%	600	32
Aug:	6127	58%	696	37
Sep:	6589	55%	1046	53
Oct:	6874	55%	1502	66
Nov:	6526	48%	1604	69
Dec:	6407	52%	1477	64

Figure 7. Facade Use Mapping

One of the incentives of the Condenser is its use of naturally available resources. As with other methods of Vertical Farming, this advanced approach to cultivation would mean careful planning, a larger initial investment, and environmental monitoring. However, this approach eliminates hermetic, resource-redundant environments. This uncommon way of farming could very well increase crop productivity, marketability, and eco-tourism. Effectively, these small 'flux' decisions relay their demands throughout the tower, ushering in a different way to conceptualize the design process.

The limitations of vertical farming are exacerbated by the very nature of the tower typology itself. Vertical farming, as a commercial enterprise, would overwhelm the vertical circulation system, structural frame, and plumbing systems of a typical tower. During the design process, myriad pipes and ducts must be organized. Additional storage space and lifts may be necessary to accommodate harvests. This relates to vertical circulation scheduling. The preparation of timetables for harvest periods, in relation to other functions in the tower, would prevent crops jamming the lifts during peak business hours. There would also need to be a strategy for keeping the growing spaces flexible for other uses. Together, these factors as a whole come across as damning but essential aspects for the vertical farm's design development process. This becomes crucial when considering the plumbing systems required to foster the advanced horticultural systems proposed. For instance, the number of pipes that are necessary to distribute seawater and the amount of fresh water the system can condense is unknown.

An extensive study of the interior organization of the tower and the plants it produces could ease the burdens of vertical farming. Arranging crops by their propagation and maturation requirements could ensure that each crop receives the appropriate resources, positioned either closer to the core, or nearer to the facade (see Figure 8). Furthermore, preparing a mapping of the daylight and water

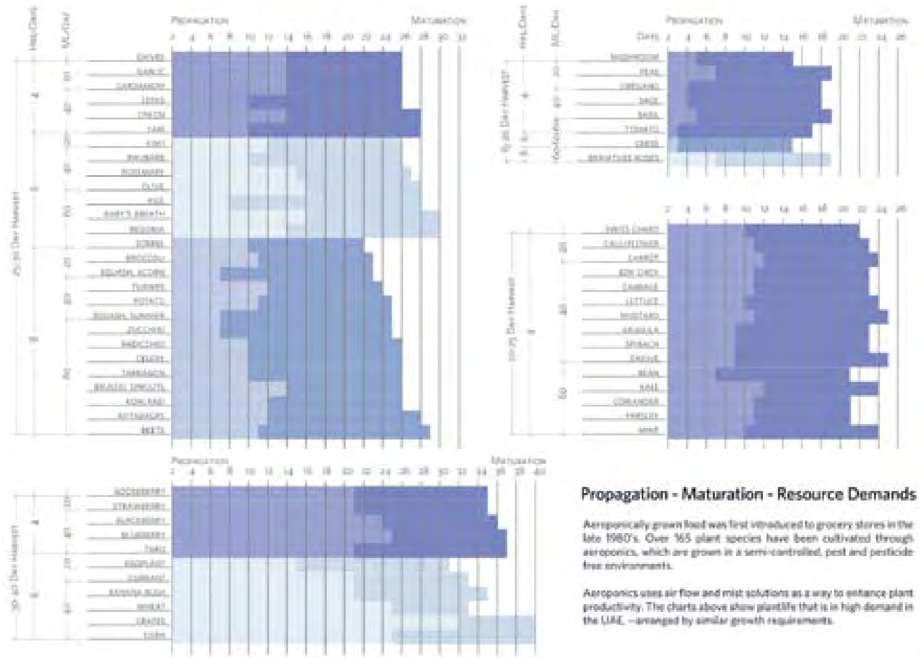


Figure 8. Propagation Maturation Demands

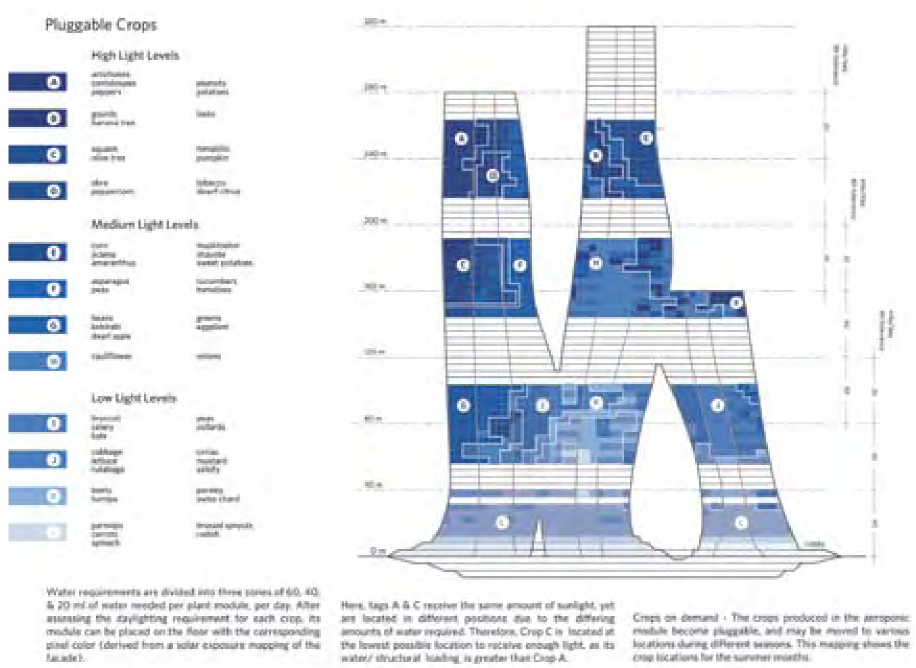


Figure 9. Pluggable Crops - Tower Diagram

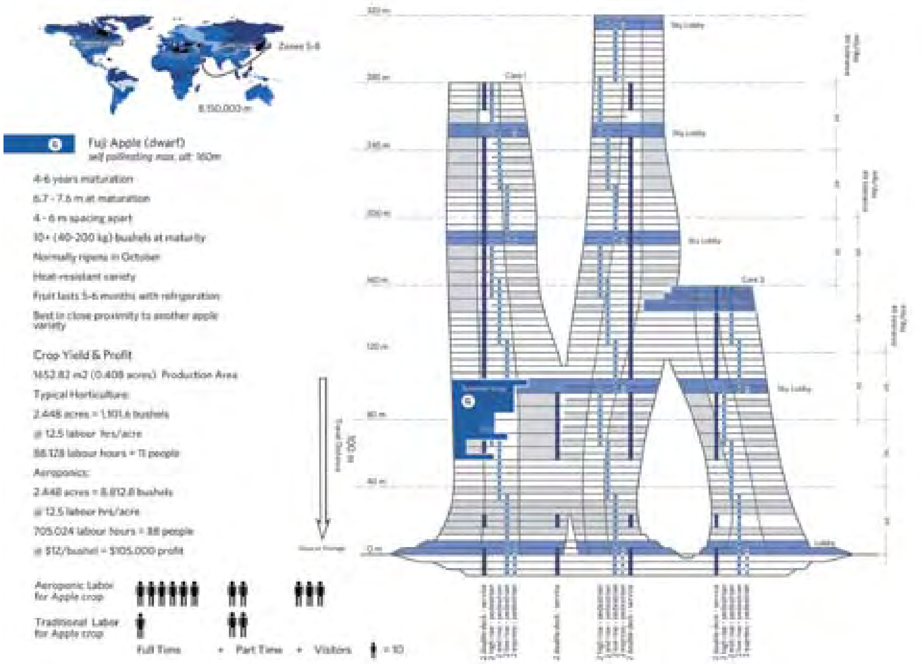


Figure 10. Seasonality Labor and Food Miles - Tower Diagram

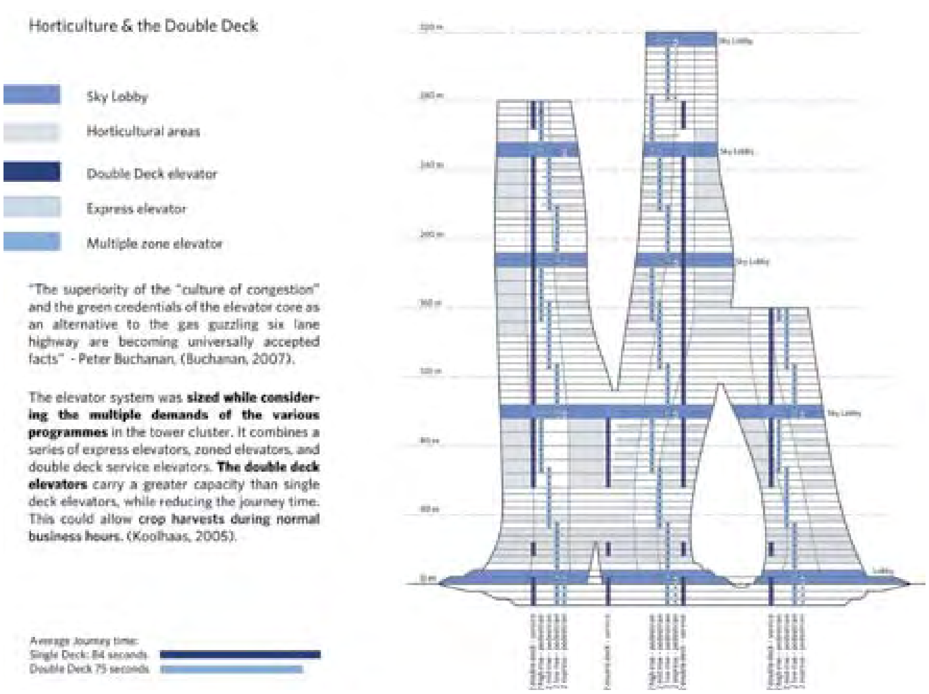


Figure 11. Double Deck Elevator - Tower Diagram

requirements of each crop allows farmers to arrange each crop grouping. This simple list makes sense of what might go where, when a crop is in demand. Crops requiring less water are on a higher floor, while thirsty crops that need a lesser amount of light are closer to greater water sources at the base of the tower (see Figure 9). This bottom-up strategy allows crops to be situated for efficient productivity, while reducing structural and plumbing burdens.

The Condenser is a tower that never sleeps. Demanding the next order of attention is the excessive burdens placed on the vertical circulation system of the hybrid Condenser. Lifts would necessarily redistribute massive quantities of horticulture to kitchens, containment areas, or shops (see Figures 10,11) (Koolhaas, 2005). In a hybrid vertical farm, harvests would inevitably cause 'delirium', as crops, people, and services would necessitate a 24-hour cycle of events (Koolhaas, 1994). Double Decker lifts and careful scheduling could ease a 'crop-jamming' crisis. Another solution may be the distribution of harvests off-peak, after office hours and custodial work, but before hotel check-in times and housekeeping.

Condenser Tower Typology: Outro

The technical aspects of this project pertain to a highly optimistic scenario where merged towers maximize efficiency and share resources. Thus, two towering masses bridge, they meet mid-air at the flux-farming spaces. The benefit is that together, these conjoined towers mitigate services and circulation burdens. They form large, productive, green, social spaces that expand across the towers. Hypothetically, one tower could be dedicated to horticultural production, while its mate is used for other programmatic issues. For example, maturing plants could partition learning centers, food courts, office environments, and fitness amenities. Therefore, crops on demand also become social situations on demand[6]. The ability to germinate plants on a variety of floors calls for architects to create flexible, adaptable, and convertible Flux spaces. This method of climate control and farming is also dependent on spaces that are open to fresh airflow, the seawater system, atrium ventilation, and moderate sunlight. These organizational methods, dependant on seasonality and natural resources, relay their demands throughout the tower interior. This creates different social patterns between farmers, residents, and workers who become woven into a 24-hour cycle of events. Through these processes, the towers become burdened with being more flexible and adaptive. As a result, the open-air base of the tower becomes responsive to the demands of the cityscape, which deviates from the typical relationship towers have to social life and the metropolis.

Optimistically, most of the technical burdens entailed can be overcome via trial, error, and the evolution of any vertical farm concept. Yet, the greater site of the city must contextualize it to create bespoke experiences. As creative local variations emerge, the vertical farm would take on the specificity of its urban context, which would in turn reinvent each tower's internal organization. In this sense, the concept of the vertical farm would evolve along the path of its predecessors, such as the distinctive New York and Chicago office tower typologies; guided by grids, grain, code, finance, and ambition. ■

...shards of glass

> "Whatever you may have felt about Mr. Gehry's design – too big, too flamboyant – there is little doubt that it was thoughtful architecture. His arena complex, in which the stadium was imbedded in a matrix of towers resembling falling shards of glass, was a striking addition to the Brooklyn skyline; it was also a fervent effort to engage the life of the city below."
>
> *Mr. Ouroussoff, architecture critic of the NY Times, is critiquing the switch of designers by developer Forest City Ratner for the Atlantic Yards development in Brooklyn, NYC. The Atlantic Yards will include a new home for the NY Nets basketball team along with residential and office towers. The designer was changed from Frank Gehry to Ellerbe Becket. From 'NY Times,' page C1, The Arts issue of June 9, 2009*

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Footnotes

[1] Seawater Greenhouse Prototypes have been developed in the Canary Islands, Abu Dhabi, and Oman.

[2] It is important to note that, despite my focus on humidity collection, myriad proposals for 'green' towers exist and my rationale for such a proposal lays heavy burdens on their presence. The earliest modern proposal might have been a century ago in Life Magazine's 1909 theorem, which was revived by Rem Koolhaas in Delirious New York (Koolhaas, 1994). Other projects include Le Corbusier's Immeubles-Villas, 1922 and SITE's Highrise of homes, 1981. Recent noteworthy projects are: Ken Yeang's Bioclimatic Skyscraper (Menara Mesiniaga, built 1992); Despommier's Vertical Farm, 2000; MVRDV's PigCity, 2000; Pich-Aguilera's Garden Towers, 2001 (Ruby, 2005).

[3] Inventors of the Seawater GreenHouse LTD, have proposed the use of Desiccant panels for non-horticultural, HVAC systems for projects in the UAE. The panels are intended to be a substitution for traditional HVAC systems.

[4] One point of reference for other 'technical utopias' using seawater is the founder of Biorock, Wolf Hilbertz. See his publication "The architects of a new Atlantis" at http://www.biorock.net/Technologies/index.html, for more information.

[5] This list of factors is not exhaustive: 1) The amount of humidity in the air, 2) the surface area that the seawater is in contact with, 3) the performance of the 'water panel', and 4) the temperature of the 'cool' seawater pipes in the atrium.

[6] In reference to Andrea Branzi's Agronica.