THE [HYDRO-GEN] CELL_

A HYDROPONIC, REGENERATIVE, MODULAR SYSTEM FOR OPTIMIZED VERTICAL FARMING_

THESIS PROPOSAL PRESENTED TO THE FACULTY OF THE DEPARTMENT OF
ARCHITECTURE AND CONSTRUCTION MANAGEMENT BY_

JOSE ASBIEL SAMANIEGO_

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE_

BACHELOR OF ARCHITECTURE_

KENNESAW STATE UNIVERSITY, MARIETTA, GEORGIA
SPRING SEMESTER 2020

ACKNOWLEDGEMENTS_

THROUGHOUT MY TIME IN THIS PROGRAM I HAVE BEEN BLESSED TO HAVE HAD THE OPPORTUNITY TO MEET CERTAIN INDIVIDUALS THAT WOULD HAVE A LIFE-LONG IMPACT IN BOTH MY PROFESSIONAL AND PERSONAL GROWTH. FIRST, AND FOREMOST I WOULD LIKE TO THANK BOTH MY MENTOR AND THESIS ADVISOR DR. ARASH SOLEIMANI, FOR BEING AN OUTSTANDING EDUCATOR AND FOR BEING A GREAT ROLE MODEL WITHIN THE DEPARTMENT. THANK YOU FOR YOUR GUIDANCE, YOUR COMMITMENT, AND MOST IMPORTANTLY FOR PAVING THE ROAD OF MY CAREER.

I WOULD ALSO LIKE TO THANK DR. GIOVANNI LORETO FOR PROVIDING ME THE RESOURCES TO CARRY OUT MY PROJECT. TO RACHEL JOHNSON FOR ALWAYS ALLOWING ME TO 3D PRINT PRACTICALLY EVERYTHING I WOULD PRESENT TO HER. TO THE PEOPLE THAT WORK IN THE WOODSHOP THANK YOU FOR YOUR PATIENCE. WITHOUT YOUR SUPPORT THIS PROJECT WOULD NOT HAVE BEEN FABRICATED.

TO THE DEPARTMENT OF ARCHITECTURE AND CONSTRUCTION MANAGEMENT THANK YOU FOR SUCH AN ENRICHING EXPERIENCE. THESE PAST FIVE YEARS IN THE PROGRAM HAVE TAUGHT ME ALOT ABOUT OUR PROFESSION AND HAS HELPED ME MATURE INTO BECOMING A PROMINENT ARCHITECT.

I WOULD ALSO LIKE TO THANK MY COLLEAGUES AS THEY HAVE BEEN ON THE SAME JOURNEY AS ME THESE PAST FIVE YEARS. THANK YOU FOR ALL THE PRECIOUS MOMENTS WE'VE SHARED, FOR ALL THE LATE NIGHTS WE'VE PULLED TOGETHER, BUT MOST IMPORTANTLY FOR ALWAYS LOOKING AFTER ONE ANOTHER. NHAN, CALEB, ANA, HALA, MICHELLE, NELLY, EDDIE, DIANA, AND NOAH A SPECIAL THANK YOU GOES OUT TO YOU GUYS FOR BEING SUCH A UNIQUE GROUP OF PEOPLE WHOM I'VE REALLY GROWN INTO. YOU GUYS MEAN THE WORLD TO ME AND I HONESTLY DON'T KNOW HOW I WOULD'VE GOTTEN THROUGH THE PROGRAM WITHOUT YOU GUYS. THANK YOU FOR HAVING OFFERED ME YOUR FRIENDSHIP, YOUR TRUST, AND FOR ALL THE BEAUTIFUL MEMORIES.

LASTLY, I WOULD LIKE TO THANK MY FAMILY FOR BEING MY BACKBONE THESE PAST FIVE YEARS. THANK YOU DAD FOR BEING A STRONG CHARACTER IN MY LIFE. NOW THAT I'M OLDER I FINALLY UNDERSTAND WHY YOU WERE SO HARD ON ME. YOU HAVE SHOWN ME THAT THROUGH HARD WORK AND PERSEVERANCE ANYONE REGARDLESS OF THEIR BACKGROUND CAN SUCCEED IN LIFE. THANK YOU FOR SCULPTING ME INTO THE MAN I AM TODAY.

MY BELOVED MOTHER, THANK YOU FOR BEING MY NUMBER ONE FAN. YOUR LOVE AND SUPPORT HAVE BEEN FUNDAMENTAL IN THESE PAST FIVE YEARS. THANK YOU FOR ALWAYS MAKING SURE I WAS WELL FED AND FOR TEACHING ME TO SEE LIFE FROM A POSITIVE PERSPECTIVE EVEN WHEN THINGS WEREN'T GOING SO WELL. GRACIAS MAMA.

TO MY SIBLINGS JEAN AND ANDREA, I WOULD LIKE TO THANK YOU GUYS FOR ALWAYS KEEPING ME COMPANY WHENEVER I WORKED FROM HOME. FOR BEING CURIOUS ABOUT WHAT I WAS WORKING ON AND FOR CHEERING ME ALL THE WAY THROUGH THE PROGRAM. AS YOUR OLDER BROTHER I ALWAYS STRIVED TO BE AS PERFECT AS I COULD TO MOTIVATE YOU GUYS IN PURSUING YOUR OWN DREAMS.

DEDICATION_

I WOULD LIKE TO DEDICATE THIS PROJECT TO MY UNCLE AND GRANDFATHER, BOTH WHOM WERE EAGER AND EXCITED FOR ME TO ATTEND COLLEGE. TIO CHOFO THANK YOU FOR BELIEVING IN ME AND FOR SELECTING ME AS THE PRIMARY ROLE MODEL IN THE FAMILY BRANCH.

LASTLY, I WOULD LIKE TO DEDICATE THIS PROJECT TO THE FUTURE GENERATIONS. ITS BECAUSE OF PROJECTS LIKE THIS ONE THAT MOTIVATES YOUNGER MINDS TO DREAM AND VISUALIZE A BETTER WORLD. I HOPE THAT THIS THESIS RESEARCH PROJECT INSPIRES THE NEXT GENERATION TO DREAM AND IMAGINE A HEALTHIER PLANET EARTH.

DEPARTMENT OF ARCHITECTURE_

COLLEGE OF ARCHITECTURE AND CONSTRUCTION MANAGEMENT
KENNESAW STATE UNIVERSITY

THESIS TITLE_

"THE [HYDRO-GEN] CELL_
A HYDROPONIC, REGENERATIVE, MODULAR SYSTEM FOR OPTIMIZED VERTICAL FARMING"

STUDENT NAME_

JOSE ASBIEL SAMANIEGO

THESIS ADVISOR_

DR. ARASH SOLEIMANI, PHD

THESIS COORDINATOR_

ELIZABETH MARTIN-MALKIAN

DEPARTMENT CHAIR_

DR. ANTHONY RIZZUTO, PHD

THE [HYDRO-GEN] CELL_

A HYDROPONIC, REGENERATIVE, MODULAR SYSTEM FOR OPTIMIZED VERTICAL FARMING_

THESIS STATEMENT_

THIS RESEARCH PROJECT AIMS TO DESIGN, DEVELOP, AND TEST AN INTELLIGENT HYDROPONIC SYSTEM THAT CAN BE INTEGRATED INTO THE BUILT ENVIRONMENT FOR ADVANCING SUSTAINABILITY.

PROPOSAL_

THE PROJECT SPECIFICALLY AIMS AT ADDRESSING THE IMPACT CLIMATE-CRISIS HAS HAD ON THE AGRICULTURE IN THE MUNICIPALITY OF RIO GRANDE IN ZACATECAS, MEXICO. BY TESTING AND GROWING CROPS IN A CONTROLLED ENVIRONMENT BY MICROMANAGING DIFFERENT VARIABLES THAT AFFECT A CERTAIN TYPE OF PLANTS GROWTH.

THROUGH THE APPLICATION OF THE **ARDUINO** SOFTWARE THE **[HYDRO-GEN] CELL** WILL BE AN INTELLIGENT SYSTEM WITH MULTIPLE APPLICATIONS THAT WILL OPTIMIZE THE WAY IT PERFORMS BASED ON THE PLANT[S] ITS GROWING AND ITS SURROUNDINGS. THE PROTOTYPE WILL EVENTUALLY BE INTEGRATED WITHIN THE MID-TO HIGH-RISE BUILDING TYPOLOGY IN AN URBAN SETTING.

THE **HYDROPONIC-REGENERATIVE** OR **[HYDRO-GEN] CELL** IS ENVISIONED AS **BIO-MECHANICAL HYBRID MACHINERY** THAT, WHILE DESIGNED TO BE USED IN MID-TO HIGH-RISE BUILDINGS IT WOULD ADDRESS SUSTAINABLE ASPECTS SUCH AS FOOD PRODUCTION, ENHANCEMENT OF AIR CLEANING CAPACITY, AND REDUCTION OF ENERGY CONSUMPTION.

RESEARCH CONTEXT_

THIS THESIS WILL EXPLORE THE ADVANCEMENTS IN HYDROPONIC TECHNOLOGY AND AI INTEGRATION WITHIN THE FIELD OF AGRICULTURE AND ANALYZE HOW THESE SYSTEMS WORK. BY UNDERSTANDING HOW THE SYSTEMS FUNCTION THE DEVELOPMENT OF A NEW HYDROPONIC SYSTEM **[HYDRO-GEN] CELL** WILL BE MADE USING 3D PARAMETRIC MODELING SOFTWARE TO PRODUCE **CELLULAR ORGANIC MODULES**. THE SYSTEM WILL BE COMPRISED OF THE SPECIAL MODULES THAT WILL BE DESIGNED FOR VARIOUS SOLAR CONFIGURATIONS. THE MODULES WILL ATTACH AND DETACH FROM A HEXAGONAL STRUCTURE.

THE INTEGRATION OF THE **ARDUINO** SOFTWARE WILL BE APPLIED WITHIN THE HYDROPONIC SYSTEM AS IT WILL ALLOW FOR EASY MONITORING OF THE IMMEDIATE SURROUNDINGS VIA SPECIFIC SENSORS. THE FINAL PROTOTYPE WILL BE A **VERTICAL PARAMETRIC HYDROPONIC SYSTEM** THAT WILL RESEMBLE AND PAY HOMAGE TO THE **MEXICAN FAN PALM**; A NATIVE SPECIES OF PALM THAT HAS BEEN ERADICATED IN THE REGION IN ORDER FOR FARMERS TO HAVE MORE SPACE TO GROW THEIR CROPS.

RESEARCH QUESTIONS_

1) **CHANGE IN MEXICO**: HOW ARE FARMERS IN THE MUNICIPALITY OF RIO GRANDE, ZACATECAS DEALING WITH THE ISSUE OF WATER SCARCITY AND HOW HAS IT AFFECTED THEIR ABILITY TO GROW CROPS?

2) **THE [HYDRO-GEN] CELL**: HOW DOES THE **[HYDRO-GEN] CELL** ENHANCE THE FOOD PRODUCTION AND AIR CLEANING CAPACITIES IN THE CONTEXT OF BUILT AND NATURAL ENVIRONMENTS?

3) **BUILDING INTEGRATION**: HOW CAN THE **[HYDRO-GEN] CELL** BE INTEGRATED INTO MID AND HIGH-RISE BUILDINGS THROUGHOUT MEXICO TO OPTIMIZE CULTIVATION PRACTICES?

METHOD OF INQUIRY_

1) **SURVEY/QUESTIONNAIRE**: A DISPERSE SURVEY STUDY AND QUESTIONNAIRE WILL BE CONDUCTED IN THE REGION ASKING BOTH THE OLDER AND NEWER GENERATIONS QUESTIONS REGARDING THEIR ABILITY TO HARVEST CROPS IN RESPONSE TO THE CHANGING CLIMATIC CONDITIONS.

2) **RESEARCH THROUGH DESIGN**: THE **[HYDRO-GEN] CELL** WILL BE DESIGNED, BUILT, TESTED, AND MODIFIED TO MEET CERTAIN FOOD PRODUCTION AND AIR CLEANING CRITERIA.

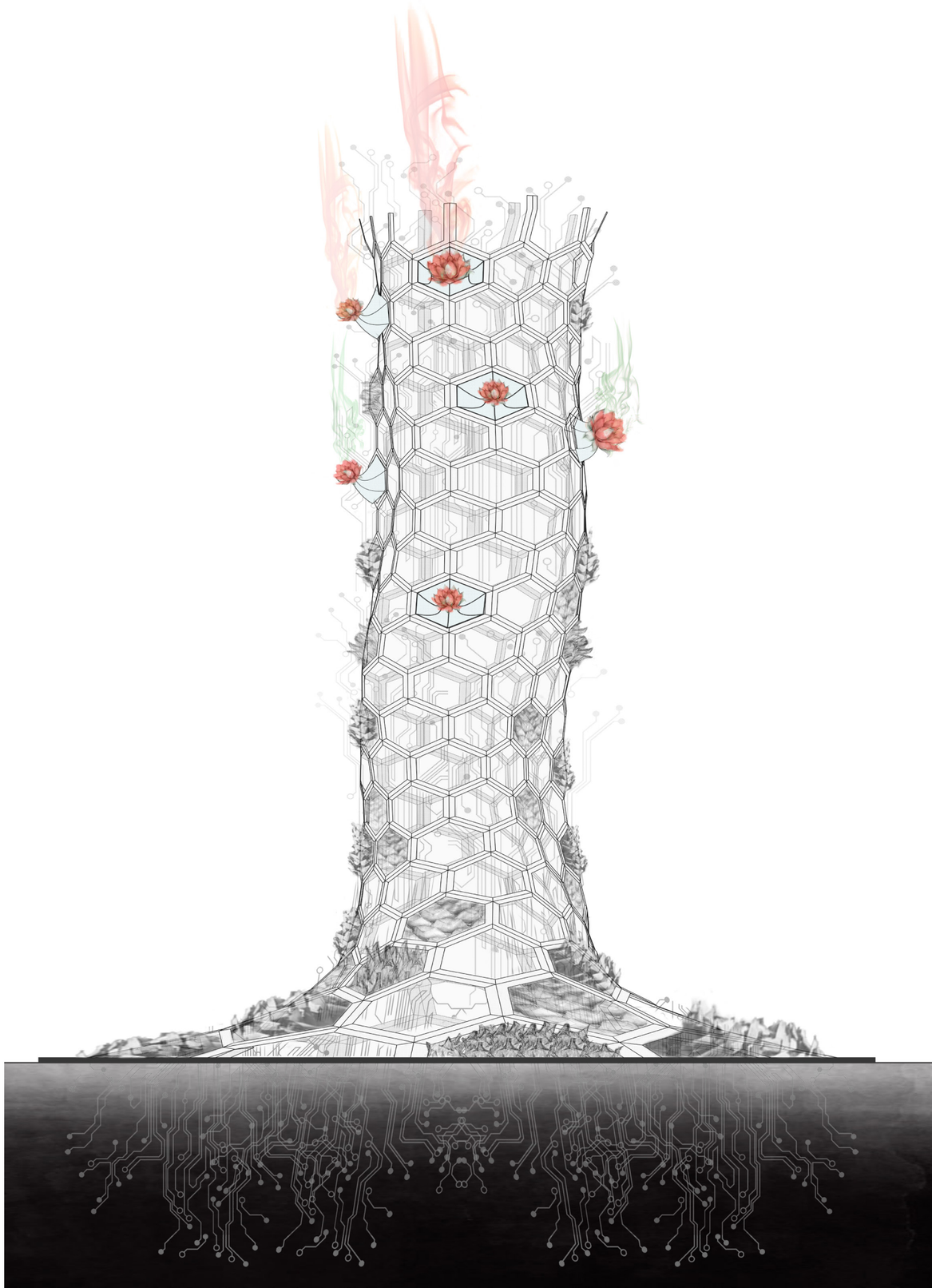
3) **RESEARCH THROUGH DESIGN**: THE **[HYDRO-GEN] CELL** SYSTEM WILL BE INTEGRATED WITHIN THE MID-TO HIGH-RISE BUILDING TYPOLOGY AND BASED ON SPECIFIC PARAMETERS SUCH AS; PLANT SPECIES USED, NATURAL LIGHTING AND ATMOSPHERIC PRESSURE WILL DETERMINE THE STRATEGIC PLACEMENT AND LOCATION OF THE [HYDRO-GEN] CELL SYSTEM.

OBJECTIVE_

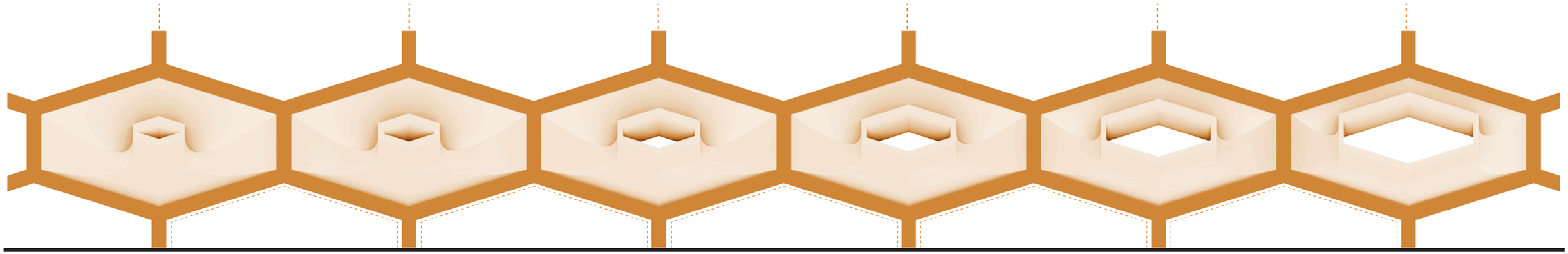
THE GOAL OF THE [HYDRO-GEN] CELL IS FOR IT TO BE AN INTELLIGENT HYDROPONIC SYSTEM THAT IS CAPABLE OF ADJUSTING OR RECONFIGURING ITS SHAPE IN RELATION TO SOLAR GEOMETRY.

CONTRIBUTIONS_

1) AIR CLEANING CAPACITIES (REMOVAL OF CO2 EMISSIONS)
2) FOOD PRODUCTION CAPACITIES (HIGHER YIELDS)
3) LAND USE EFFICIENCY (LESS SPACE TO GROW CROPS)



" WE DO NOT INHERIT THE EARTH FROM OUR ANCESTORS; WE BORROW IT FROM OUR CHILDREN" -NATIVE AMERICAN PROVERB



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CHAPTER 01_

"AN EVOLVING PLANET"_

01

1.1 CLIMATE CRISIS_

IN OUR RECENT HISTORY SINCE THE INDUSTRIAL REVOLUTION, MANKIND HAS FIRMLY CEMENTED ITS MARK ON THE EARTH BY PRODUCING AN EXCESS OF CARBON EMISSIONS [CO2]. THE RELIANCE ON FOSSIL FUELS SUCH AS PETROLEUM, COAL, AND OTHER GASES HAVE BEEN HEAVILY EXTRACTED FROM THE EARTH. AS A BYPRODUCT WE ARE NOW BEGINNING TO SEE THE SEVERITY OF OUR CIVILIZATIONS METHOD TO SUSTAIN ITSELF.

OUR PRESENCE ON THE EARTH IS BEGINNING TO CREATE PROBLEMS NOT ONLY FOR OUR OWN EXISTENCE, BUT WE ARE ALSO CAUSING GREAT HARM TO OTHER LIFEFORMS AS WELL. JUST LIKE ANY OTHER LIVING ORGANISM THE EARTH IS BEGINNING TO RESPOND TO ITS EXTERNAL FORCES. AS A RESULT OF THE LARGE QUANTITIES OF CO2 BEING RELEASED INTO THE ATMOSPHERE THE OZONE LAYER IS BEING DAMAGED. THE OZONE LAYER SERVES AS AN OUTER SHIELD AGAINST DIRECT UV RADIATION FROM THE SUN. WITHOUT THE OZONE LAYER LIFE ON EARTH SIMPLY CANNOT THRIVE.

BESIDES THE RECEDING OZONE LAYER ANOTHER PROBLEM CAUSED BY CO2 EMISSIONS IS THAT THE PLANET AS A WHOLE IS GETTING WARMER. AS THE PLANET HEATS UP, A SERIES OF CHAIN REACTIONS OCCUR. FIRST, THE ICE CAPS ON BOTH THE NORTH AND SOUTH POLE BEGIN TO MELT RELEASING MEGATONS OF WATER INTO THE OCEANS. AS A RESULT OF ALL THE EXTRA WATER THE SEA LEVELS WILL BEGIN TO RISE SUBSTANTIALLY. TO PUT INTO PERSPECTIVE IF ALL THE ICE CAPS WERE TO MELT, THE SEA LEVEL WOULD RISE 230 FEET.

ITS OBVIOUS THAT HUMANITY IS AT THE ROOT OF THE PROBLEM, HOWEVER ITS IMPORTANT TO POINT OUT THAT CHANGES IN THE CLIMATE ALSO OCCUR WHEN EARTH'S SYSTEMS INTERACT WITH EACH OTHER. EARTH'S SYSTEMS ARE COMPRISED OF THE HYDROSPHERE [OCEANS AND THE WATER CYCLE], THE CRYOSPHERE [ICE AND SNOW], THE BIOSPHERE [ANIMALS AND PLANTS], THE PEDOSPHERE [SOIL], AND THE LITHOSPHERE [ROCK]. THESE COMPONENTS DEFINE THE CLIMATE SYSTEM.

THE SYSTEMS WORK HAND IN HAND, IF SOMETHING OCCURS IN ONE OF THE SYSTEMS THE OTHERS WILL BE AFFECTED IMMEDIATELY. CURRENTLY, THE EARTH IS GOING THROUGH A NATURAL CYCLE IN WHICH THE TECTONIC PLATES BELOW THE EARTH'S CRUST ARE MORE ACTIVE CAUSING MORE FREQUENT VOLCANIC ACTIVITY AND EARTHQUAKES. THE EARTH IS GOING THROUGH A CLIMATE CRISIS THAT IF NOT TAKEN SERIOUSLY WILL EVENTUALLY PUT HUMANITY ON THE VERGE OF EXTINCTION. THE RESPONSIBILTY FALLS UPON MANKIND AND ITS ACTIONS, FOR THE SAKE OF SURVIVAL; HUMANITY IS OBLIGATED TO CHANGE ITS WAY OF LIFE IN ORDER TO ENSURE THAT FUTURE GENERATIONS CAN TAKE PART ON THIS PLANET.

"CLIMATE CHANGE IS NO LONGER SOME FAR-OFF PROBLEM; IT IS HAPPENING HERE, IT IS HAPPENING NOW." - BARACK OBAMA

ONE OF THE LEADING CAUSES FOR THE RISING TEMPERATURES AROUND THE WORLD IS BECAUSE OF WHAT MANKIND HAS DONE IN ORDER TO PROSPER AS A SPECIES. **OUR CITIES** ARE THE LEADING PROBLEM AS THEY ARE LARGE MASSIVE OBJECTS THAT ARE DRAINING TONS OF NATURAL RESOURCES AND ARE ALWAYS RELEASING EXCESS **CARBON EMISSIONS** [CO2].

EVERY CITY ON THE PLANET RELIES HEAVILY ON **FOSSIL FUELS** IN ORDER TO FUNCTION. LARGE POWERPLANTS THAT PRODUCE ELECTRICITY AND OTHER MEANS OF ENERGY BURN THESE FUELS WHICH THEN GET EMITTED INTO THE ATMOSPHERE.

IN MANY PARTS OF THE WORLD THE AIR LEVELS HAVE BECOME TOXIC TO THE INHABITANTS BECAUSE OF EXCESSIVE SMOG ACCUMULATION. SUCH CITIES INCLUDE MEXICO CITY, DELHI, SHOUGUANG AND LOS ANGELES TO NAME A FEW.

1.2 WATER_

WATER IS A PREREQUISITE FOR ALL LIFE ON EARTH. WATER HAS BEEN CALLED EARTH'S LIFE-SUPPORT SYSTEM AND IS THE MOST VALUABLE AND PRECIOUS COMMODITY ON THE PLANET AND MUST BE PRESERVED BY ALL MEANS. HOWEVER, THERE IS A GENERAL ASSUMPTION THAT BECAUSE THE PLANET IS PREDOMINANTLY COVERED IN WATER THAT THE RESOURCE IS FREE AND UNLIMITED.

ABOUT 70% OF THE EARTH'S SURFACE IS COVERED IN WATER AND ANOTHER 5% IS STORED IN THE ICE CAPS. THIS WATER IS ALWAYS IN MOTION AND IS PART OF A CYCLE THAT IS DRIVEN BY THE ENERGY OF THE SUN. THIS LEADS TO THE EVAPORATION OF WATER, TO CONDENSATION, AND TO PRECIPITATION, AS WELL AS STREAMFLOW AND GROUNDWATER FLOW.

WATER MOVES AS WATER VAPOR IN THE ATMOSPHERE, INFILTRATES THE SOIL AS PRECIPITATION, FLOWS THROUGH THE GROUND AS GROUNDWATER, IS ABSORBED BY THE ROOTS OF PLANTS, MOVES THROUGH THE PLANTS, LEAVES THEM AS WATER VAPOR AND MOVES INTO THE ATMOSPHERE AGAIN, WHERE IT IS TRANSPORTED BY THE WIND THROUGH THE ATMOSPHERE UNTIL IT CONDENSES IN CLOUDS AND FALLS AS PRECIPITATION, THUS CLOSING THE WATER CYCLE.

HUMAN CULTURE IS LINKED WITH A STEADY INTENSIFICATION OF THE USE OF NATURAL RESOURCES. THIS IS ESPECIALLY OBVIOUS IN THE AMOUNT OF ENERGY CONSUMED IN ORDER TO MAINTAIN A CERTAIN LIFESTYLE. A PERSON'S DAILY ENERGY CONSUMPTION HAS INCREASED MORE THAN A HUNDREDFOLD IN THE COURSE OF 15,000 YEARS OF SOCIETAL DEVELOPMENT. OUR "REQUIREMENTS" RESPECT TO NATURAL RESOURCES ARE IN DIRECT COMPETITION WITH THE "REQUIREMENTS" OF EARTH'S LIFE SUPPORT SYSTEM.

AS WE ARE USING EVER-INCREASING AMOUNTS OF THE RELEVANT NATURAL RESOURCES, HERE WATER, THEY ARE BEING TAKEN OUT OF THE NATURAL LIFE-SUPPORT SYSTEM AND ARE BEING SUBJECT TO OUR OWN RULES AND DECISIONS. TO MAKE MATTERS WORSE WE ARE NOT TREATING THIS VALUABLE RESOURCE PROPERLY. WATER IS BEING CONTAMINATED BY AGRICULTURAL RUNOFF THAT INCLUDES A WIDE VARIETY OF PESTICIDES AND FERTILIZERS THAT ULTIMATELY END UP IN STREAMS, RIVERS, AND THE OCEAN.

DESPITE THE ADVANCES MADE IN WATER SUPPLY AND HYGIENE IN THE PAST 30 YEARS, ONE BILLION PEOPLE STILL DO NOT HAVE ACCESS TO ADEQUATE DRINKING WATER AND 2.8 BILLION DO NOT HAVE ACCESS TO SUFFICIENT SANITATION. THESE NUMBERS ARE ONLY GOING TO INCREASE AS BOTH THE STANDARD OF LIVING IN DEVELOPING COUNTRIES AND THEIR POPULATIONS BEGIN TO INCREASE. WATER WILL BE THE "NEW GOLD" IN THE NEAR FUTURE AND WILL BECOME A SCARCE RESOURCE TO OBTAIN.

"THE FIRST FEW FEET OF SEA-LEVEL RISE ALONE WILL DISPLACE MORE THAN 100 MILLION PEOPLE WORLDWIDE AND TURN ALL OUR MAJOR GULF AND ATLANTIC COAST CITIES INTO PRE- KATRINA NEW ORLEANS - BELOW SEA LEVEL AND FACING SUPER-HURRICANES." - JOSEPH J. ROMM

AS THE TEMPERATURES AROUND THE WORLD INCREASE. THE INEVITABLE MELTING OF THE ICE CAPS ARE TO OCCUR. AS THESE ICE CAPS MELT THEY RELEASE MEGATONS OF WATER BACK INTO THE OCEANS.

KEEP IN MIND THAT THIS IS WATER THAT'S BEEN STORED FOR MILLIONS OF YEARS. ALTHOUGH THE MAJORITY OF IT IS FRESHWATER IT STILL ADDS A SIGNIFICANT AMOUNT OF ADDITIONAL LIQUID INTO OUR ALREADY **PREDOMINANT WATER** COVERED PLANET.

MORE WATER IN THE OCEANS MEANS HIGHER SEA LEVELS AND THE CHANCES OF SHORE CITIES TO GET WIPED OUT BY **HURRICANES** OR **TYPHOONS** WILL INCREASE EXPONENTIALLY. FOR MANY LARGE CITIES ON THE COAST THIS PROBLEM POSES A SERIOUS THREAT AND NOT MUCH CAN BE DONE TO PROTECT THESE CITIES IF THE SEA LEVEL WERE TO RISE.

1.3 FEEDING THE POPULATION_

TODAY THERE ARE 7.7 BILLION PEOPLE ROAMING THE EARTH. WITH 795 MILLION NOT HAVING ENOUGH FOOD TO LIVE A HEALTHY LIFESTYLE. THAT'S 1 IN EVERY 9 PEOPLE GLOBALLY. IT IS IN OUR NATURE AS A SPECIES TO MULTIPLY AND HAVE OFFSPRING. HOWEVER, WE ARE NOW IN A TIME WHERE THE HUMAN RACE IS GROWING AT AN ALARMING RATE. IT WAS THE SCIENTIFIC/TECHNOLOGICAL REVOLUTION THAT PROVIDED FOR THE RECENT POPULATION EXPLOSION IN ITS ENTIRE MAGNITUDE.

MUCH OF THE RAPID POPULATION GROWTH IS COMING FROM DEVELOPING COUNTRIES. AS THEY ARE NOW PROGRESSING AND MOVING FORWARD WITH THEIR RESPECTIVE AGENDAS THEY ARE SEEING IMPROVEMENTS IN ECONOMIC DEVELOPMENT, TECHNOLOGY, AND HEALTHCARE. THE STANDARD OF LIVING IS IMPROVING IN DEVELOPING COUNTRIES MEANING THAT THE DEMANDS OF THE PEOPLE ARE GOING TO INCREASE. FOOD WILL BE ONE OF THE TOP NEEDS FOR GROWING COUNTRIES.

IF THE AGRICULTURAL USE OF THE EARTH'S SURFACE HAS NOT YET REACHED THE BREAKING POINT FOR THE REMAINDER OF THE BIOSPHERE, THEN WE CAN BE CERTAIN THAT IT SOON WILL. EACH YEAR MILLIONS OF ACRES WORTH OF FORESTS ARE BEING CUT DOWN FOR AGRICULTURAL USE. AS A CONSEQUENCE NATURAL ECOSYSTEMS ARE BEING DESTROYED AND ARE PUSHING ANIMAL AND PLANT SPECIES ON THE VERGE OF EXTINCTION.

MUCH OF THESE FORESTS ARE DEFORESTED THROUGH THE "SLASH AND BURN" TECHNIQUE IN WHICH THE FORESTS ARE BURNED DOWN AND IN DOING CREATE A TOP LAYER OF NUTRIENT RICH TOPSOIL. THE DOWNSIDE TO THIS METHOD IS THAT THE TOPSOIL IS ONLY GOOD FOR ABOUT 2-5 YEARS AS THE NUTRIENTS ARE QUICKLY DEPLETED FROM THE HARVESTS. NUTRIENT LOSS IN SOIL IS COMMON IN MOST AGRICULTURAL PRACTICES, THEREFORE THERE IS A HIGH DEMAND FOR FERTILIZER APPLICATIONS.

AGRICULTURE IS ONLY ONE OF MANY THREATS TO OUR GLOBAL BIOSPHERE. HOWEVER, THERE ARE NEW WAVES OF TECHNOLOGY EMERGING WITHIN THE AGRIBUSINESS SECTOR THAT COULD IMPROVE CULTIVATION PRACTICES. WE HAVE NO OTHER CHOICE BUT TO PRESERVE THE REMAINDER OF NATURAL OR NEARLY NATURAL ECOSYSTEMS THROUGH A QUALITATIVE IMPROVEMENT OF AGRICULTURE AS A WHOLE.

"OVERPOPULATION IN VARIOUS COUNTRIES HAS BECOME A SERIOUS THREAT TO THE HEALTH OF PEOPLE AND A GRAVE OBSTACLE TO ANY ATTEMPT TO ORGANIZE PEACE ON THIS PLANET"

- ALBERT EINSTEIN

THE WORLD IS QUICKLY RUNNING OUT OF SPACE AND PRETTY SOON OUR CITIES WILL BE OVERPOPULATED. WITH MORE AND MORE PEOPLE TO FEED THE LIMITATIONS ON THE PLANET WILL FAR EXCEED ANYTHING THAT'S EVER SEEN BEFORE.

THIS COULD POTENTIALLY LEAD TO WAR BETWEEN NATIONS OR CIVIL WARS WITHIN COUNTRIES. AS THE GAP BETWEEN THE RICH AND THE POOR CONTINUES TO INCREASE IT WOULDN'T BE ALARMING TO SEE THE LOWER HALF OF SOCIETY BECOME AGGRESSIVE.

THE SAD REALITY IS THAT THERE WILL BE EVEN MORE PEOPLE TOMORROW THAT WILL HAVE TO FACE HUNGER THAN THERE ARE TODAY. FEEDING EVERY SINGLE PERSON IN THE WORLD IS GOING TO BE QUITE SOME TASK GOING INTO THE FUTURE. THE AMOUNT OF PEOPLE EXPECTING TO ARRIVE IN THE NEXT 30 YEARS IS AROUND 2 BILLION. THE PLANET WILL NOT BE ABLE TO SUPPORT SUCH A LARGE AMOUNT OF PEOPLE WITH ITS CURRENT SYSTEMS. SOMETHING HAS TO CHANGE IF WE ARE TO AVOID A FOOD SHORTAGE CRISIS.

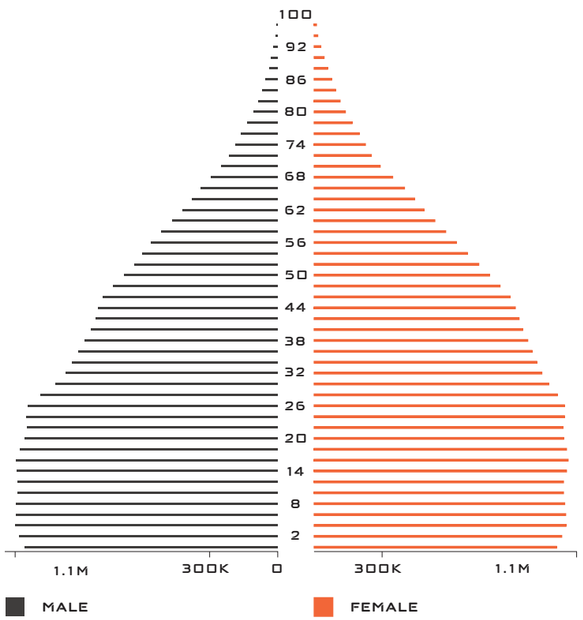
1.4 A RISING POPULATION_

MEXICO IS CURRENTLY RANKED AS THE 10TH MOST POPULOUS COUNTRY IN THE WORLD. IT IS THE LARGEST SPANISH SPEAKING COUNTRY AND ITS POPULATION IS ON A STEADY, POSITIVE GROWTH EXPANSION AS A RESULT OF BETTER MEDICATION AND VACCINES, WHICH GREATLY REDUCE THE CHANCES OF DEATH AND INCREASES THE CHANCES OF SUCCESSFUL BIRTHS.

MEXICO IS HOME TO ONE OF THE LARGEST AND MOST DENSE CITIES IN THE WORLD. MEXICO CITY, IS HOME TO OVER 20 MILLION INHABITANTS MAKING IT A MEGALOPOLIS WHICH IS A MEGA CITY. JUST LIKE ANY OTHER CITY AROUND THE WORLD MEXICO CITY CONSUMES ENORMOUS AMOUNTS OF ENERGY IN ORDER TO POWER THE URBAN GRID.

THE CITY IS GROWING RAPIDLY BECAUSE OF THE LOCAL POPULATION ITSELF AND BECAUSE OF OUTSIDE INTERNATIONAL BUSINESSES THAT ARE MOVING IN. MEXICO CITY IS HOME TO NUMEROUS FOREIGN HEADQUARTERS THAT BRING IN PEOPLE FROM ALL OVER THE WORLD. THE CITY ITSELF IS A VERY POPULAR TOURIST ATTRACTION WELCOMING 2.4 MILLION PEOPLE A YEAR.

POPULATION PYRAMID _



MAP OF MEXICAN STATES_

COMPONENTS OF POPULATION CHANGE _

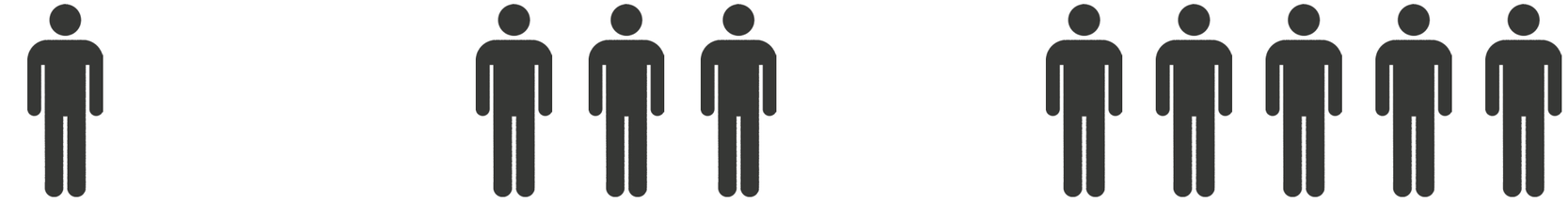
ONE BIRTH EVERY
14 SECONDS

ONE DEATH EVERY
41 SECONDS

ONE NET MIGRANT EVERY
9 MINUTES

NET GAIN OF ONE PERSON EVERY
23 SECONDS

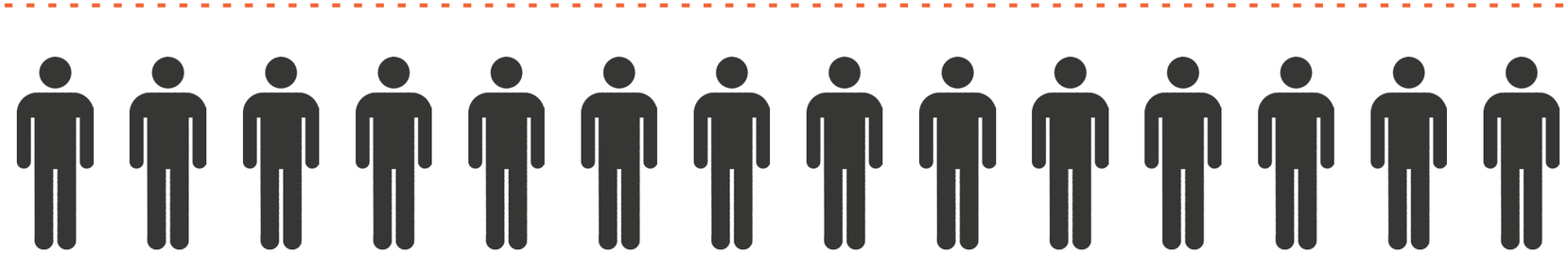
PROJECTED POPULATION GROWTH_



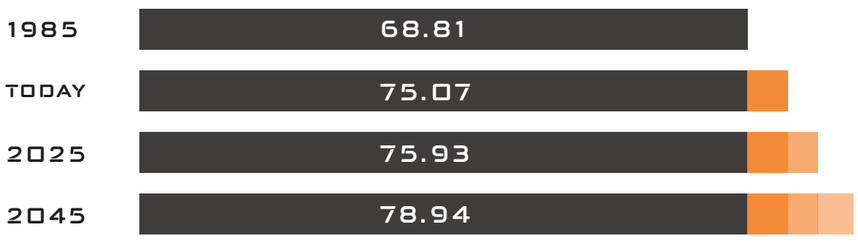
1985
75,980,000

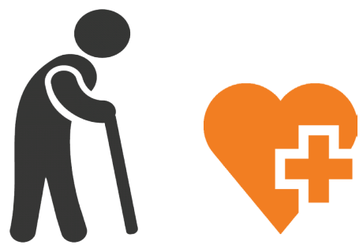
TODAY
127,580,000

2025
135,280,000



2045
152,890,000





INCREASED LONGEVITY_

LONGEVITY OF THE AVERAGE PERSON IS EXPECTED TO INCREASE IN THE UPCOMING YEARS WITH A 0.24% INCREASE PER YEAR.

1.5 WATER SCARCITY_

RECENT STUDIES HAVE SHOWN THAT MEXICO AS A COUNTRY HAS GOTTEN WARMER SINCE THE 1960'S WITH THE AVERAGE TEMPERATURE CONTINUING TO RISE. SCIENTISTS PREDICT THAT BY THE END OF THE CENTURY THE AVERAGE TEMPERATURE ON THE NORTHERN PART OF THE COUNTRY COULD POTENTIALLY SEE A RISE OF 5.4 - 7.2 DEGREES FAHRENHEIT. THE REST OF THE COUNTRY IS EXPECTED TO SEE A 2.7 - 4.5 RISE AS WELL, WHICH WOULD BRING MORE PROBLEMS TO THE COUNTRY.

THE BIGGEST CONCERN FOR THE PEOPLE IS WATER SECURITY, IF TEMPERATURES CONTINUE TO RISE THEN MORE MOISTURE WILL EVAPORATE FROM LAKES, RIVERS, AND ANY OTHER VALUABLE SOURCES OF WATER. CONSEQUENTLY, IF THIS IS TO HAPPEN MORE DROUGHTS WILL OCCUR. MAKING ACCESSIBILITY TO THE VITAL FLUID A MAJOR CONCERN GOING INTO THE FUTURE.

IN EARLY 2010 WATER BECAME A HUGE TALKING POINT WHEN THE NATIONAL GOVERNMENT RELEASED AN ADVERTISING CAMPAIGN TITLED "FEBRUARY 2010: THE CITY MAY RUN OUT OF WATER". CERTAIN CITIES IN MEXICO ARE AT THE RISK OF BEING COMPLETELY VOID OF WATER. MOST WATER IS OBTAINED THROUGH UNDERGROUND RESERVOIRS, HOWEVER THEY ARE CURRENTLY BEING DEPLETED AT A FASTER RATE THAN THE AMOUNT OF TIME IT TAKES FOR THEM TO NATURALLY REFILL.

MEXICO'S NATURAL GEOGRAPHY PLAYS A MAJOR ROLE IN THE COUNTRY'S LACK OF WATER. THE COUNTRY IS MAINLY COMPRISED OF TWO LARGE MOUNTAIN RANGES. THE SIERRA MADRE OCCIDENTAL AND THE SIERRA MADRE ORIENTAL THESE TWO LARGE GEOGRAPHIC FEATURES BLOCK ANY CLOUDS CARRYING PRECIPITATION FROM BOTH THE GULF OF MEXICO AND THE PACIFIC OCEAN. WITH THE TROPIC OF CANCER RUNNING RIGHT THROUGH THE COUNTRY IT FALLS IN A REGION OF INTENSE RADIATION EXPOSURE, THUS MOST OF THE COUNTRY CONTAINS A SEMI-ARID CLIMATE.

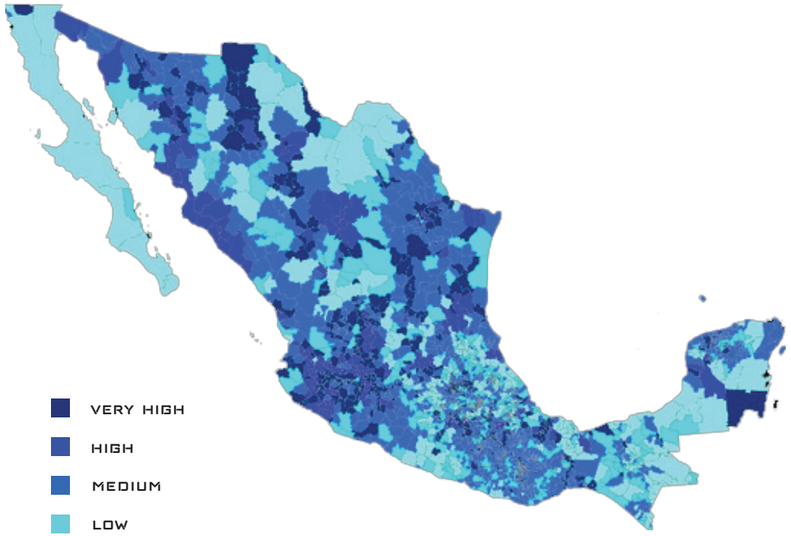
WATER USE _

77% OF WATER IS USED ON AGRICULTURE

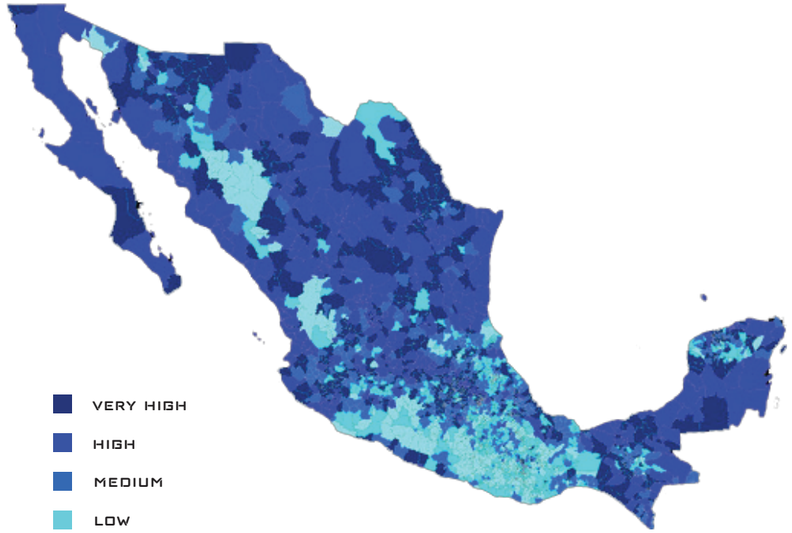
13% OF WATER IS USED FOR DOMESTIC USE

10% OF WATER IS USED FOR INDUSTRY

ECONOMIC VULNERABILITY TO DROUGHT_



SOCIAL VULNERABILITY TO DROUGHT_



MOST AFFECTED STATES_

[NUEVO LEON] [DURANGO] [ZACATECAS] [COAHUILA] [SONORA] [TAMAULIPAS] [CHIHUAHUA]

"WE NEVER KNOW THE WORTH OF WATER TILL THE WELL IS DRY."
- THOMAS FULLER

"FEBRUARY 2010: THE CITY MAY RUN OUT OF WATER". WAS THE NAME OF THE HEADLINE THAT STRUCK FEAR IN THE HEARTS OF MANY CITIZENS. THAT YEAR MEXICO WAS GOING THROUGH ITS WORST DROUGHT IN RECORDED HISTORY AND AS A RESULT WATER BECAME THE MAIN TALKING POINT.

THE SITUATION QUICKLY GOT BAD THAT MANY VILLAGES ON THE OUTSKIRTS HAD NO RUNNING WATER. THE MEXICAN GOVERMENT HAD TO STEP IN AND TRANSPORT WATER TO THESE VERY UNFORTUNATE VILLAGES. APPROXIMATELY, 113 VILLAGES WERE WITHOUT WATER AND NEEDED SUPPLY.

THE IMAGE TO THE RIGHT CAPTURES THE SEVERITY OF THE PROBLEM WITH MANY PEOPLE IN DESPERATE NEED OF WATER. THE WATER CRISIS LASTED ONLY ABOUT A COUPLE OF WEEKS, BUT WITH THE AVERAGE TEMPERATURES CONTINUING TO RISE YEARLY THE PROBABILITY OF ANOTHER WATER CRISIS IS MOST LIKELY TO HAPPEN AGAIN.

1.6 ECONOMY AND ENVIRONMENT_

DUE TO THE INCREASED TEMPERATURES, GROWING CROPS HAS BECOME MUCH MORE DIFFICULT OVER THE LAST 2 DECADES AND AS A RESULT MANY FARMERS ARE BEGINNING TO SEE A DECREASE IN THEIR YIELD OUTPUT. EACH YEAR MILLIONS OF DOLLARS ARE LOST IN CROP FAILURE DUE TO THE CLIMATE CRISIS. HISTORICALLY, MEXICO HAS ALWAYS DEPENDED ON ITS AGRICULTURE AS ONE OF ITS MAJOR EXPORTS. MEXICO IS RANKED 7TH IN THE WORLD FOR AGRICULTURAL PRODUCTION.

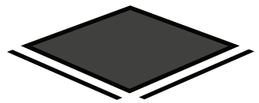
MEXICO'S EXPORTS ARE OF HIGH IMPORTANCE ESPECIALLY WITH THE U.S. AS THEY ARE THE COUNTRIES SECOND LARGEST AGRICULTURAL PARTNER. BUSINESS BETWEEN THE TWO NATIONS SEES AROUND 45 BILLION DOLLARS IN AGRICULTURE ALONE. IF SOMETHING DRASTIC WERE TO HAPPEN WITH MEXICAN AGRICULTURE THE COUNTRY ITSELF WOULDN'T BE THE ONLY ONE AFFECTED, THE U.S AND MANY OTHER COUNTRIES AROUND THE WORLD WILL BE AFFECTED TO SOME DEGREE.

FROM AN ENVIRONMENTAL PERSPECTIVE MEXICO HAS NUMEROUS ISSUES THAT IF NOT ADDRESSED WILL BRING MAJOR PROBLEMS TO THE MAJORITY OF THE POPULATION. THE COUNTRY FALLS SHORT AND HAS ALOT OF WORK TO DO IN ORDER TO ACHIEVE A MORE SUSTAINABLE MODEL.

ONE OF THE BIGGEST ISSUES WITH ITS CURRENT AGRICULTURAL PRACTICES IS THE CLEARING OF NATURAL ECOSYSTEMS IN ORDER TO CREATE MORE SPACE FOR CROPS. AS A CONSEQUENCE NATIVE SPECIES OF PLANTS AND ANIMALS BEGIN TO PERISH. THIS OFFSETS THE NATURAL BALANCE OF THE ENVIRONMENT CREATING UNSTABLE WEATHER PATTERNS THAT ULTIMATELY HAVE AN AFFECT ON THE YIELD OUTPUT OF MANY CROPS. IN SEVERE CASES FARMERS TEND TO LOSE THEIR ENTIRE HARVESTS, FOR MANY FARMING IS THE ONLY SOURCE OF INCOME THAT THEY RECEIVE.

ECONOMIC CONSEQUENCES_

19 OF 32 STATES HAVE A LACK OF WATER SUPPLY

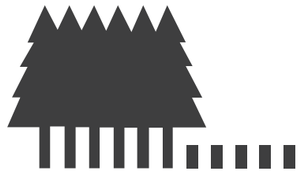


100,000 HECTARES GET AFFECTED ANNUALLY

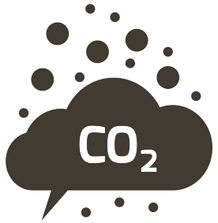
60% OF BEAN PRODUCTION WAS LOST IN 2012

ENVIRONMENTAL CONSEQUENCES_

5TH LARGEST COUNTRY WITH THE MOST DEFORESTATION



380,000 ACRES OF FOREST LOST EACH YEAR DUE TO DEFORESTATION



2ND LARGEST EMITTER OF CARBON EMISSIONS IN LATIN AMERICA

"DESTROYING RAINFOREST FOR ECONOMIC GAIN IS LIKE BURNING A RENAISSANCE PAINTING TO COOK A MEAL"
- E.O WILSON

THE CLIMATE OF MEXICO IS HIGHLY VARIED. THE **TROPIC OF CANCER** DIVIDES THE COUNTRY INTO TEMPERATE AND TROPICAL ZONES. LAND IS NORTH OF THE 24TH PARALLEL EXPERIENCES LOWER TEMPERATURES DURING THE WINTER MONTHS. WHILE SOUTH OF THE 24TH PARALLEL, TEMPERATURES ARE FAIRLY CONSTANT YEAR ROUND.

WITH DIFFERENT CLIMATES THERE ARE DIFFERENT **BIOMES** WITH DIFFERENT ECOSYSTEMS. ECOSYSTEMS LIKE THE ONE IN THIS IMAGE ARE CONSTANTLY BEING CUT DOWN BY THE **MEXICAN GOVERNMENT** IN ORDER TO CREATE MORE HORIZONTAL SPACE FOR AGRICULTURAL PURPOSES.

THE IMAGE TAKEN IS OF A TYPICAL TROPICAL RAINFOREST ECOSYSTEM. ECOSYSTEMS LIKE THIS ONE RUN A HUGE RISK AS THEY ARE IN ENDANGER OF LOSING MANY OF ITS PLANT AND ANIMAL LIFE.

RIO GRANDE, ZACATECAS_

1.7 RIO GRANDE CASE STUDY_

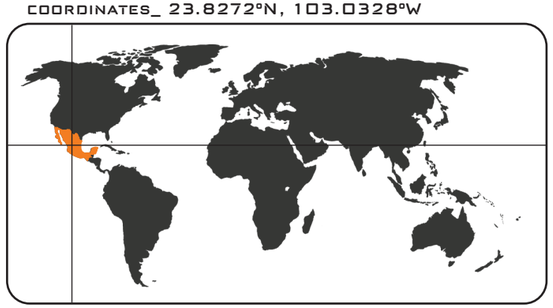
THE MUNICIPALITY OF RIO GRANDE, ZACATECAS WAS SELECTED AS THIS IS THE PLACE OF MY HERITAGE. ANOTHER REASON WHY IT WAS CHOSEN WAS BECAUSE OF IT'S LOCATION. THE TROPIC OF CANCER RUNS RIGHT THROUGH THE STATE OF ZACATECAS. THIS PLUS THE GEOGRAPHIC FEATURES OF THE AREA MAKES IT VULNERABLE TO MASSIVE AMOUNTS OF BOTH DIRECT AND INDIRECT RADIATION.

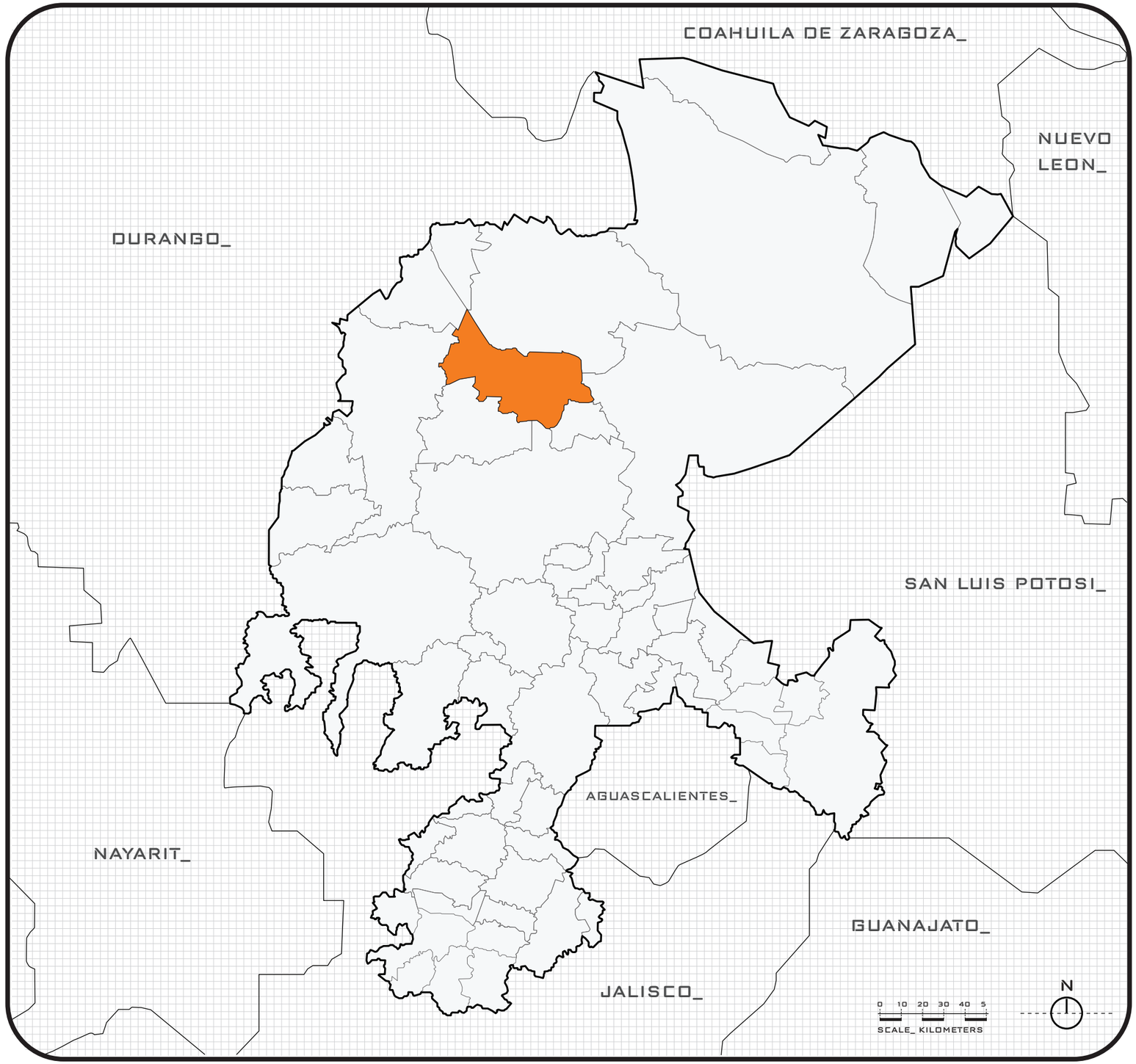
THE RADIATION IN THE REGION IS ANOTHER CONTRIBUTING FACTOR AS TO WHY CULTIVATION PRACTICES ARE SOMEWHAT DIFFICULT. ONLY VERY SPECIFIC TYPES OF PLANTS/CROPS ARE ABLE TO GROW IN THE REGION WITH BEANS AND MAIZE BEING THE PREDOMINANT CROPS THAT ARE ABLE TO GROW. THESE CROPS HAVE MANAGED TO SURVIVE IN THE REGION FOR CENTURIES AND HAVE DEVELOPED A CERTAIN DEGREE OF DROUGHT RESISTANCE.

IN THE LAST 50 YEARS THE REGION HAS SEEN MAJOR CHANGES IN THE ENVIRONMENT. WHAT WERE ONCE LUSH AND GREEN LANDSCAPES ARE NOW BECOMING DRY AND ARID ONES. ACCORDING TO MANY OF THE LOCALS IN PARTICULAR THE ELDERS. THEY HAVE STATED THAT MANY OF THE STREAMS THAT ONCE SUPPLED THE WATER NEEDED FOR FIELD IRRIGATION ARE ALMOST DRIED UP.

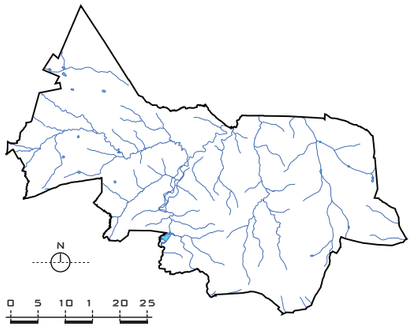
FARMERS ARE HAVING A DIFFICULT TIME KEEPING UP WITH THE CLIMATIC CONDITIONS. THE COLD SEASON APPROACHES A LOT QUICKER MEANING THAT IF CROPS AREN'T SELECTED THEY'LL FREEZE OVER. THE RAIN SEASON IS ALSO VERY UNPREDICTABLE SOMETIMES IT OVER RAINS OR SOMETIMES IT DOESN'T RAIN AT ALL. THESE ARE JUST A FEW OF THE THINGS THAT TRADITIONAL CULTIVATION PRACTICES DEAL WITH.

COORDINATES_ 23.8272°N, 103.0328°W

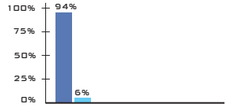




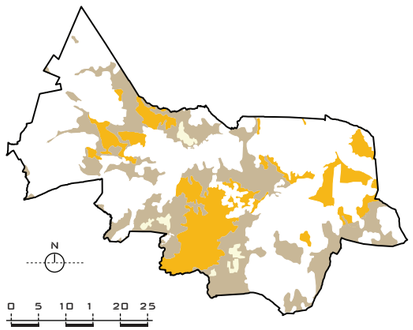
[0.1] WATER SOURCES_



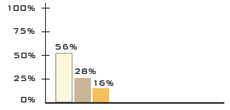
LEGEND_
- STREAMS
- LAKES/PONDS



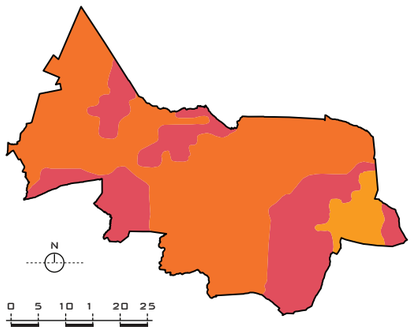
[0.2] LAND USE_



LEGEND_
- AGRICULTURE
- PASTURE
- SHRUBLAND



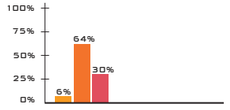
[0.3] DIRECT NORMAL IRRADIATION_



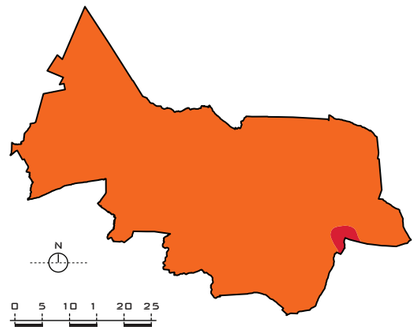
LEGEND_

DAILY TOTALS:	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	7.0	7.4	7.8	8.2
YEARLY TOTALS:	1241	1387	1534	1680	1826	1972	2118	2264	2410	2556	2702	2848	2995

* BOTH DAILY & YEARLY TOTALS ARE MEASURED IN KWH/M²



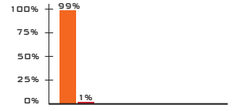
[0.4] GLOBAL HORIZONTAL IRRADIATION_



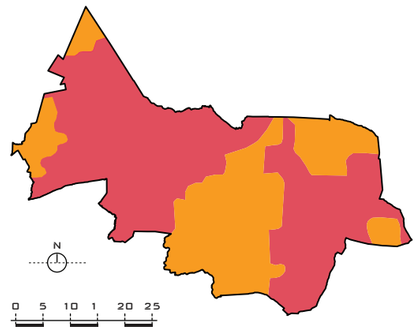
LEGEND_

DAILY TOTALS:	4.6	5.0	5.4	5.8	6.2	6.6
YEARLY TOTALS:	1680	1826	1972	2118	2264	2410

* BOTH DAILY & YEARLY TOTALS ARE MEASURED IN KWH/M²
* LONG TERM AVERAGE OF GHI, PERIOD 1999-2015



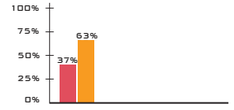
[0.5] PV POWER POTENTIAL_



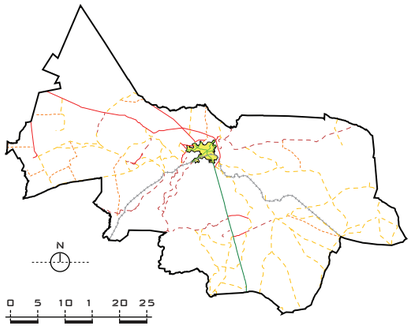
LEGEND_

DAILY TOTALS:	3.8	4.2	4.6	5.0	5.4
YEARLY TOTALS:	1387	1534	1680	1826	1972

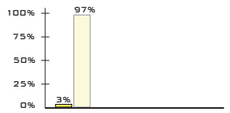
* BOTH DAILY & YEARLY TOTALS ARE MEASURED IN KWH/M²
* LONG TERM AVERAGE OF PVOUT, PERIOD 1999-2015



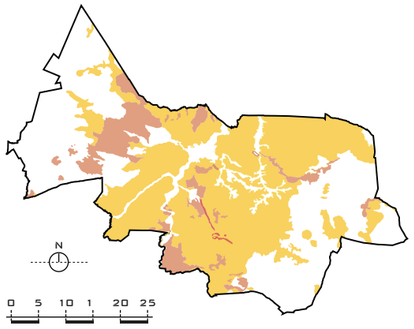
[0.6] TRANSPORTATION_



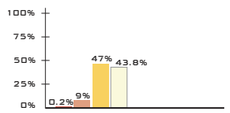
LEGEND_
- ROAD W/T MORE THAN 2 LANES
- ROAD W/T 2 LANES
- GRAVEL ROADS
- BREACH
- SIDEWALKS
- STREETS
- TRAINTRACKS
- URBAN ZONE



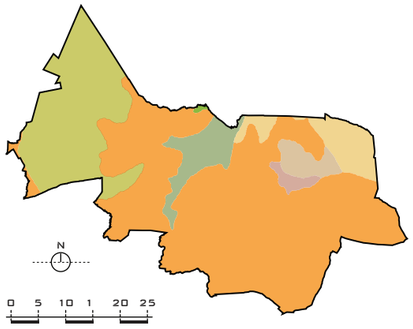
[0.7] GEOLOGY_



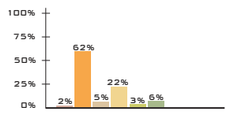
LEGEND_
- INTRUSIVE IGNEOUS
- EXTRUSIVE IGNEOUS
- SEDIMENTARY
- GROUND



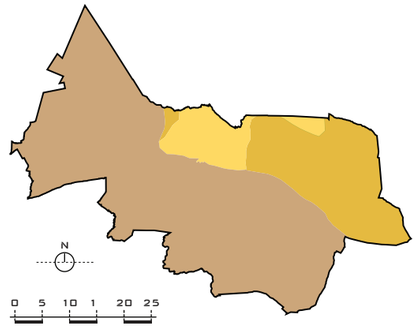
[0.8] GEOGRAPHICAL RELIEVE_



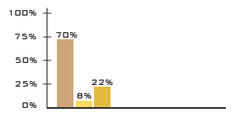
LEGEND_
- LOW SIERRA/JAGGED
- LOW HILLS
- PLATEAU
- DESCENT W/T LOW HILLS
- DESERT PLAIN
- VALLEY



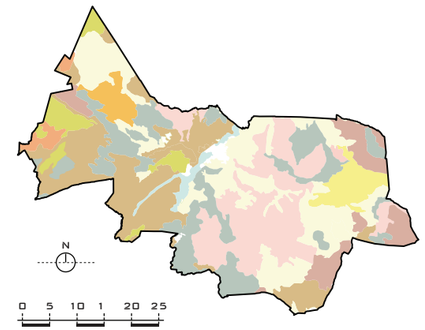
[0.9] CLIMATES_



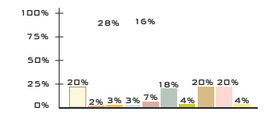
LEGEND_
- TEMPERATE W/T SUMMER RAINS
- SEMI-DRY W/T SUMMER RAINS
- DRY W/T SUMMER RAINS



[1.0] PEDOLOGY_



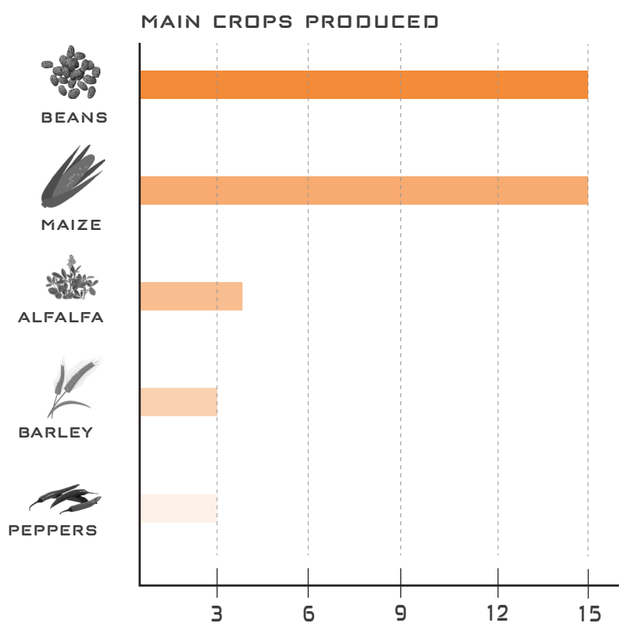
LEGEND_
- CALCISOL
- CAMBISOL
- DURISOL
- FLUVISOL
- KASTANOZEM
- LEPTOSOL
- LUVISOL
- PHAEOZEM
- REGOSOL
- SOLONCHAK



1.8 QUESTIONNAIRE AND RESULTS_

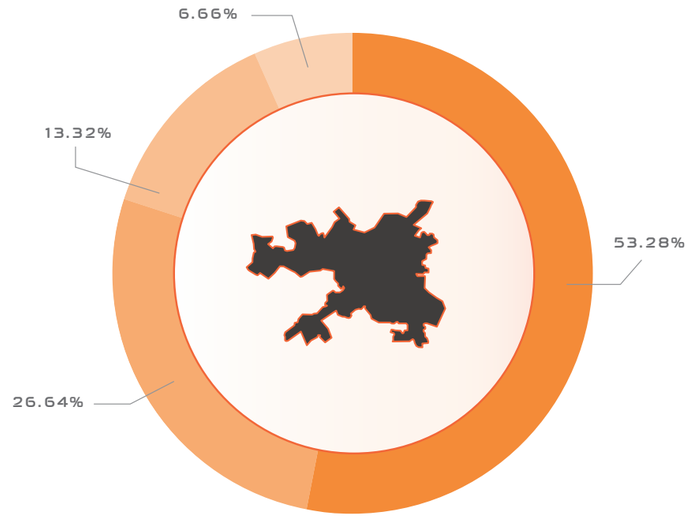
THIS PAST SUMMER I DECIDED TO VISIT MY PARENTS HOMETOWN IN RIO GRANDE, ZACATECAS TO INTERVIEW AND SPEAK WITH THE LOCAL FARMERS OF THAT AREA TO SEE WHAT THEIR HARDSHIPS WERE IN RELATION TO PRODUCING CROPS.

A DISPERSE SURVEY STUDY AND QUESTIONNAIRE WAS CONDUCTED TARGETING THE LOCAL FARMERS OF THE AREA TO SEE FIRST HAND WHAT THEIR EXPERIENCES ARE LIKE. SEVERAL QUESTIONS WERE ASKED REGARDING THEIR ABILITY TO GROW CROPS WITHIN THE REGION. THE FOLLOWING ARE THE QUESTIONNAIRE RESULTS.



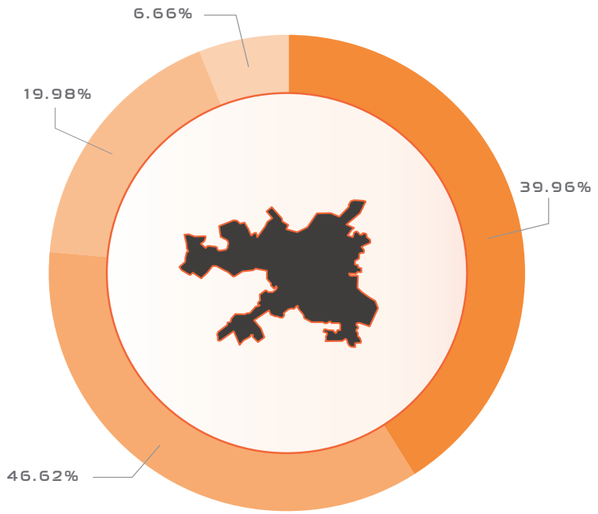
Q1_ WHY IS AGRICULTURE SO IMPORTANT TO YOU?

- WAY OF LIFE
- BUSINESS
- MAIN INCOME
- TO SUSTAIN FAMILY



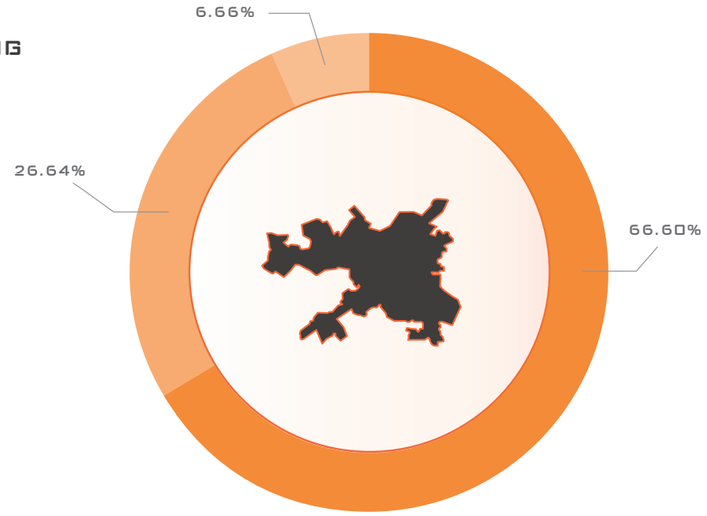
Q2_ EXPLAIN EXACTLY HOW THE CLIMATE HAS AFFECTED YOUR ABILITY TO HARVEST?

- NOT AFFECTED
- FASTER COLD SEASON
- LATE RAIN SEASON
- DROUGHTS



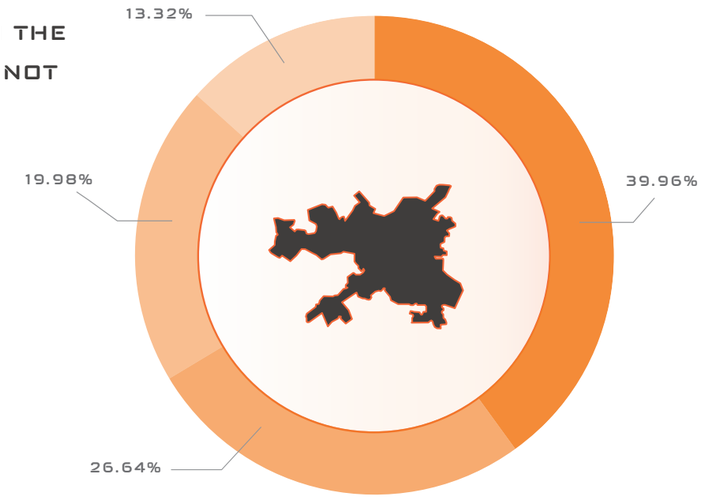
Q7_ WHAT METHODS ARE BEING USED TO OBTAIN WATER?

- WATER TANKS
- WAIT FOR RAIN
- WATER WELLS



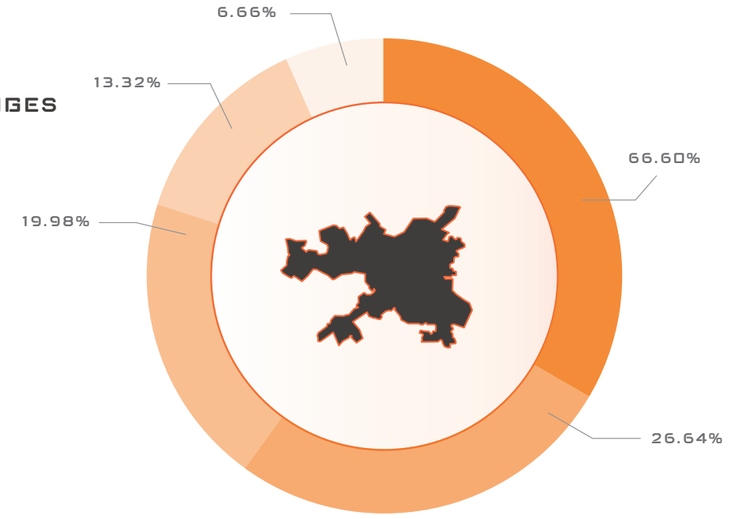
Q8_ WERE THERE CROPS ON THE SURVEY THAT YOU DID NOT SEE, YET CULTIVATE?

- WHEAT
- QUINCE
- SQUASH
- OATS



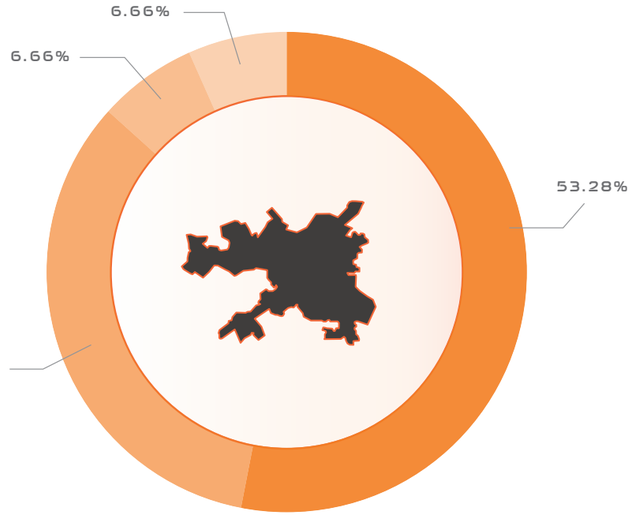
Q9_ IN YOUR OPINION, WHAT HAS ALTERED THE CHANGES IN THE ENVIRONMENT ?

- LACK OF RAIN
- RISING TEMPERATURES
- WEAK GOVERNMENT
- DEFORESTATION
- WASTE CONTAMINATION



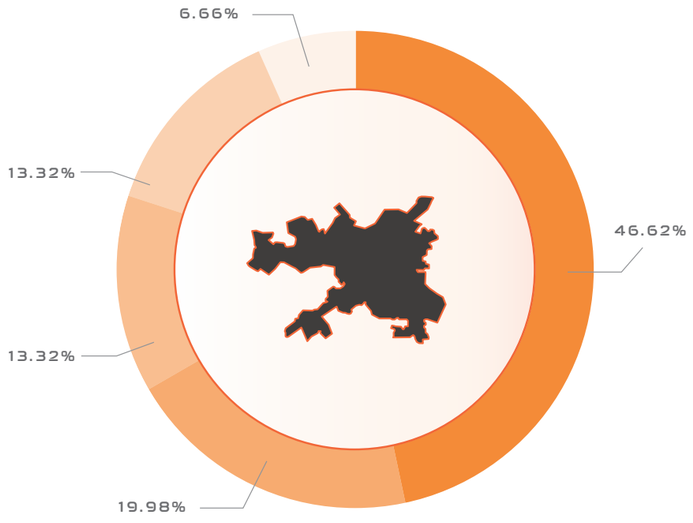
Q10_ WHAT ADVICE WOULD YOU GIVE THE GENERATION OF TOMORROW?

- CONSERVE WATER
- TO REFOREST
- DON'T POLLUTE
- CARE FOR THE ENVIRONMENT



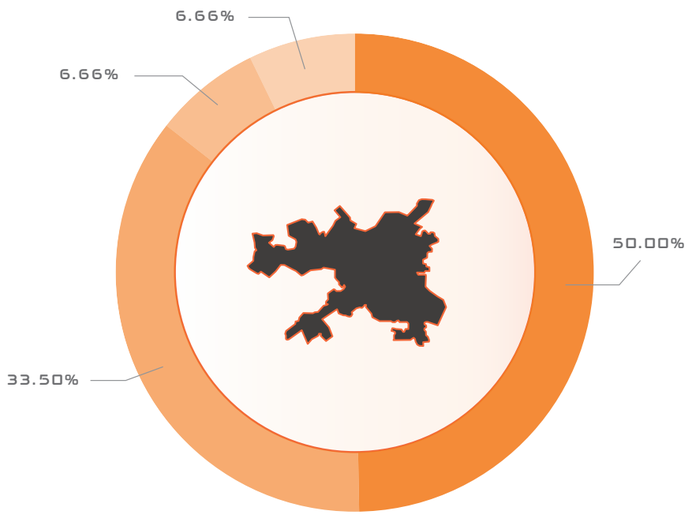
Q3_ WHAT STRATEGIES DO YOU HAVE IN RELATION TO CLIMATE-CRISIS?

- FORESTATION
- HOPE FOR THE BEST
- CULTIVATE ON TIME
- WATER COLLECTION
- NONE



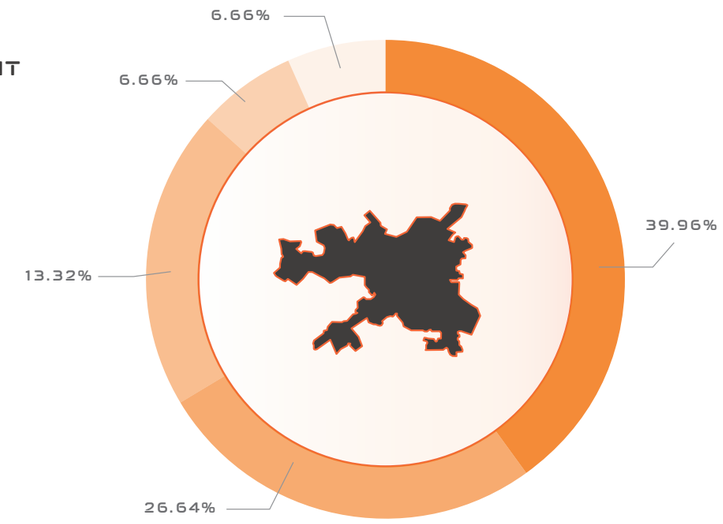
Q4_ HAS THERE BEEN ANY CHANGES IN THE ENVIRONMENT OVER THE LAST 30-60 YEARS?

- NO CHANGES
- WIND EROSION
- EXTREME HEAT & COLD
- DELAYED RAIN SEASON



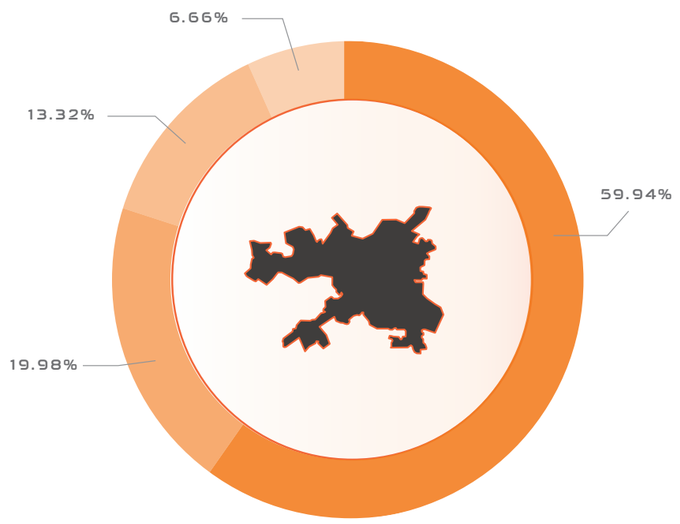
Q5_ WHAT ARE SOME PLANT OR ANIMAL SPECIES THAT HAVE VANISHED IN THE AREA?

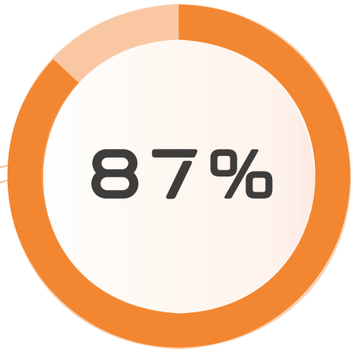
- EAGLE
- DEER
- WOLF/COYOTE
- FOX
- PALMERA



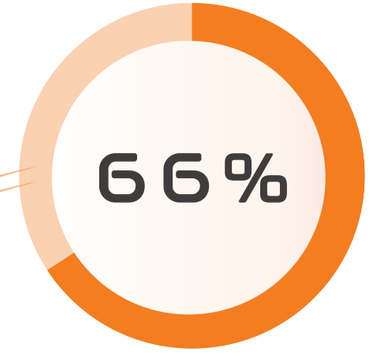
Q6_ WHAT TYPE OF ON-FIELD PROCESSES DO YOU CONDUCT FOR HARVESTS?

- APPLY HERBICIDE
- FALLOW
- SOWING
- TILLING

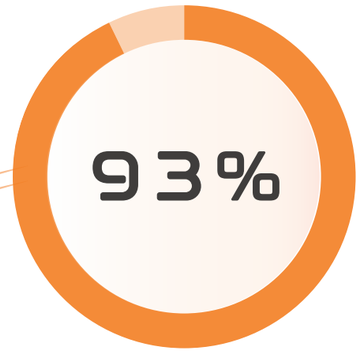




OF FARMERS BELIEVE THAT BAD WEATHER HAS LIMITED THEIR ABILITY TO GROW CROPS.



OF FARMERS OBTAIN THEIR IRRIGATION WATER THROUGH DEEP WATER WELLS.



OF FARMERS HAVE TO PROTECT THEIR CROPS AGAINST PESTS AND PLAGUES.

OF FARMERS SAID THAT WATER IS A VERY SCARCE RESOURCE IN THE AREA.

CHAPTER 02_

"A NEW AGE IN FARMING"_

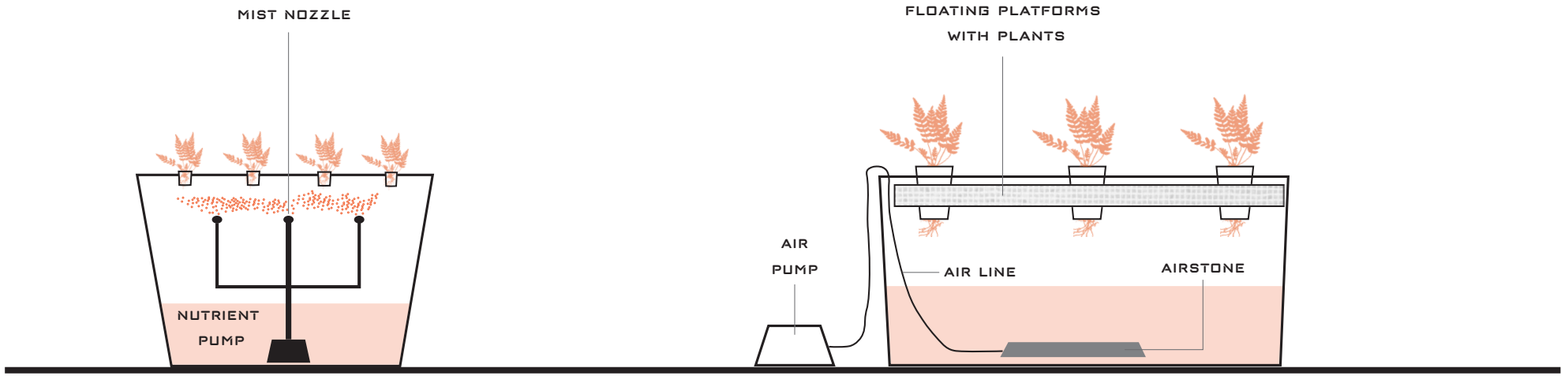
02

2.1 WHAT IS VERTICAL FARMING?_

AS THE LAND CURRENTLY BEING USED FOR GROWING CROPS BECOMES LESS SUITABLE DUE TO LAND DEGRADATION, THE IDEA OF VERTICAL FARMING HAS PRESENTED ITSELF AS A POTENTIAL SOLUTION FOR THE WAY IN WHICH WE GROW CROPS IN THE FUTURE. VERTICAL FARMING IS THE PRACTICE OF GROWING PRODUCE IN VERTICALLY STACKED LAYERS AND IMPLEMENTS CERTAIN TECHNOLOGIES SUCH AS HYDROPONICS AND AEROPONICS.

HYDROPONICS IS PERHAPS THE EASIEST OUT OF THE TWO IF ONE WERE TO CONSTRUCT A VERTICAL GROWING SYSTEM. HYDROPONICS IS A METHOD OF GROWING PLANTS WITHOUT THE USE OF SOIL. THE USE OF A WATER-BASED SOLUTION PROVIDES THE NECESSARY NUTRIENTS TO THE PLANTS ROOT SYSTEM. AEROPONICS IN A VERY SIMILAR WAY DELIVERS THE NECESSARY NUTRIENTS, BUT THROUGH A WATER MIST. BOTH SYSTEMS ARE VERY EFFICIENT AND CAN GROW BETWEEN 70-90% LESS WATER THAN FIELD GROWING.

SUB-SYSTEMS_

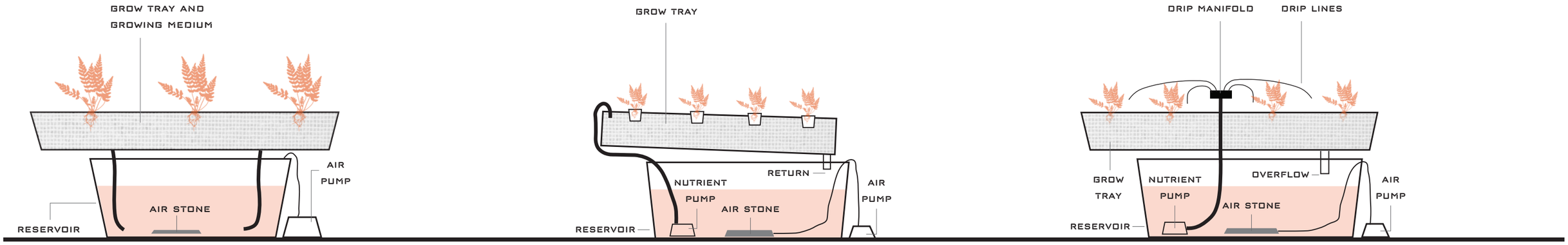


AEROPONICS_

PLANTS ROOTS HANG IN THE AIR AND ARE MISTED WITH NUTRIENT SOLUTION. THE MISINGS ARE DONE EVERY FEW MINUTES TO KEEP ROOTS FROM DRYING.

WATER CULTURE_

THE PLATFORM THAT HOLDS THE PLANTS IS MADE OUT OF STYROFOAM AND FLOATS DIRECTLY ON THE NUTRIENT SOLUTION.



WICK SYSTEM_

A PASSIVE SYSTEM THAT CONTAINS NO MOVING PARTS. THE NUTRIENT SOLUTION IS DRAWN INTO THE GROWING MEDIUM FROM THE RESERVOIR WITH A WICK.

NUTRIENT FILM_

NUTRIENT SOLUTION IS PUMPED INTO THE GROWING TRAY AND FLOWS OVER THE ROOTS OF THE PLANTS, AND THEN DRAINS BACK INTO THE RESERVOIR.

DRIP SYSTEM_

A TIMER CONTROLS A SUBMERGED PUMP. THE TIMER TURNS THE PUMP ON AND NUTRIENT SOLUTION IS DRIPPED ONTO THE BASE OF EACH PLANT BY A SMALL DRIP LINE.

"WE HAVE NO OTHER CHOICE BUT TO CONCLUDE THAT FARMING ON SOIL IS NOT A LONG-TERM SUSTAINABLE SOLUTION TO MEETING OUR POPULATIONS ENERGY NEEDS, PERIOD."
-(DESPOMMIER, 137).

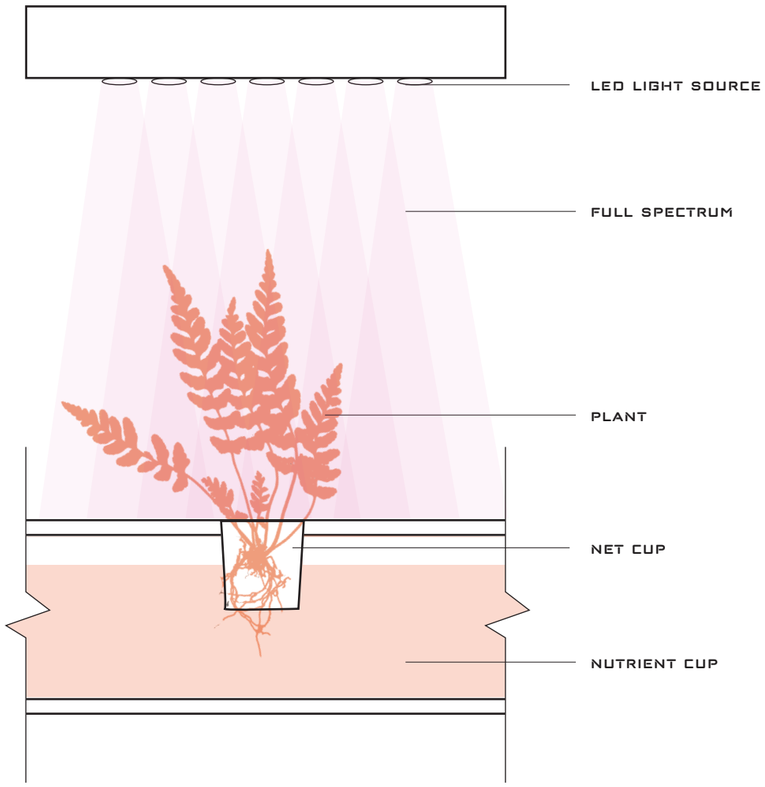
WITH VERTICAL FARMING COMES MANY BENEFITS BUT PERHAPS THE MOST IMPORTANT IS THAT INDOOR FARMERS DO NOT HAVE TO PRAY FOR RAIN, OR SUNSHINE, OR MODERATE TEMPERATURES, OR ANYTHING ELSE RELATED TO THE PRODUCTION OF FOOD CROPS, FOR THAT MATTER. THAT IS BECAUSE THEY GET TO CONTROL EVERYTHING: THE TEMPERATURE AND HUMIDITY, AS WELL AS THE AMOUNT OF LIGHT AND THE DENSITY OF THE PLANTS (DESPOMMIER, 148)

HAVING TOTAL CONTROL OVER ANY PLANTS DEVELOPMENTAL PHASE IS A HUGE BOOST IF WE ARE TO PRODUCE CLEANER AND BETTER QUALITY CROPS FOR THE FUTURE.

2.2 VERTICAL VS HORIZONTAL_

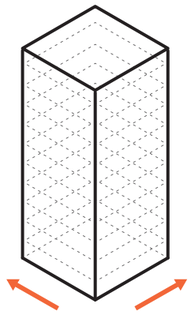
WITH VERTICAL FARMING COMES MANY ADVANTAGES THAT TRADITIONAL FARMING TECHNIQUES LACK. THE FIRST AND MOST OBVIOUS IS THE SPACE FACTOR. ONE CAN PRODUCE MORE CROPS WITHIN A SMALLER FOOTPRINT SIMPLY BY GOING VERTICAL. THE AMOUNT OF WATER ONE CAN SAVE BY UTILIZING A VERTICAL GROWING SYSTEM IS PERHAPS THE MOST IMPORTANT BENEFIT. INSTEAD OF IRRIGATING AN ENTIRE FIELD WASTING HUNDREDS OF GALLONS OF WATER ONE CAN UTILIZE A FEW GALLONS AND BE ABLE TO REUSE THE WATER.

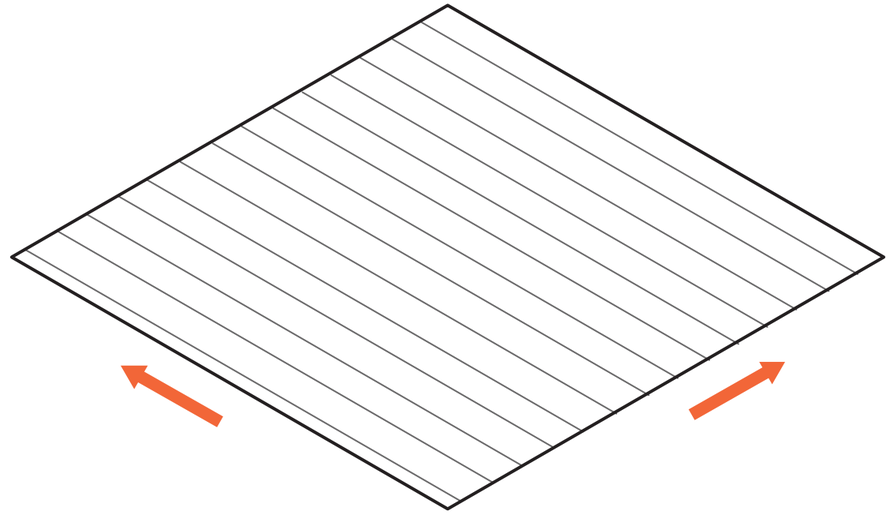
ANOTHER MAJOR ADVANTAGE IS THAT THE FARMER OR USER HAS FULL CONTROL OF ALL THE VARIABLES THAT GO INTO THE PLANT'S GROWTH. FOR EXAMPLE, CROPS GROWN INDOORS RELY ON THE USE OF ARTIFICIAL LIGHTING. THE LIGHT WAVELENGTH OR SPECTRUM CAN BE ADJUSTED TO BEST SUIT THE PLANT SPECIES. SIMILARILY, OTHER VARIABLES SUCH AS WATER TEMPERATURE, PH LEVELS AND INDOOR TEMPERATURE CAN BE TAILORED TO BEST SUIT THE PLANT SPECIES GROWN.



COMPARISON_

1 ACRE = 6 ACRES





ON AVERAGE A VERTICAL FARM CAN PRODUCE THE SAME AMOUNT OF PRODUCE UTILIZING ONLY 1 ACRE OF SPACE, WHEREAS REGULAR FIELD FARMING NEEDS 6 ACRES OF LAND TO GROW THE SAME AMOUNT. ALSO, USES 90% LESS WATER.

ADVANTAGES_

NUTRIENTS
COMPLETE CONTROL OVER NUTRIENT BALANCE

NO YARD NEEDED
CREATE A GARDEN IN ANY INDOOR SPACE

WATER-SAVINGS
CAN USE UP TO 90% LESS WATER

AFFORDABLE
CAN START ONE WITH LOW BUDGET

HIGHER YIELDS
FAR MORE PRODUCTIVE FOR THEIR SIZE

NO CHEMICALS
NO NEED FOR TOXIC CHEMICALS

YEAR-ROUND
GROW CROPS ANY TIME OF THE YEAR

WEATHER-PROOF
CROPS ARE PROTECTED FROM OUTDOOR ELEMENTS

PEST-FREE
INSECTS CAN'T AFFECT THE CROPS

LESS LABOR
NOT AS PHYSICALLY INTENSIVE

'we have no other choice but to conclude that farming on soil is not a long-term sustainable solution to meeting our populations energy needs, period.
- (despommier, 137)

going vertically offers more benefits than one can imagine. once the right technologies used to operate vertical systems decrease in costs will we see a major green revolution.

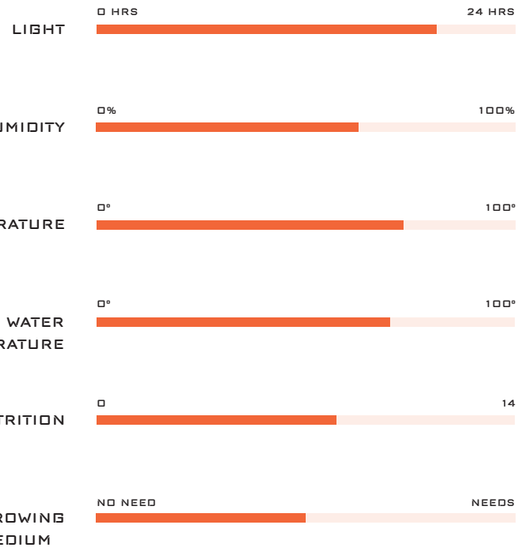
Designing a large, secure home for plants requires intimate knowledge of what a plant needs and how it all works together to allow for maximum growth (Despommier, 184).

2.3 VERTICAL FARM FACILITIES_

IN THE LAST 15 YEARS MANY STARTUP COMPANIES HAVE BEGUN TO BUILD THEIR OWN INDOOR VERTICAL FARM FACILITIES. THESE COME IN DIFFERENT SIZES RANGING FROM WAREHOUSES TO SHIPPING CONTAINERS. MANY OF THESE STARTUPS ARE RUN BY UTILIZING HYDROPONIC OR AEROPONIC SYSTEMS.

THOSE THAT HAVE MANAGED TO CONSTRUCT LARGE VERTICAL FARM FACILITIES HAVE BENEFITED TREMENDOUSLY AS THEY HAVE MADE LARGE PROFITS FROM THEIR BUSINESS. A VERTICAL FARM HAS THE POTENTIAL TO OPEN UP MANY JOB OPPORTUNITIES TO PEOPLE OF ALL BACKGROUNDS AND SERVES AS A LEARNING EXPERIENCE.

AVERAGE CONDITIONS_



* AVERAGES ARE SUBJECT TO CHANGE NUMBERS VARY BASED ON PLANT SPECIES.

THE KAMEOKA PLANT_

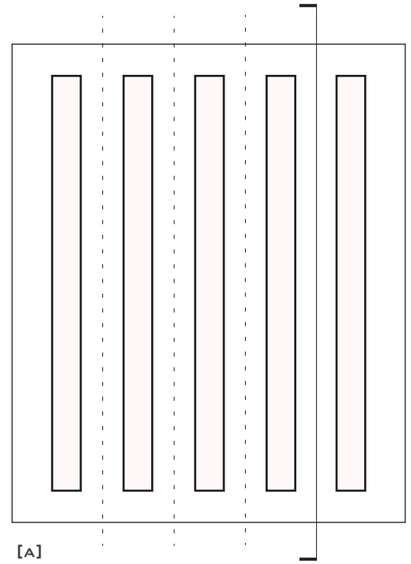
LOCATION: KAMEOKA, KYOTO JAPAN

CONSTRUCTED IN 2007 THE KAMEOKA PLANT SERVED AS THE FIRST MAJOR PLANT PRODUCTION FACTORY IN THE WORLD. THE FACTORY WORKS BY APPLYING CULTIVATION TECHNOLOGIES THAT ALLOWS FOR A LARGE 97% YIELD RATE PRODUCTING OVER 21,000 HEADS OF LETTUCE EACH DAY. THE FACILITY PRIORITIZES HEALTHY AND CLEAN FOOD BY THE USE OF A PROTOCOL WHERE CERTAIN PRECAUTIONS ARE TAKEN TO ENSURE THAT THE HYGIENE OF THE WORKING SPACE IS AS CLEAN AS POSSIBLE.

AEROFARMS_

LOCATION: 212 ROME ST, NEWARK, NEW JERSEY

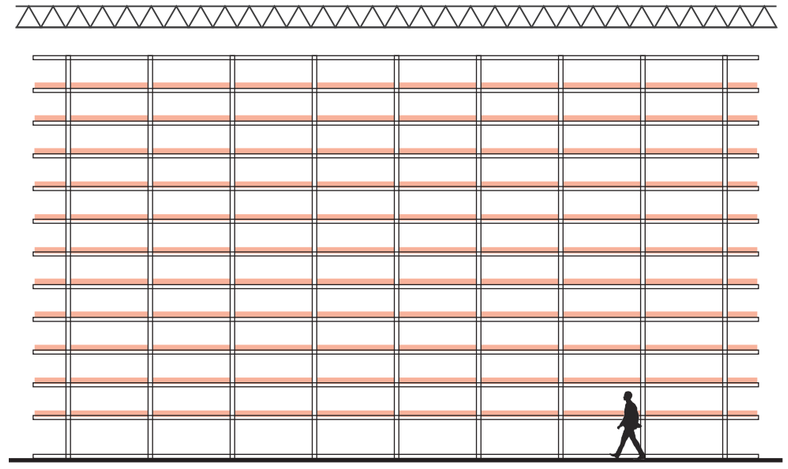
AEROFARMS ARE CURRENTLY THE LEADING COMMERCIAL BUSINESS IN INDOOR FARMING THANKS TO THEIR HIGH-TECH AEROPONIC SYSTEMS. THIS FACILILTY WAS MADE TO BE A PRODUCTIVE PLANT FACTORY WITH THE MISSION OF PROVIDING CLENA SECURE PRODUCE. THE PLANT FACTORY IS EFFICIENT AS MULTI SYSTEMS ARE INTEGRATED IN ORDER TO PRODUCE LEAFY GREENS RELATIVELY FAST. THE USE OF A CLOSED LOOP SYSTEMS ALLOWS FOR WATER TO BE RECYCLED SAVING 95% OF WATER COMPARED TO REGULAR FIELD FARMING.



[A]

[A] PLAN: LAYOUT AND ARRANGEMENT

[B] SECTION: VERTICAL STACK SYSTEM



[B]

IOT HYDROPONICS_

2.4 FABRICATION/ASSEMBLY_

THE PROJECT CONSISTS OF 3 MAIN COMPONENTS; PIPE ASSEMBLY, CONTAINER ASSEMBLY AND ARDUINO INTEGRATION. THE PIPES SERVE TO NOT ONLY CONTAIN WATER, BUT TO HOUSE PLANTS AND OTHER SENSORS AS WELL. THE CONTAINER MAINLY MADE UP FROM POPLAR AND MDF SERVES AS THE MAIN HOUSING UNIT FOR THE PIPES AND THE ELECTRICAL COMPONENTS. ARDUINO ACTS LIKE THE BRAIN BEHIND THE ENTIRE SYSTEMS FUNCTIONALITY.

THE MAIN COMPONENTS ARE THE ARDUINO UNO R3 WHICH IS THE MICROCONTROLLER. WATER AND AIR PUMPS WHICH ARE KEY IN KEEPING THE FLOW OF WATER OXYGENATED AND CIRCULATED THROUGHOUT THE PIPES. FINALLY, A WIDE RANGE OF SENSORS ARE INTEGRATED SUCH AS LIGHT, HUMIDITY, TEMPERATURE, ETC. IN ORDER TO KEEP RECORD OF THE INTERIOR ENVIRONMENT IN WHICH THE PLANTS WILL GROW.

THE SYSTEM AS A WHOLE ALLOWS FOR CERTAIN VARIABLES TO BE MEASURED AND ADJUSTED IF NEEDED. ONCE THE ENTIRE SYSTEM IS CONNECTED PROPERLY THE ARDUINO SOFTWARE ON ANY COMPUTER IS ABLE TO READ ALL THE SENSORS DATA AND IS ABLE TO RECORD IT AT EVERY SECOND. BY READING THE OUTPUTS OF THE SENSORS ONE IS THEN ABLE TO MAKE INFORMED DECISIONS ON CONTROLLING THE AMOUNT OF LIGHT THE PLANT MAY RECEIVE OR INCREASE/DECREASE THE ROOM TEMPERATURE.

WITH IT BEING A CLOSED-LOOP SYSTEM THE PRESERVATION OF WATER IS RETAINED AND CYCLED BACK INTO THE SYSTEM. CONTROL OF THE VARIABLES AFFECTING THE PLANTS GROWTH IS WHAT MAKES HYDROPONICS A BETTER ALTERNATIVE TO OUTDOOR FARMING WHERE ONE HAS LITTLE TO NO CONTROL.

THE HYDROPONIC SYSTEM IS READY FOR SEEDLINGS AFTER THEY'RE ABOUT 2 WEEKS OLD. THAT WAY THE ROOTS ARE LONG ENOUGH TO WHERE THEY CAN ABSORB THE NUTRIENT RICH WATER. BEFORE TRANSPLANTING A PLANT INTO THE SYSTEM, PERLITE A TYPE OF GROWING MEDIAN HAS TO WASHED AND THEN PUT INTO A NET CUP WITH SOME SPACE BIG ENOUGH FOR THE PLANT BEING PLACED INTO THE SYTEM.

AFTER SUCCESSFULLY TRANSPLANTING THE PLANT IT'S IMPORTANT TO MAKE SURE ONE KNOWS EXACTLY HOW MUCH LIGHTING, WATER PH LEVEL AND AND TEMPERATURE IS IDEAL FOR WHATEVER TYPE OF PLANT IS TO BE GROWN INSIDE THE HYDROPONIC SYSTEM THAT WAY THE BEST RESULTS CAN BE OBTAINED.

UPPER_ PIPES

[A] 90° ELBOW X 4
[B] T-PIECE X 6
[C] PVC PIPE X 2
[D] PVC PIPE X 8

LOWER_ PIPES

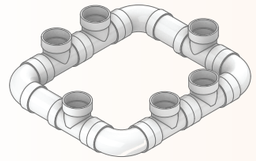
[E] 90° ELBOW X 4
[F] T-PIECE X 1
[G] PVC PIPE X 1
[H] PVC PIPE X 4

BOX_ASSEMBLY

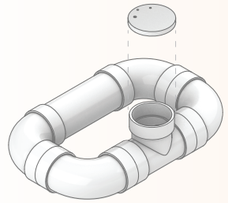
[I] ¾" POPLAR WOOD X 1
[J] ½" MDF BOARD X 1
[K] ½" POPLAR WOOD X 1
[L] ¾" POPLAR WOOD X 2
[M] ½" POPLAR WOOD X 2
[N] ½" POPLAR WOOD X 2
[O] ¾" POPLAR WOOD X 1
[P] ½" POPLAR WOOD X 1
[Q] ½" POPLAR WOOD X 1
[R] ½" POPLAR WOOD X 1
[S] ½" WOOD DOWELS X 5
[T] ½" WOOD DOWELS X 2
[U] ½" WOOD DOWELS X 4
[V] ⅛" MDF BOARD X 1
[W] ⅛" MDF BOARD X 1

[CONTAINER_ ASSEMBLY]

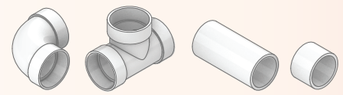
[PIPE_ ASSEMBLY]



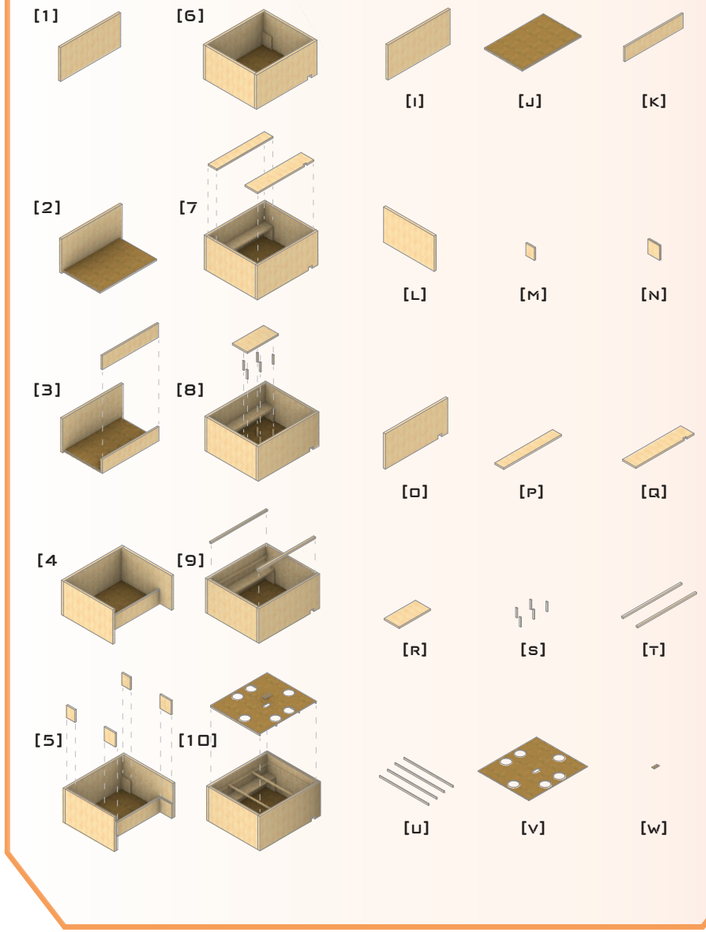
UPPER_ PIPES



LOWER_ PIPES



[BOX_ ASSEMBLY]

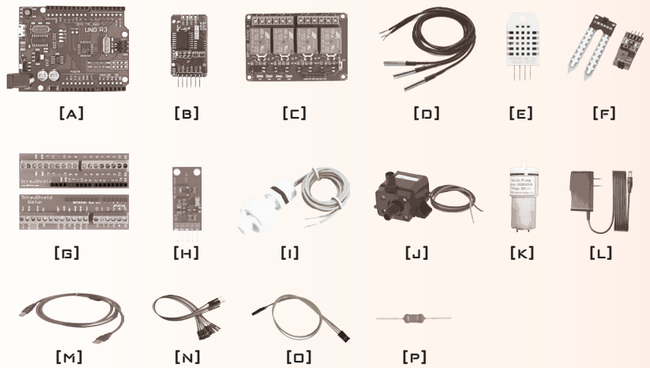


PIECES_ELECTRONICS

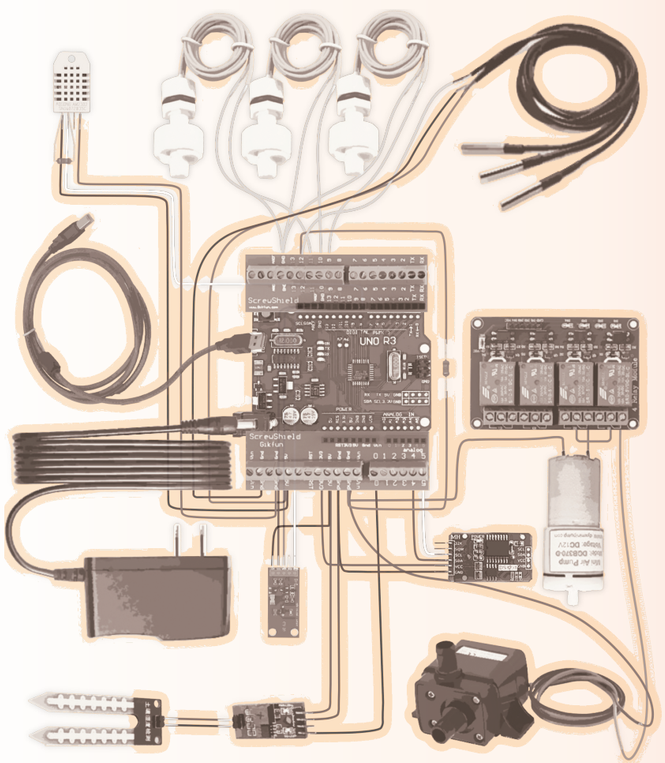
[A] ARDUINO UNO R3 X 1
[B] IIC RTC X 1
[C] 4-CHANNEL RELAY X 1
[D] WATER TEMP. SENSOR X 1
[E] DHT22 X 1
[F] HYGROMETER X 1
[G] SKREW SHIELD V2 X 1
[H] BH1750FVI X 1
[I] FLOAT SWITCH X 3
[J] WATER PUMP X 1
[K] AIR PUMP X 1
[L] 9V PLUG-IN X 1
[M] PRINTER CABLE X 1
[N] MALE-FEMALE PINS X 20
[O] FEMALE-FEMALE PINS X 2
[P] 4.7K OHM RESISTOR X 2

[ARDUINO_ CONNECTIONS]

[PIECES_ ELECTRONICS]



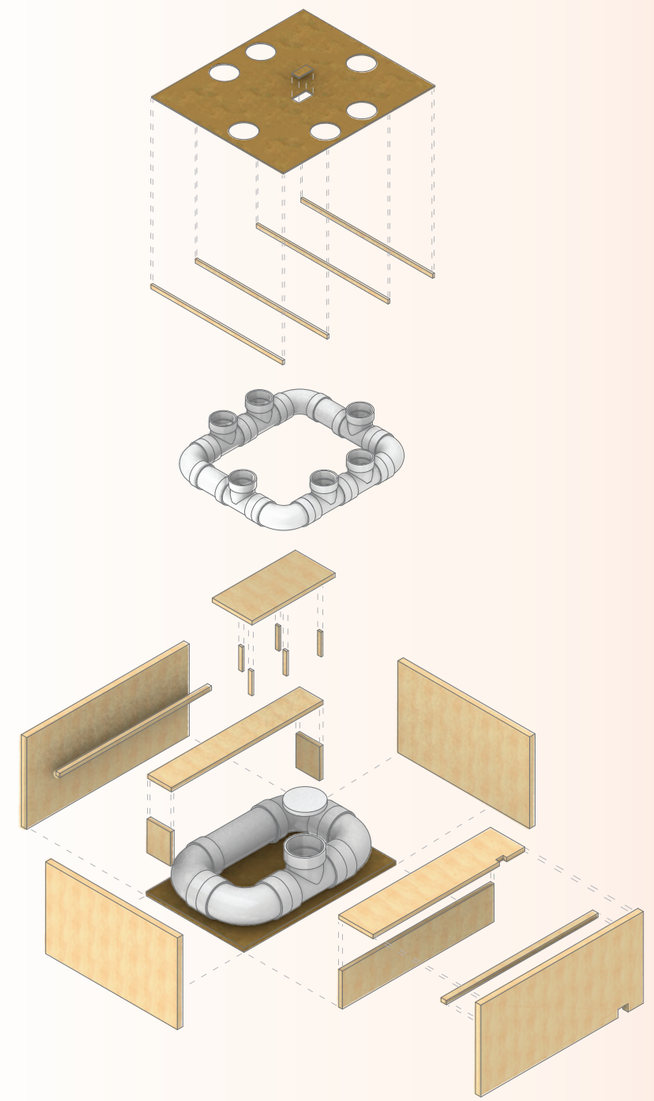
[ARDUINO_ SCHEMATIC]



FINAL SCHEMATIC OF ALL SENSORS & PUMPS REQUIRED IN ORDER FOR THE HYDROPONIC SYSTEM TO FUNCTION_

[CONTAINER_ AXON]

[AXON OF PIPE & CONTAINER_



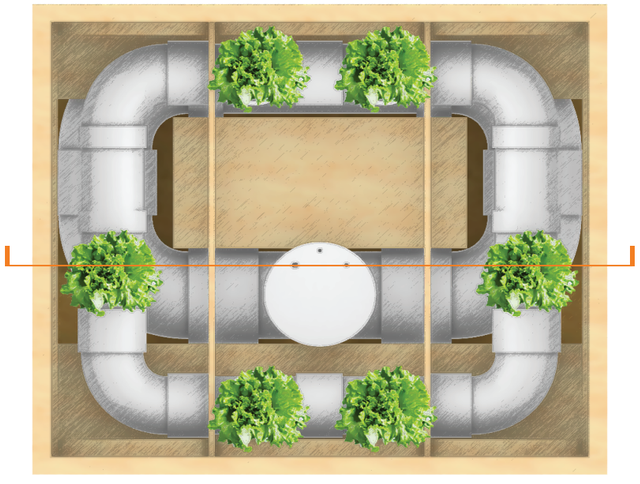
[SOURCES_ TUTORIALS]

- HTTPS://CITYOS.IO/TOPIC/301/BUILD-YOUR-HYDROPONIC-SYSTEM-USING-ARDUINO
- HTTPS://CITYOS.IO/TUTORIAL/1985/PERLITE-SOIL-PREPARATION
- HTTPS://CITYOS.IO/TUTORIAL/1981/PUT-IT-ALL-TOGETHER
- HTTPS://CITYOS.IO/TUTORIAL/2015/REAL-TIME-CLOCK-RTC
- HTTPS://CITYOS.IO/TUTORIAL/1988/TEMPERATURE-SENSOR-DS18B20

2.5 TAKEAWAYS_

THIS INITIAL PROTOTYPE SERVED AS A CASE STUDY TO UNDERSTAND THE BASICS NEEDED FOR A HYDROPONIC SYSTEM TO FUNCTION. MOST IMPORTANTLY WAS LEARNING THE CONNECTIONS FOR THE ARDUINO INTEGRATION. THERE WERE WAS A LOT OF TRIAL AND ERROR DURING THE DEVELOPMENT OF THIS PROTOTYPE. MANY VALUABLE LESSONS WERE LEARNED THROUGH TRIAL AND ERROR SUCH AS WATER LEAKAGE, INCUBATING SEEDLINGS PROPERLY, AND MAKING SURE TO CHECK UP ON THE SYSTEM DAILY.

[TOP VIEW W/T LID]



[TOP VIEW W/T NO LID]

LEARNING OUTCOMES_

UTILIZING THE ARDUINO PLATFORM AS A METHOD OF COMMUNICATION BETWEEN SENSORS & THE PLANTS GROWING ENVIRONMENT.

THE IOT HYDROPONIC SYSTEM WAS USED AS A CASE STUDY TO SEE HOW IT WAS CONSTRUCTED & ASSEMBLED TOGETHER.

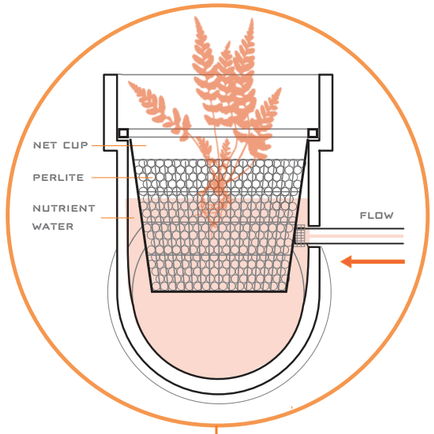
BY READING THE OUTPUTS OF THE SENSORS ONE IS THEN ABLE TO MAKE INFORMED DECISIONS ON CONTROLLING THE AMOUNT OF LIGHT THE PLANT MAY RECEIVE.

WITH IT BEING A CLOSED-LOOP SYSTEM THE PRESERVATION OF WATER IS RETAINED & CYCLED BACK INTO THE SYSTEM.

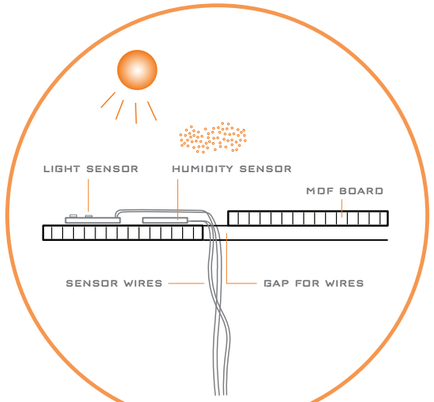
CONTROL OF THE VARIABLES AFFECTING THE PLANTS GROWTH IS WHAT MAKES HYDROPONICS A BETTER ALTERNATIVE TO OUTDOOR FARMING WHERE ONE HAS LITTLE TO NO CONTROL.

THE HYDROPONIC SYSTEM IS READY FOR SEEDLINGS AFTER THEY'RE ABOUT 2 WEEKS OLD. THAT WAY THE ROOTS ARE LONG ENOUGH TO WHERE THEY CAN ABSORB THE NUTRIENT RICH WATER.

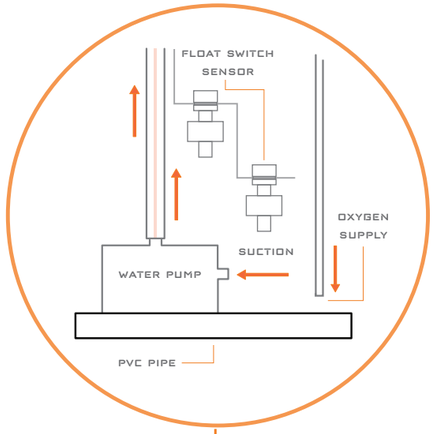
1 PLANT GROWING IN PVC POD

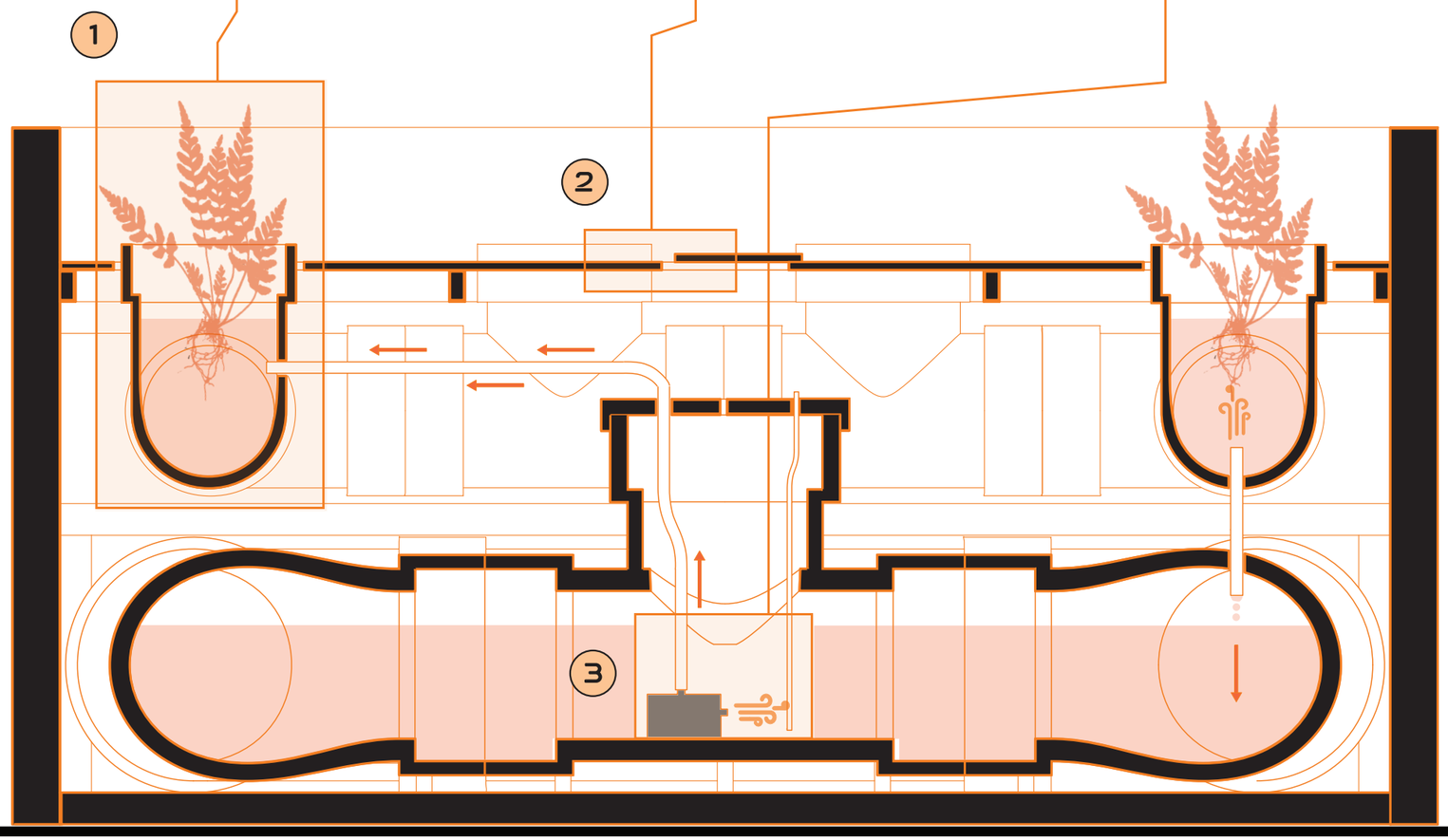


2 SENSING THE ENVIRONMENT



3 TANK WATER-LOOP CYCLE

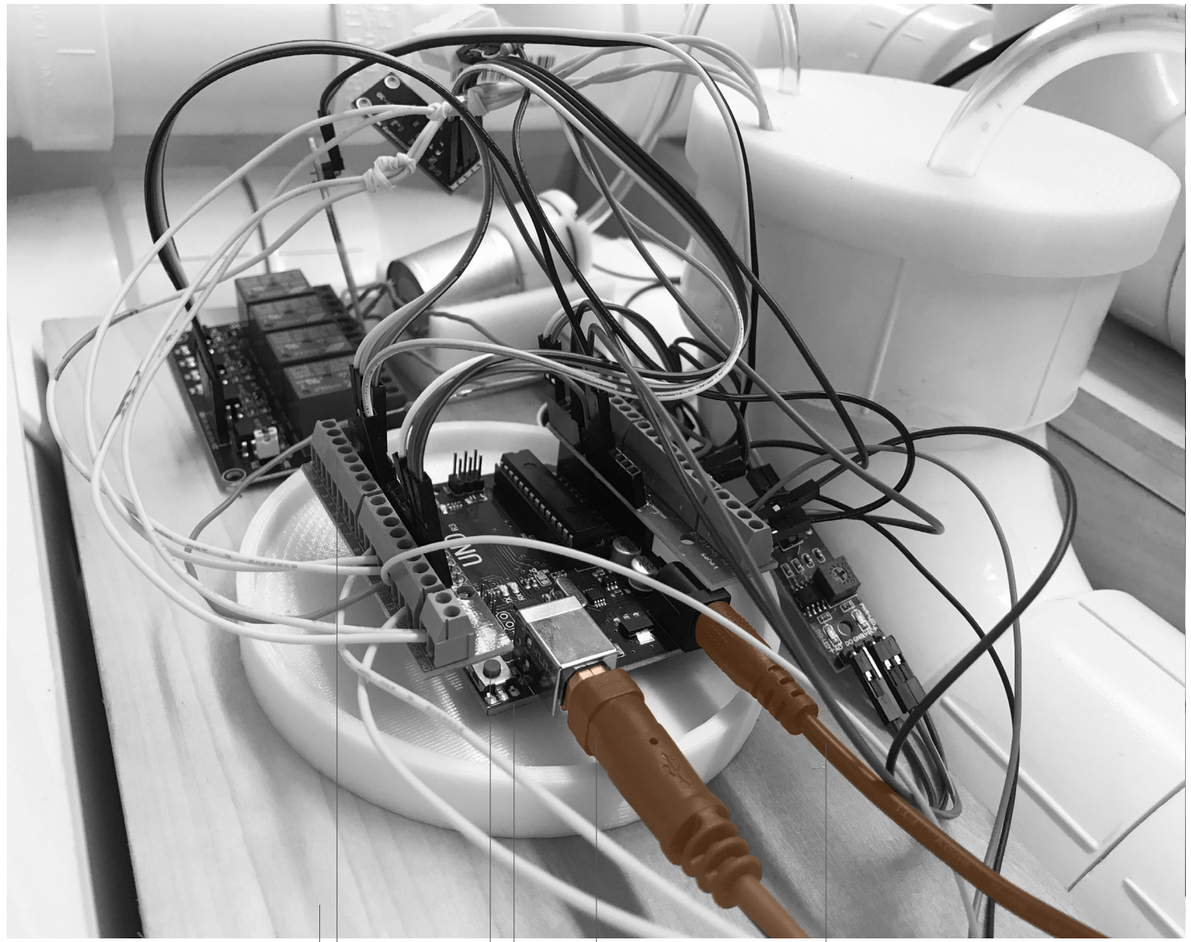




SECTION_ A

2.6 FUNCTIONING SYSTEM_

PHOTOGRAPHS OF THE HYDROPONIC SYSTEMS OPERATION.



ELEVATED WOOD PLATFORM
SKREW SHIELD V2
RESET BUTTON
ARDUINO UNO R3
PRINTER CABLE
9V PLUG-IN CABLE

PLASTIC TUBE
3D PRINTED CAP
PVC PIPE (MAIN STORAGE)
AIR PUMP
TEMPERATURE AND HUMIDITY
4-CHANNEL RELAY

PILEA PEPEROMIDIDES GROWING IN THE HYDROPONIC SYSTEM_

ROSEMARY GROWING IN THE HYDROPONIC SYSTEM_

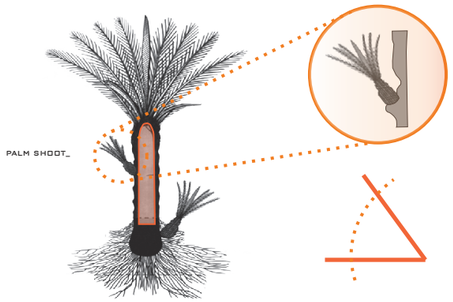
CHAPTER 03_

"REVIVING THE PALMERA"_

3.1 PALMERA ANALYSIS_

IN THE MUNICIPALITY OF RIO GRANDE, ZACATECAS THERE WAS A MAJOR DEFORESTATION ACT THAT TOOK PLACE IN THE 1950'S WHICH PERMITTED THE CLEARANCE OF HUNDREDS IF NOT THOUSANDS OF ACRES WORTH OF NATURAL ECOSYSTEMS. THE MOST NOTABLE OF THESE WAS THAT OF THE MEXICAN FAN PALM OR "PALMERA".

WHEN VISITING MEXICO I TOOK INSPIRATION FROM THE SPECIES TO SEE HOW IT COULD INFLUENCE THE DESIGN OF A MODULAR HYDROPONIC SYSTEM. THE SCALES ON THE TRUNK WAS WHERE THE FOCUS FELL UPON. THEY GROW AT AN ANGLED POSITION WHICH OPTIMIZES THEIR CHANCE OF GETTING SUNLIGHT.



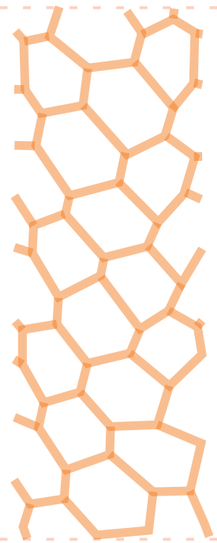
SECTION OF PALMERA

45° ANGLE

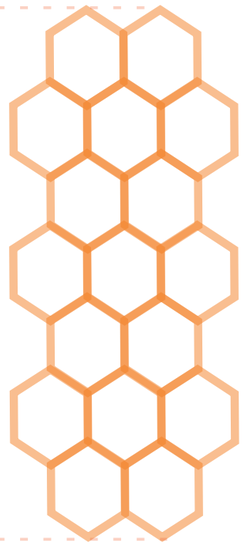
PATTERN STUDY_

MEXICAN FAN PALM "PALMERA"

FOCUS ON TRUNK



ABSTRACTED PATTERN



PATTERN REFINEMENT

"BY DESTROYING THE ANIMALS, THE AIR, AND THE TREES, WE ARE DESTROYING OURSELVES." - THIC NHAT HANH

VAST ECOSYSTEMS LIKE THIS ONE WERE CLEARED OUT IN LARGE QUANTITIES DURING THE **1950s** WHEN THE MEXICAN GOVERNMENT MADE IT LEGAL TO PEOPLE WHO WANTED TO EXPAND THEIR CULTIVATION.

MANY OF THE FARMERS TOOK ADVANTAGE AND CLEARED AWAY THESE ECOSYSTEMS WITHOUT TAKING INTO CONSIDERATION THE IMPACT IT COULD HAVE ON OTHER **WILDLIFE**.

FOR EXAMPLE THEY TOOK OUT THE **PALMERA** WHICH PLAYS A MAJOR ROLE IN BALANCING THE WATER WITHIN THE REGION. WITH THEM BEING TAKEN OUT OF THE EQUATION THE WATER BALANCE IS NO LONGER THERE. THE DEFORESTATION OF THIS SPECIES HAS CAUSED A SERIES OF CHAIN REACTIONS THAT HAVE LED TO PROBLEMS.

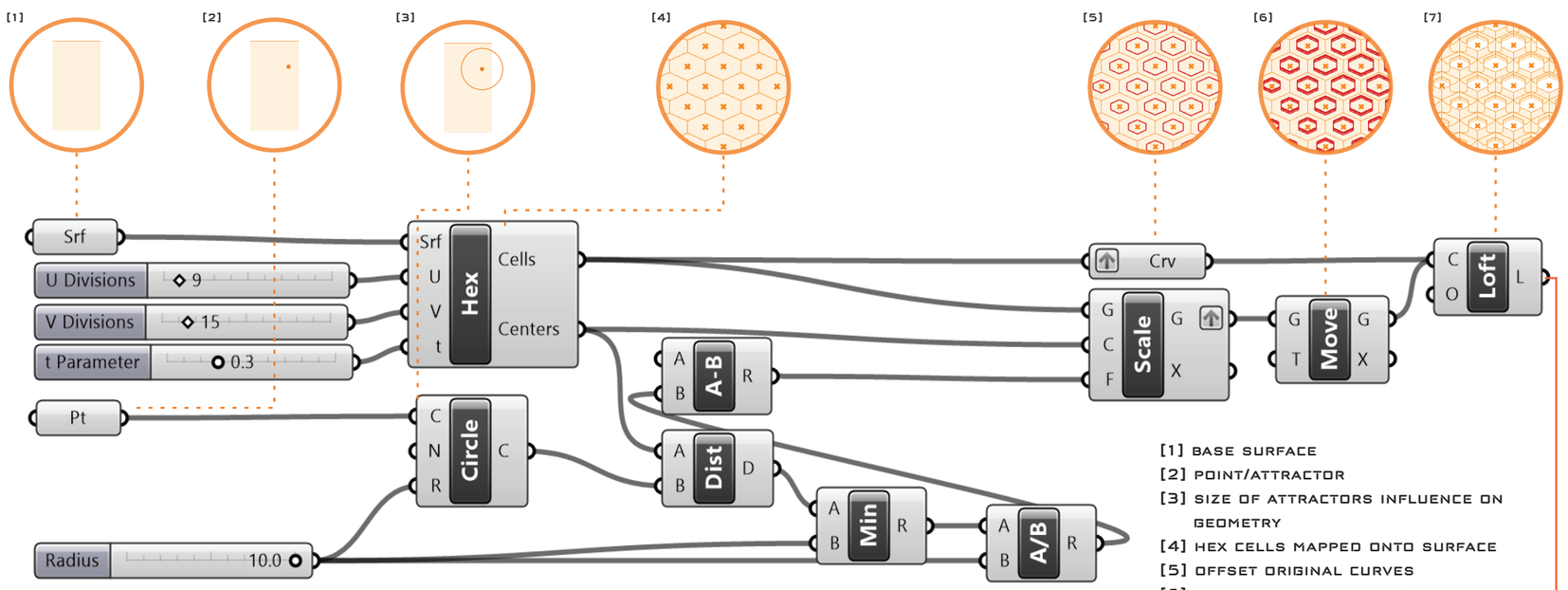
3.2 PARAMETRIC DEVELOPMENT_

THE [HYDRO-GEN] CELL IS A CELLULAR MODULE DESIGNED FOR A VERTICAL FARMING SYSTEM AND WAS CREATED IN A WAY THAT ALLOWS FOR THE MODULE TO BE RECONFIGURED IN DIFFERENT FORMS DUE TO ITS HEXAGONAL BASE. INSPIRATION WAS DRAWN FROM THE TRUNK OF A MEXICAN FAN PALM [PALMERA] AS THE SCALES ALSO HAVE A HEXAGONAL BASE AND THEY TEND TO GROW UPWARDS AT AN ANGLE. IT IS RECOMMENDED THAT FOR PLANTS GROWING IN ANY VERTICAL SYSTEM THAT THE PODS HOUSING THE PLANTS ARE ANGLED AT 45°.

THE PROCESS OF GENERATING A [HYDRO-GEN] CELL MODULE IS BY UTILIZING THE PARAMETRIC MODELING PLUGIN FOR RHINO [GRASSHOPPER]. FROM THERE 5 VARIATION WHERE DERIVED EACH EXPLORING THE QUALITIES NEEDED FOR A HYDROPONIC SYSTEM TO FUNCTION. LIGHTING, WIND, STABILITY, FUNCTION, AND FABRICATION WERE THE MAIN DRIVING FORCES IN DETERMINING THE FINAL OUTCOMES FOR THE 5 VARIATIONS OF THE [HYDRO-GEN] CELL MODULE.

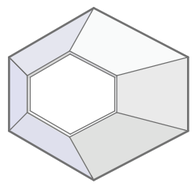
EACH VARIATION IS ABLE TO BE RECONFIGURED IN ANY WAY REGARDLESS OF ITS APPEARANCE AND CAN EASILY BE ATTACHED OR DETACHED FROM A HEXAGONAL STRUCTURAL SYSTEM. THE MODULES CAN ALSO BE DESIGNED TO WHERE THEY RESPOND TO AN ATTRACTOR POINT WHICH IN THE REAL WORLD COULD BE THE MOVEMENT OF THE SUN.

CELL DEVELOPMENT DEFINITION_

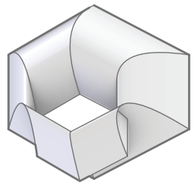


[1] BASE SURFACE
[2] POINT/ATTRACTOR
[3] SIZE OF ATTRACTORS INFLUENCE ON GEOMETRY
[4] HEX CELLS MAPPED ONTO SURFACE
[5] OFFSET ORIGINAL CURVES
[6] NEW SET OF CURVES ARE MOVED ALONG X,Y,Z COORDINATES
[7] LOFT THE NEW SET OF CURVES WITH THE ORIGINAL SET

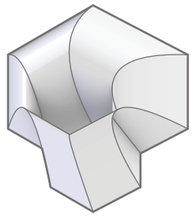
CELL VARIATIONS_



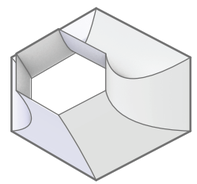
[VARIATION_ 1]



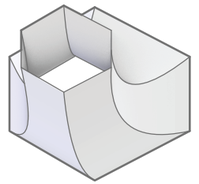
[VARIATION_ 2]



[VARIATION_ 3]

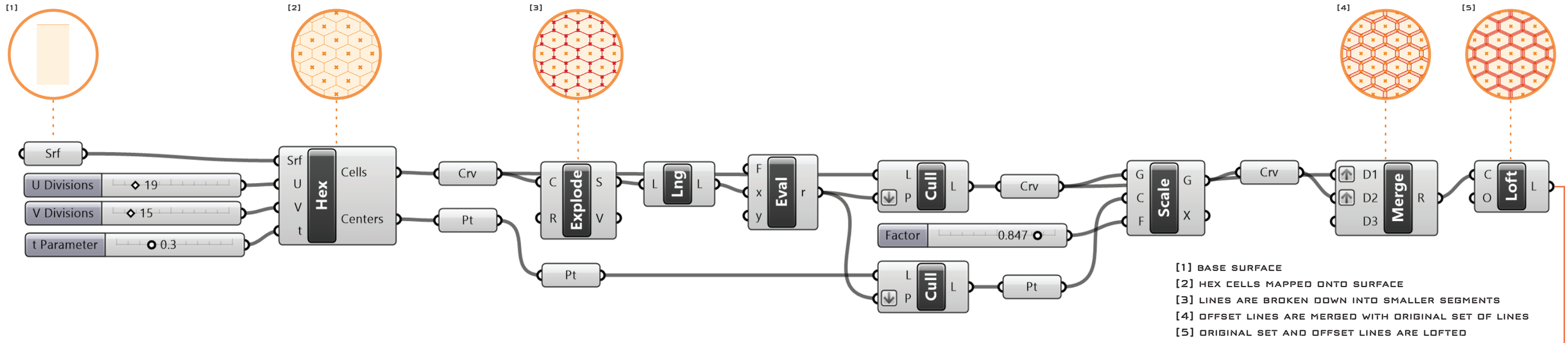


[VARIATION_ 4]



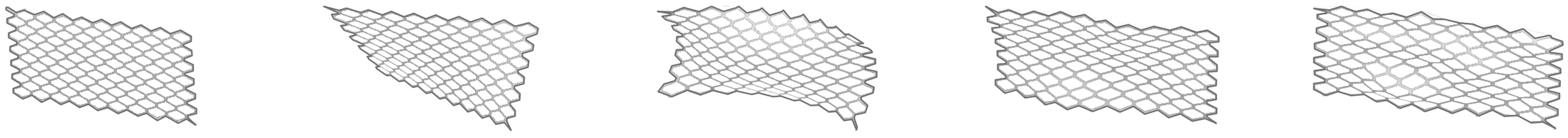
[VARIATION_ 5]

HEXAGONAL FRAME DEFINITION_



[1] BASE SURFACE
[2] HEX CELLS MAPPED ONTO SURFACE
[3] LINES ARE BROKEN DOWN INTO SMALLER SEGMENTS
[4] OFFSET LINES ARE MERGED WITH ORIGINAL SET OF LINES
[5] ORIGINAL SET AND OFFSET LINES ARE LOFTED

SURFACE APPLICATIONS_



[HEX MORPH_ 1]

[HEX MORPH_ 2]

[HEX MORPH_ 3]

[HEX MORPH_ 4]

[HEX MORPH_ 5]

3.3 [HYDRO-GEN] CELL VARIATIONS_

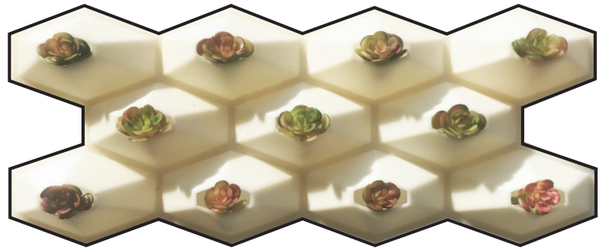
WITH THE DEVELOPMENT OF THE [HYDRO-GEN] CELL CAME MANY EXPERIMENTAL GEOMETRIES. BY UTILIZING THE SAME DEFINITION THE BASE DNA OR RULES FOR THE CELLS REMAINS THE SAME. HOWEVER, THERE IS A MOVE COMPONENT WITHIN THE DEFINITION THAT ALLOWS FOR SOME TWEAKING. WITH THE MOVE COMPONENT ONE CAN SPECIFY SPECIFIC VECTORS IN WHICH THE DIRECTION OR ORIENTATION OF THE CELLS ARE DETERMINED.

EACH VARIATION OFFERS SOMETHING DIFFERENT. SOME ARE MORE COMPLEX IN TERMS OF FABRICATION. SOME ARE STATIC WHEREAS VARIATIONS 4 AND 5 HAVE THE CAPABILITY OF POTENTIALLY BEING KINETIC. IN ALL 5 VARIATIONS THE POTENTIAL FOR A PARAMETRIC GRADIENT IS POSSIBLE. THE APERTURE SIZES IN ALL 5 CASES CAN PARAMETRICALLY HAVE A GRADIENT FROM SMALL TO LARGE ALONG ANY SURFACE.

THE VARIATION THAT OFFERED THE BEST CONDITIONS FOR PLANTS TO GROW WAS VARIATION [5]. THE FINAL PROTOTYPE BUILDS ON THE DESIGN OF THE TRUNK SHAPED GEOMETRY OFFERED BY VARIATION [5].

3D PRINTED STUDY MODELS_

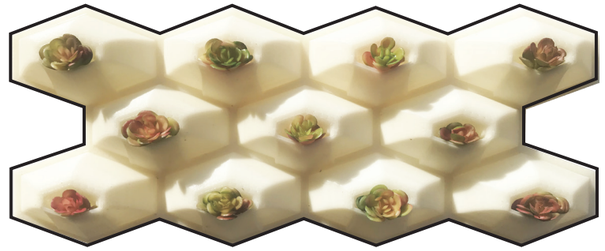
1



VARIATION_ 1

THIS WAS THE FIRST OUTCOME WHEN KEEPING THE SCRIPT AS IT IS. THE GEOMETRY IN THIS VARIATION WAS BY FAR THE SIMPLEST AS IT ONLY CONTAINS FLAT PLANAR SURFACES. IN TERMS OF FABRICATION THIS WOULD BE THE SIMPLEST FORM TO CREATE A 1-1 FULL SCALE MODULE.

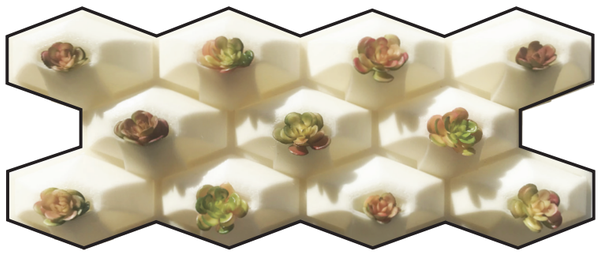
2



VARIATION_ 2

WITH THE SECOND ITERATION IN THE DESIGN OF THE [HYDRO-GEN] CELL EXPERIMENTATION WAS DONE WITH THE MOVE COMPONENT IN THE GRASSHOPPER DEFINITION. IN THIS CASE THE GEOMETRY HAS A MORE ORGANIC FORM AS THE MODULE CURVES FROM THE BASE TOWARDS

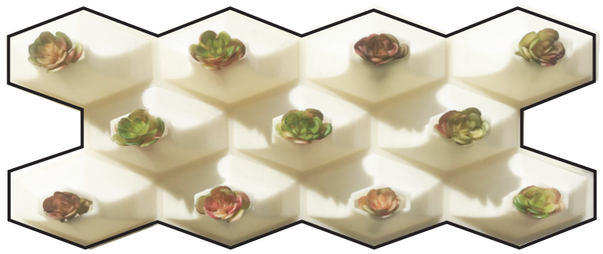
3



VARIATION_ 3

THE 3RD MODULE IS SIMILAR TO VARIATION [2] IN TERMS OF GEOMETRY. THE ONLY DIFFERENCE IS THAT THE OUTER STEM LIKE PART OVERHANGS AND DROPS DOWN FURTHER. THIS WAS ACHIEVED BY SLIGHTLY TOGGLING THE SAME VECTOR MOVEMENTS IN THE MOVE COMPONENT AS VARIATION [2].

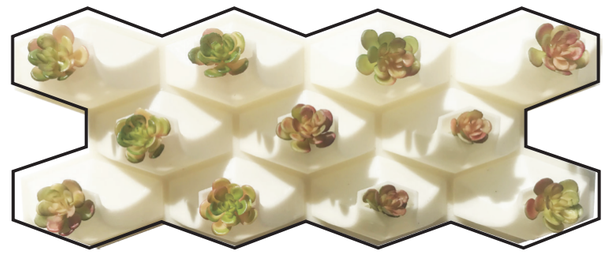
4



VARIATION_ 4

WITH THE FOURTH MODULE THE FORM COMPLETELY CHANGES. IN THIS CASE THERE IS A TRUNK-LIKE FORM THAT EMERGES AFTER DOING THE INVERSE VECTOR MOVEMENTS IN THE GRASSHOPPER DEFINITION. IN DOING SO THIS IS THE ONLY MODULE TYPE THAT COULD HAVE KINETICS INTRODUCED TO IT.

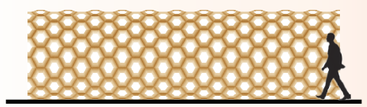
5



VARIATION_ 5

THE FIFTH AND FINAL VARIATION IS ESSENTIALLY THE SAME MODULE AS IN VARIATION [4]. THE DIFFERENCE HERE IS THAT THE FORM WAS EXPERIMENTED WITH IN ORDER TO GET A MORE ANGLED TRUNK SHAPE. THIS WAY HOUSING A PLANT WOULD BE MUCH EASIER. IT TOO HAS THE POTENTIAL FOR KINETICS.

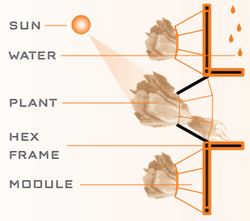
[FRONT] [RIGHT] [PERSPECTIVE]



[GREEN_ FACADE]

[ATTACHED TO HEX_ STRUCTURE]

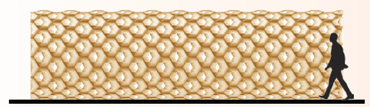
[SECTION_ 1]



[VERTICAL_ HYDROPONIC SYSTEM]

VARIATION_ 1

[FRONT] [RIGHT] [PERSPECTIVE]



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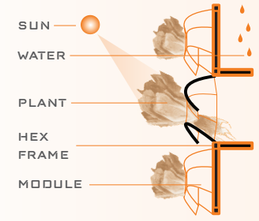
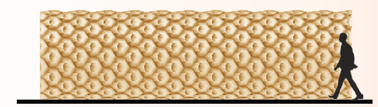
[SECTION_ 2]



[VERTICAL_ HYDROPONIC SYSTEM]

VARIATION_ 2

[FRONT] [RIGHT] [PERSPECTIVE]



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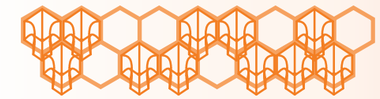

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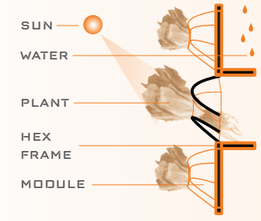
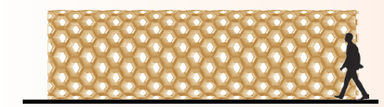
[SECTION_ 3]



[VERTICAL_ HYDROPONIC SYSTEM]

VARIATION_ 3

[FRONT] [RIGHT] [PERSPECTIVE]



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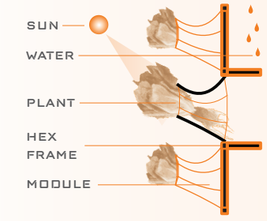
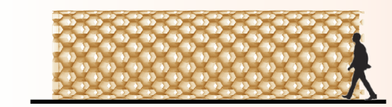
[SECTION_ 4]



[VERTICAL_ HYDROPONIC SYSTEM]

VARIATION_ 4

[FRONT] [RIGHT] [PERSPECTIVE]



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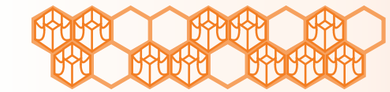

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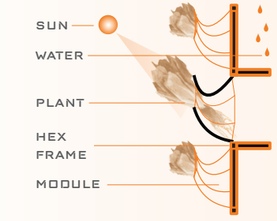
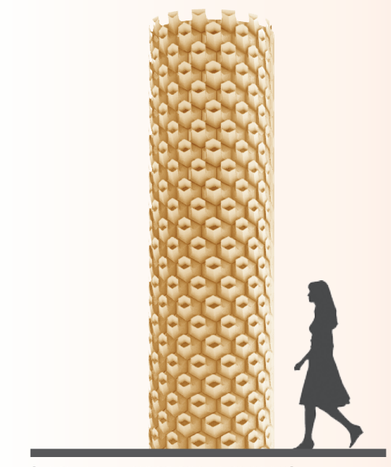




[VERTICAL_ HYDROPONIC SYSTEM]

VARIATION_ 5

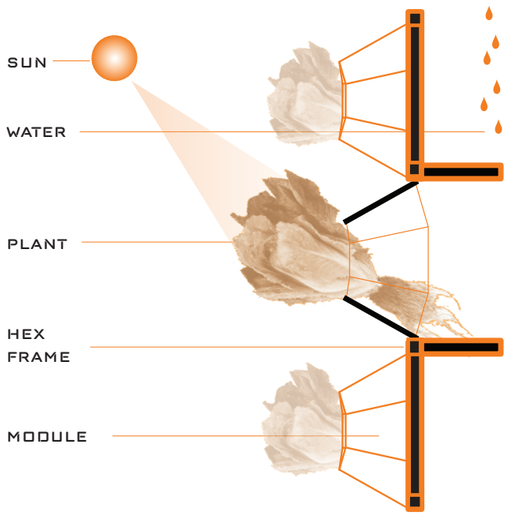
3.4 RURAL_

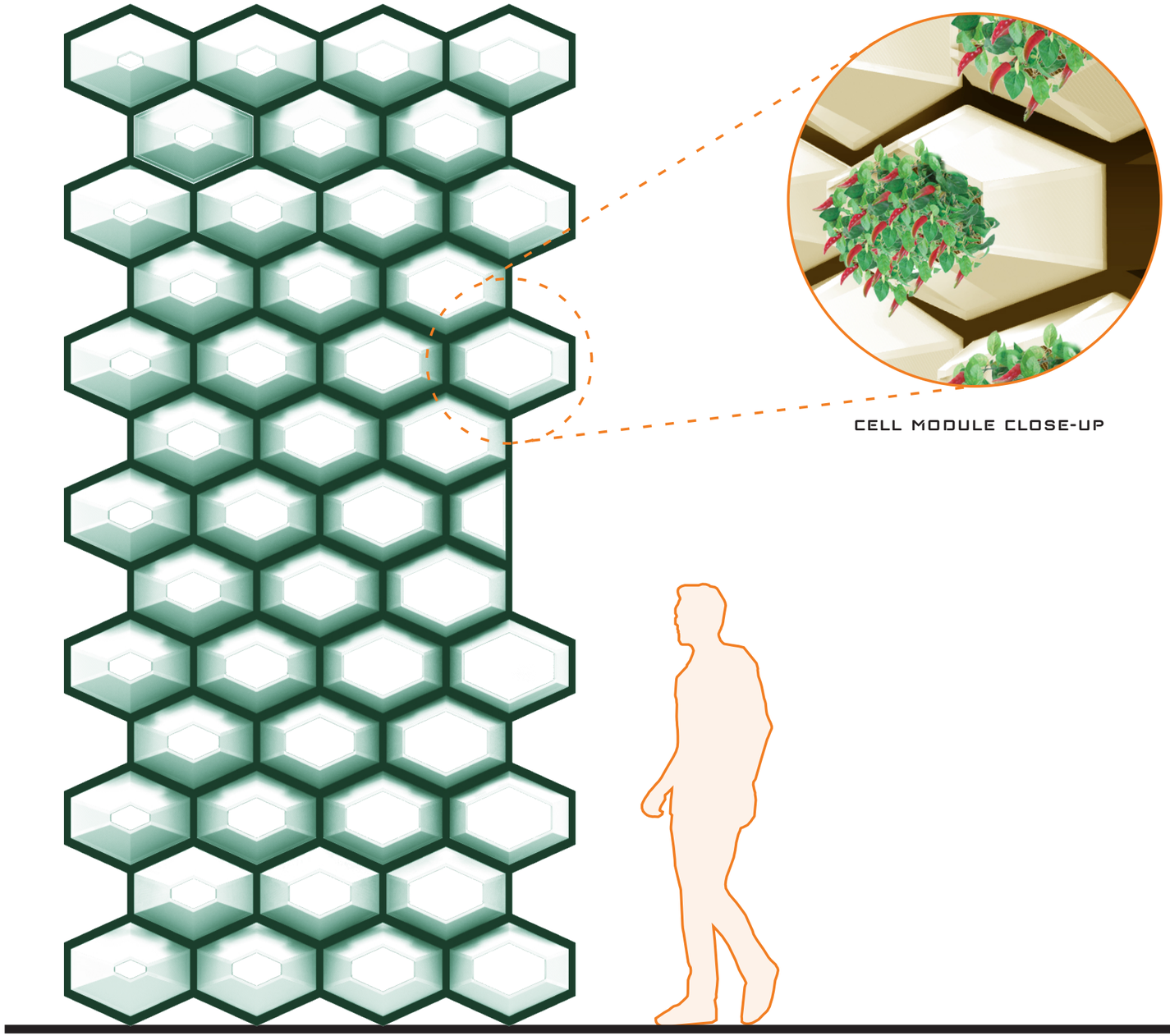
THE [HYDRO-GEN] CELL WAS DESIGNED IN THIS CASE TO FIT WITHIN THE RURAL SETTING. MORE SPECIFICALLY IT LOOKED AT HOW IT COULD POSSIBLY BE ATTACHED TO AN EXISTING WALL CONDITION. A TRADITIONAL FARMERS HOUSE IN RURAL MEXICO IS USUALLY MADE UP OF ADOBE.

THE CELL IN THIS SITUATION WAS DESIGNED TO WHERE A FARMER COULD EASILY ATTACH IT TO AN EXISTING ADOBE WALL. THE MODULE ITSELF IS CELL VARIATION_ 1 WHICH IS BY FAR THE EASIEST TO FABRICATE AND MOST COST EFFICIENT.

THE IDEA IS THAT WITHIN A RURAL SETTING THE [HYDRO-GEN] CELL CAN PROVIDE AN EASIER AND SAFER WAY TO THE OLDER FARMERS. THEY CAN GROW FROM THEIR OWN HOME INSTEAD OF OUT IN THE FIELDS.

SECTION_01





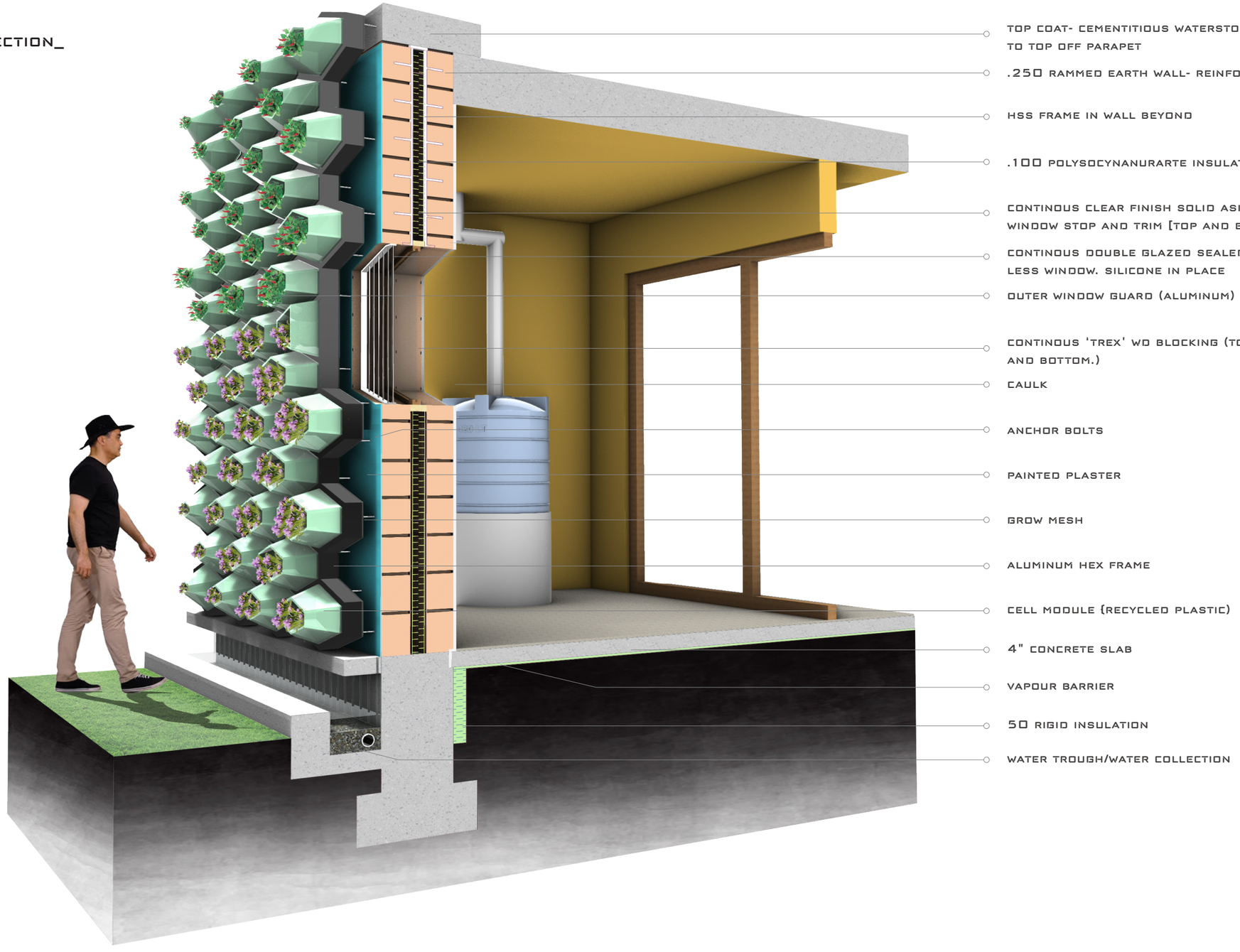
PARAMETRIC FACADE_

RURAL SETTING: RENDERED WALL SECTION_

IN THE RURAL CONTEXT THE [HYDRO-GEN] CELL IS SEEN AS A MEANS TO HELP THE RURAL FARMERS. FOR MANY OF THEM THEY HAVE TO DRIVE MANY MILES TO GO TO THE PLOT OF LAND THAT THEY USE FOR CULTIVATION.

IN MANY CASES SOME OF THESE FARMERS ARE FAR PASSED THEIR PHYSICAL CAPABILITY TO MAKE THE LONG TRIPS AND NOT TO MENTION THE INTENSE PHYSICAL LABOR THAT COMES WITH TENDING THE LAND. THE AVERAGE FARMER OWNS AS MUCH AS UP TO 12 ACRES WORTH OF LAND.

WITHIN THE RURAL CONTEXT THE IDEA IS THAT SOME OF THE ELDER FARMERS CAN CULTIVATE AND GROW CROPS FROM THE COMFORT OF THEIR HOME.



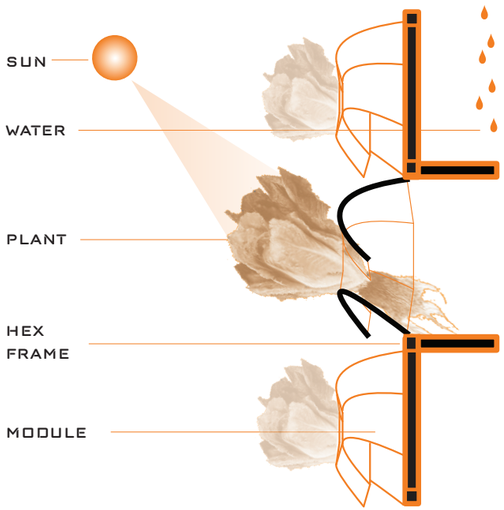
3.5 INDUSTRIAL_

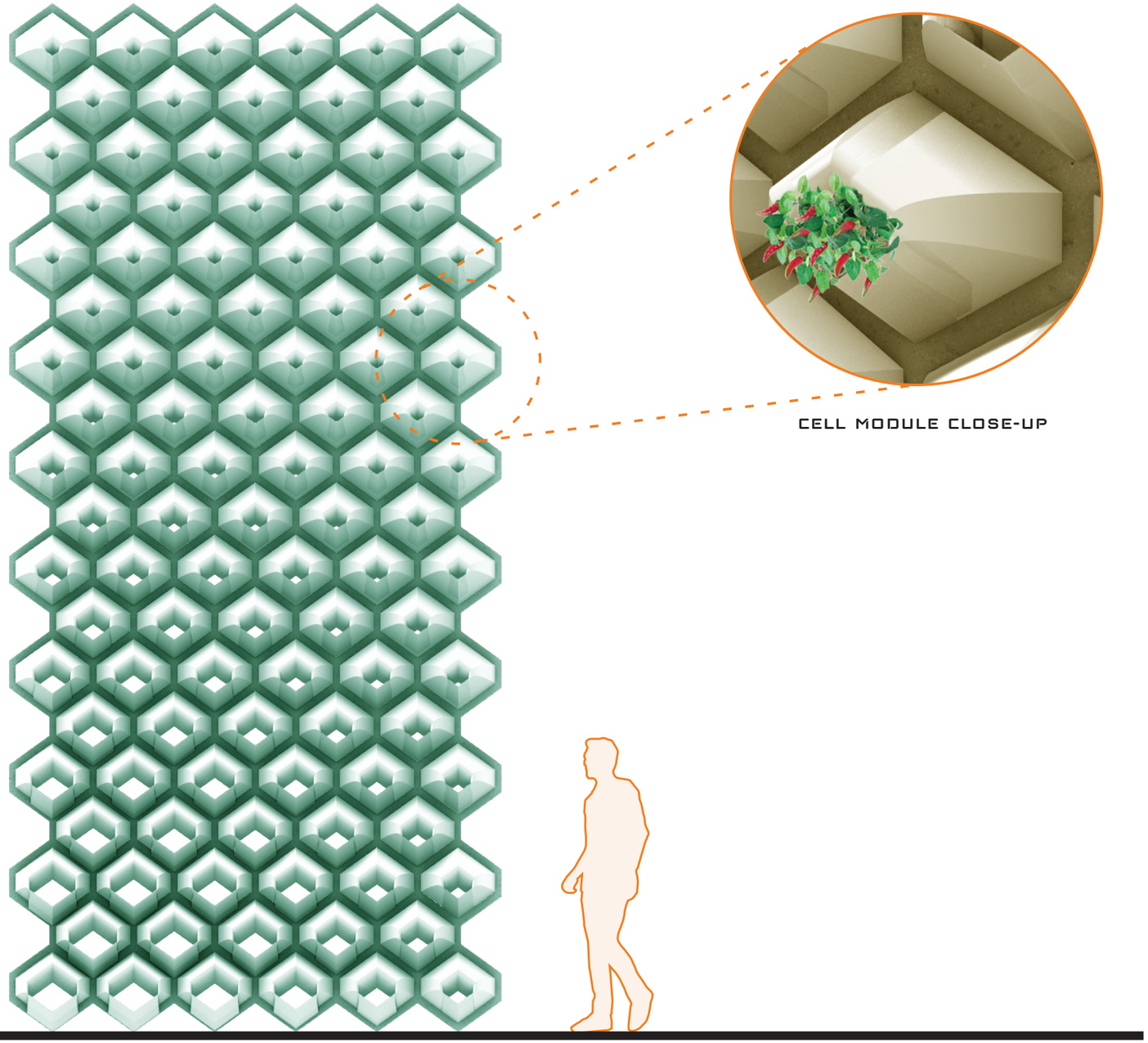
THE [HYDRO-GEN] CELL WAS DESIGNED IN THIS CASE TO FIT WITHIN THE INDUSTRIAL SETTING. MORE SPECIFICALLY IT LOOKED AT HOW IT COULD POTENTIALLY BE ATTACHED OR BE BUILT INTO AN EXISTING WALL CONDITION. MOST STANDARD INDUSTRIAL BUILDINGS IN RURAL MEXICO ARE MADE UP OF CMU UNITS.

THE CELL IN THIS SITUATION WAS DESIGNED TO WHERE THE FACADES OF INDUSTRIAL BUILDINGS COULD EASILY ADOPT THE [HYDRO-GEN] CELL. IN THIS CASE THE USE OF ARTIFICIAL INTELLIGENCE OR AI WILL BE INTEGRATED IN ORDER TO KEEP THE PLANTS MONITORED.

THE IDEA IS THAT WITHIN AN INDUSTRIAL SETTING THE [HYDRO-GEN] CELL CAN PROVIDE A WAY OF CLEANING THE TOXIC AIR FROM THE SOURCE THROUGH THE PLANTS NATURAL CO_2 CLEANING CAPACITIES.

SECTION_02





CELL MODULE CLOSE-UP

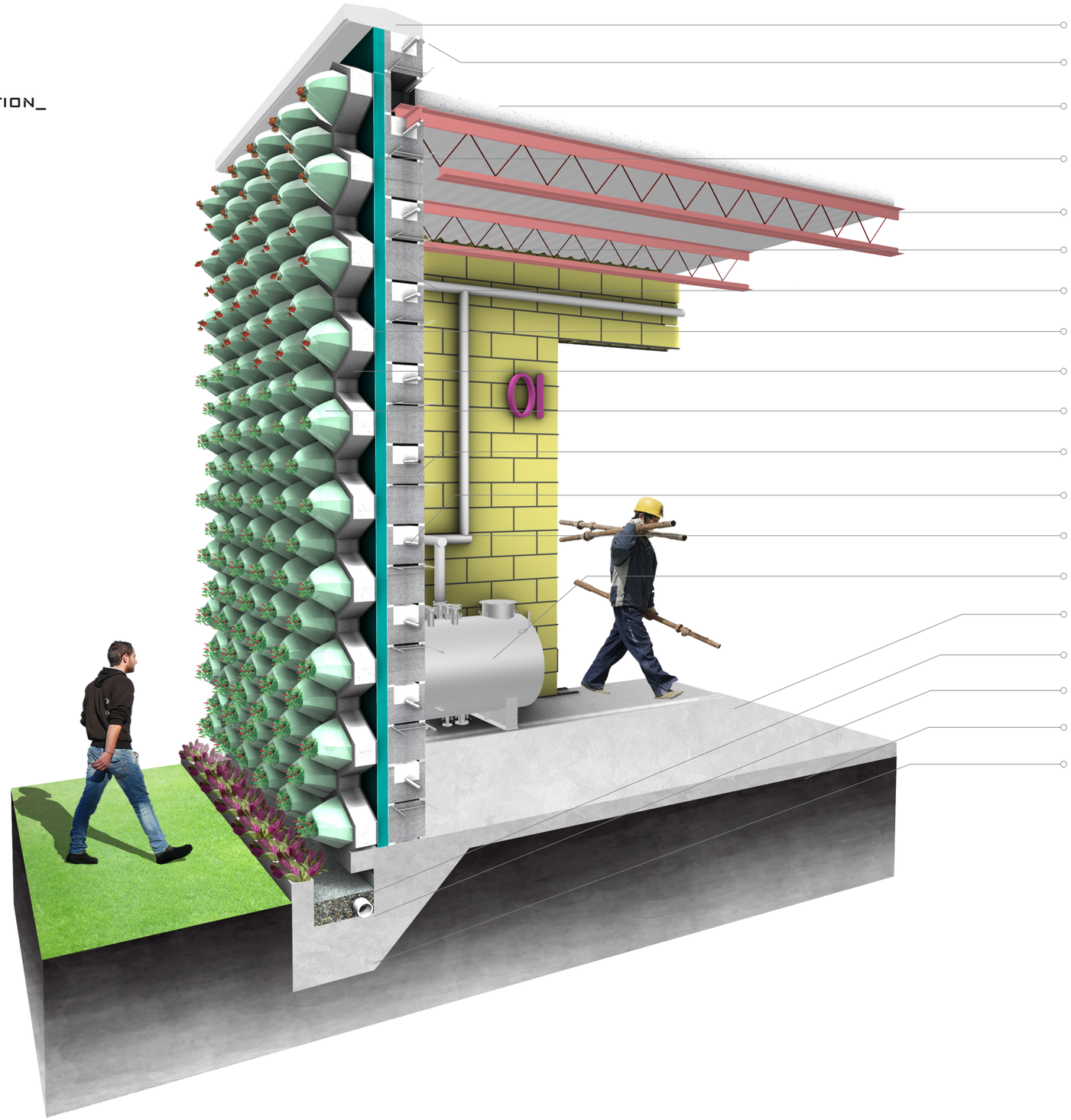
PARAMETRIC FACADE_

INDUSTRIAL SETTING: RENDERED WALL SECTION_

IN THE INDUSTRIAL CONTEXT THE [HYDRO-GEN] CELL WOULD BE UTILIZED TO REMOVE TOXIC POLLUTANTS FROM THE AIR. IT WOULD WORK AS AN IMMEDIATE SOLUTION TO FILTER THE AIR AROUND FACTORIES.

ONLY NATIVE VEGETATION CAN BE UTLIZED AROUND THE FACADE IN THIS SCENARIO, BECAUSE IF ONE WERE TO ATTEMPT TO GROW ANY TYPE OF PRODUCE THERES A RISK OF THE PLANTS GETTING CONTAMINATED BY DIRECTLY MAKING CONTACT WITH FUMES AND SMOG.

THE OVERALL IDEA BEHIND ITS APPLICATION IN THE INDUSTRIAL SETTING IS THAT BY DOING SO PLACES THAT BURN FOSSIL FUELS FOR ENERGY CAN HAVE LARGE AMOUNTS OF CO2 REMOVED FROM THE AIR. THIS WOULD HOPEFULLY SLOW DOWN THE RATE AT WHICH THE OZONE LAYER GETS DEPLETED.



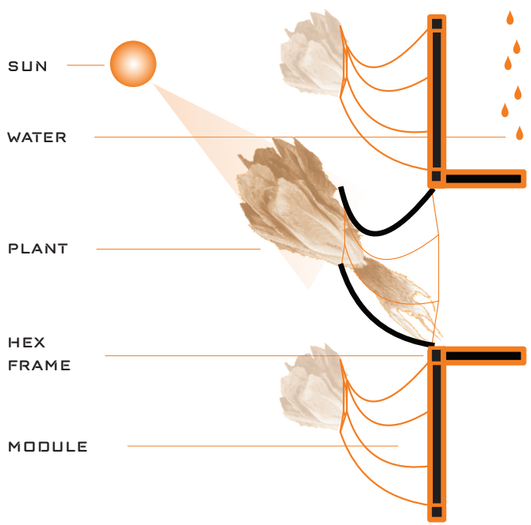
3.6 URBAN_

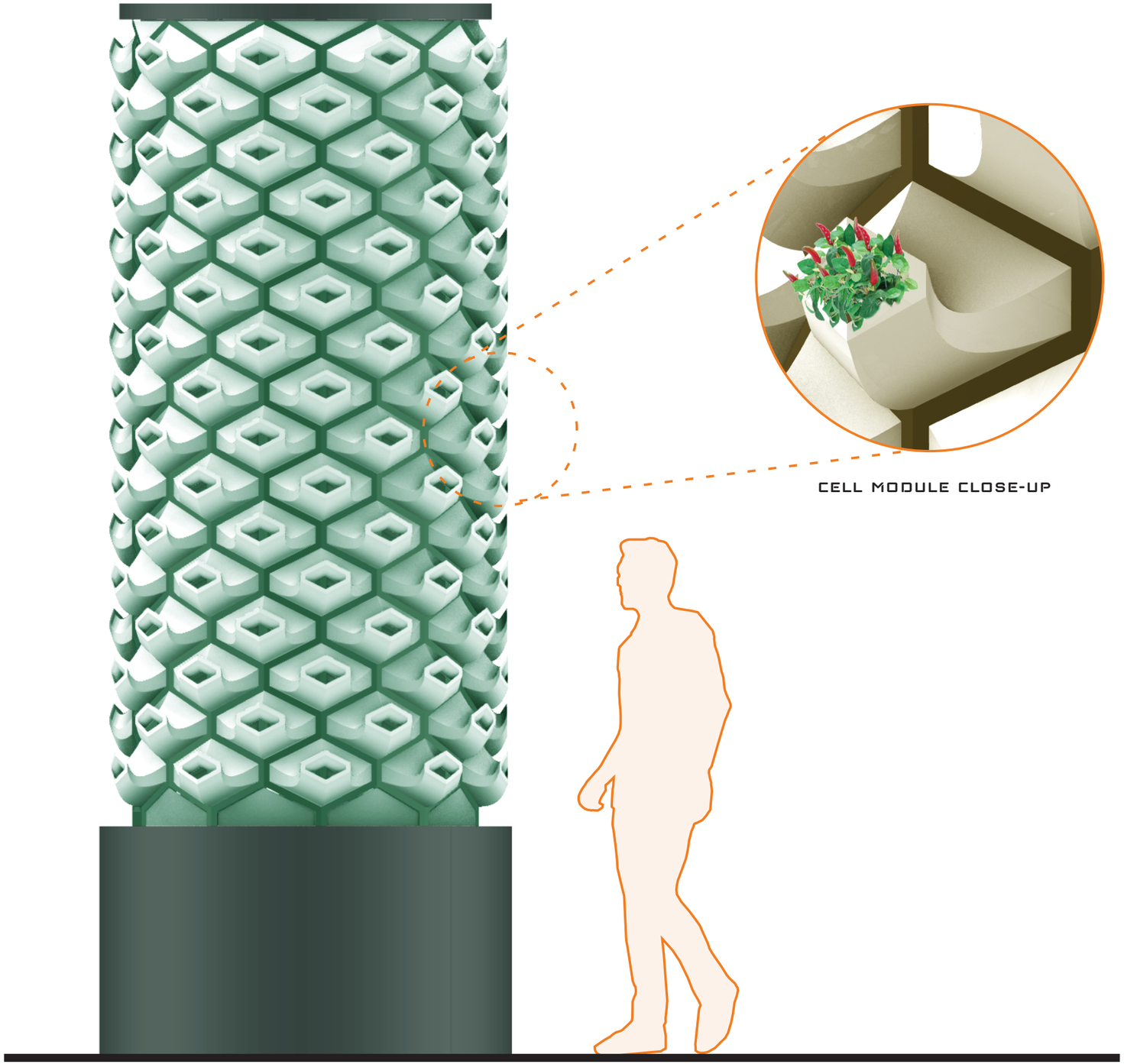
THE [HYDRO-GEN] CELL WAS DESIGNED IN THIS CASE TO FIT WITHIN THE URBAN SETTING. MORE SPECIFICALLY IT LOOKED AT HOW IT COULD POTENTIALLY BE DESIGNED INTO A VERTICAL GROWING POD. THESE PODS WOULD BE IDEAL FOR PRODUCING LARGE AMOUNTS OF FOOD FOR DENSE CITIES.

THE CELL IN THIS SITUATION WAS DESIGNED TO WHERE THE MODULE ITSELF HAS THE CAPABILITY OF MOVING AND TRACKING THE SUN. ITS TRUNK LIKE DESIGN ALLOWS FOR IT TO FLEX INTO DIFFERENT POSITIONS.

THE IDEA IS THAT WITHIN AN URBAN SETTING THE [HYDRO-GEN] CELL CAN IMPLEMENTED WITHIN THE INTERIOR OF MID OR HIGH RISE BUILDINGS THROUGH THE USE OF THESE VERTICAL POD DESIGNS.

SECTION_03





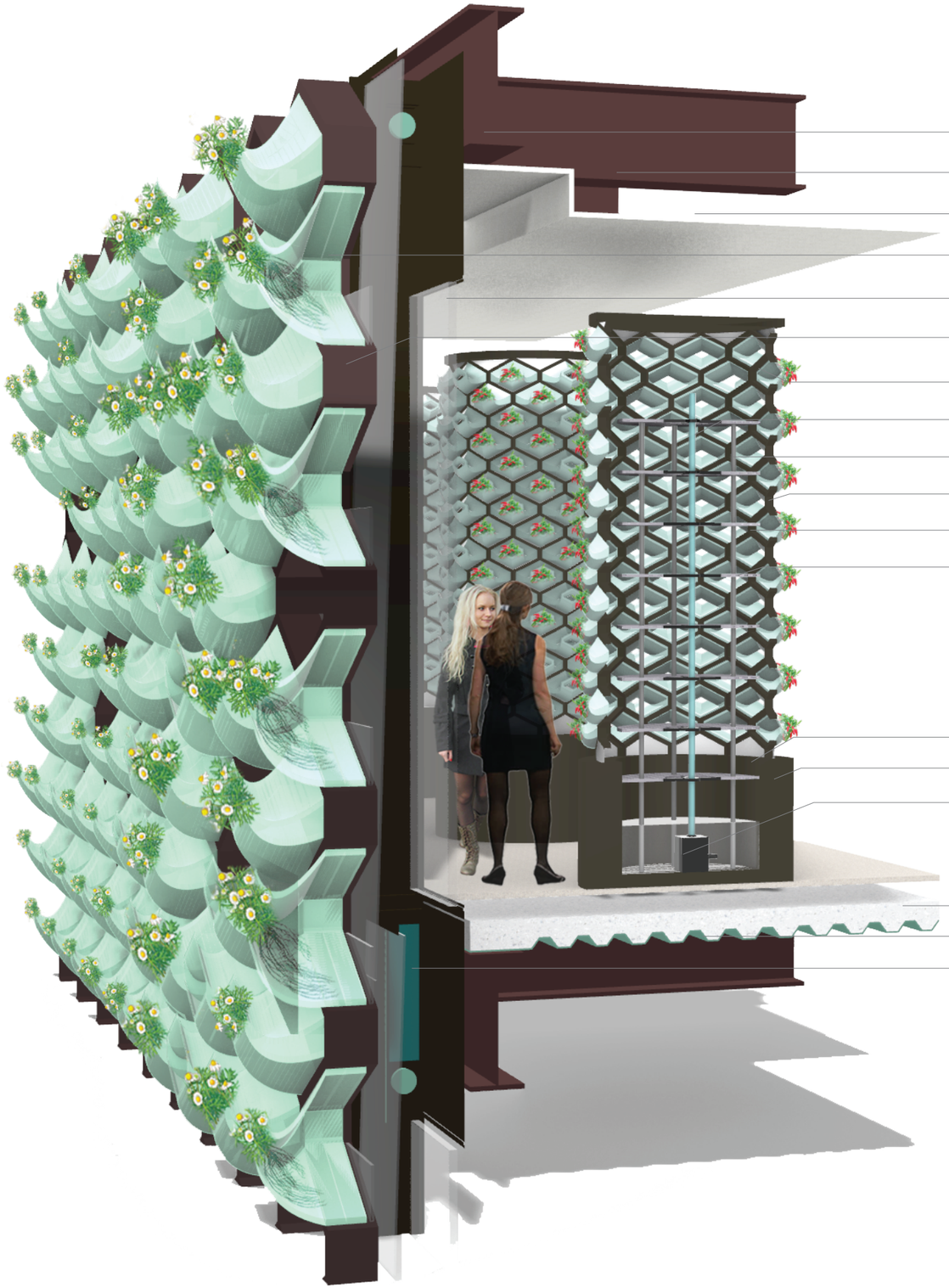
CELL MODULE CLOSE-UP

PARAMETRIC GROW POD

URBAN SETTING: RENDERED WALL SECTION_

IN THE URBAN CONTEXT THE [HYDRO-GEN] CELL IS SEEN PRIMARILY AS AN AESTHETIC FUTURISTIC PARAMETRIC FACADE WITH KINETIC MODULES THAT RESPOND TO DIFFERENT SOLAR CONDITIONS. HOWEVER, ITS TRUE INTENTION IN A URBAN ENVIRONMENT IS THAT THE MODULES WITH PLANTS HOUSED IN THEM WILL ACT AS AIR FILTRATION INTERVENTIONS.

BY STRATEGICALLY UTILIZING NATIVE VEGETATION FROM THE LOCAL REGION THE FACADES OF EXISTING MID- TO HIGH-RISE BUILDINGS CAN ADOPT THE FACADE AND BENEFIT FROM IT. THE AIR-CLEANING CAPACITY OF THE CELLS WILL BENEFIT CITIES THAT DEAL WITH AIR POLLUTION. AS A FACADE SYSTEM IT CAN ALSO BE UTILIZED TO SHADE AND KEEP BUILDINGS FROM OVERHEATING DURING THE SUMMER. THE [HYDRO-GEN] CELL BRINGS BACK THE CONCEPT OF THE VERTICAL FARM WITHIN AN URBAN SETTING AND COULD VERY WELL BE APPLIED.



CHAPTER 04_

"PROTOTYPE DEVELOPMENT"_

04

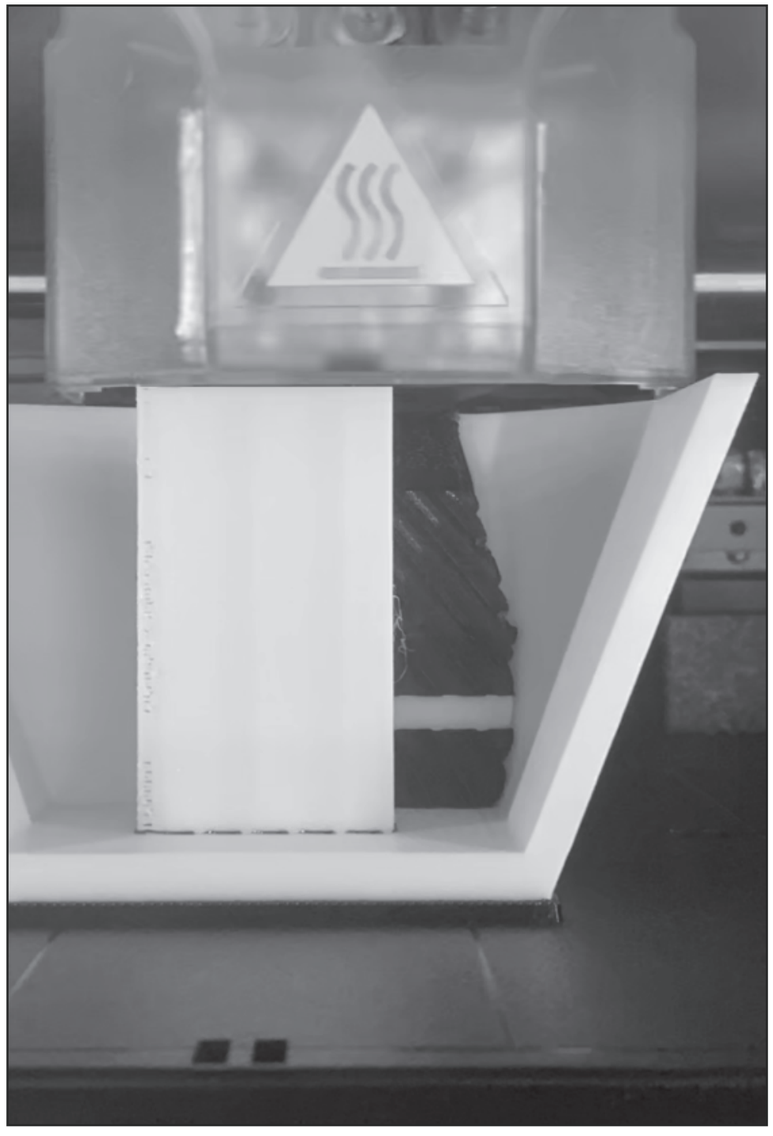
4.1 FABRICATION PROCESS _

THIS JOB TOOK ALL SEMESTER TO COMPLETE AS THERE WERE MULTIPLE CHALLENGES TO OVERCOME.

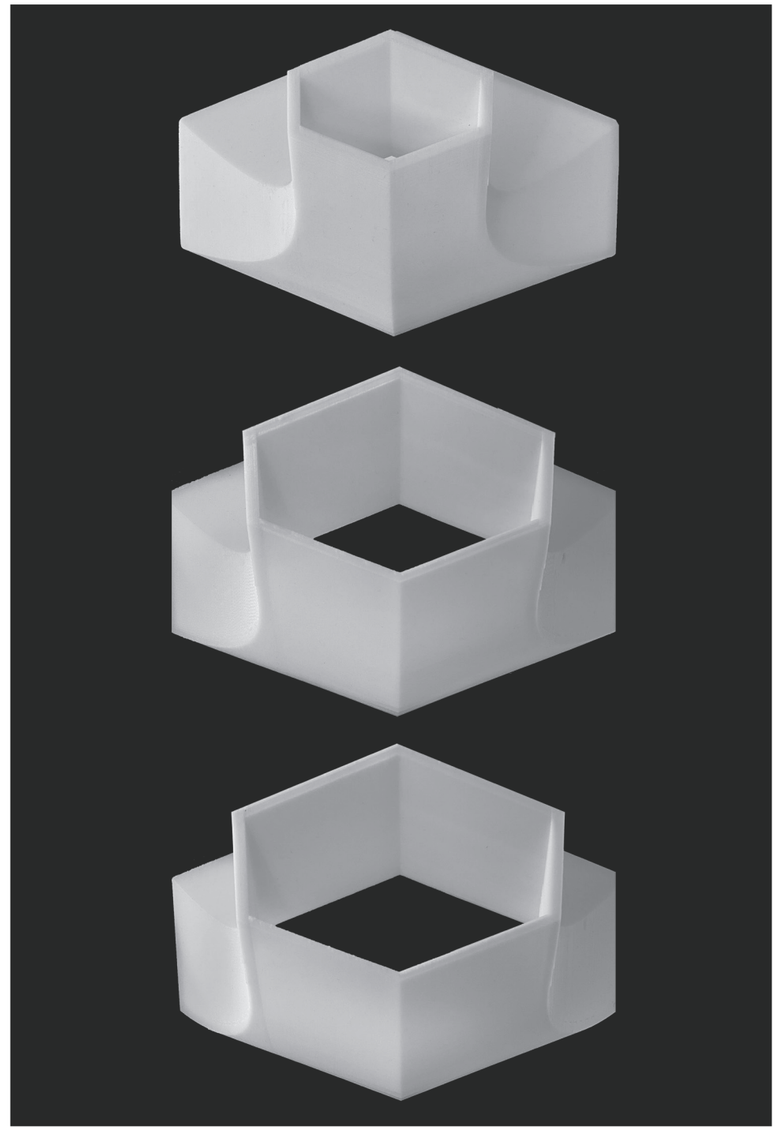
SUCH AS, GETTING A SPECIAL ORDER OF FILLAMENT APPROVED BY THE DEPARTMENT FOR 3D PRINTING. AND HAVING TO FIND AN ALTERNATIVE METHOD TO CREATE CUSTOM PLASTIC CONTAINERS FOR THE BACKSIDE OF THE MODULES.

THE FOLLOWING ARE A SERIES OF PHOTOGRAPHS CAPTURING THE ENTIRE FABRICATION PROCESS OF THE LARGE SCALE PROTOTYPE.

3D PRINTED MODULES_



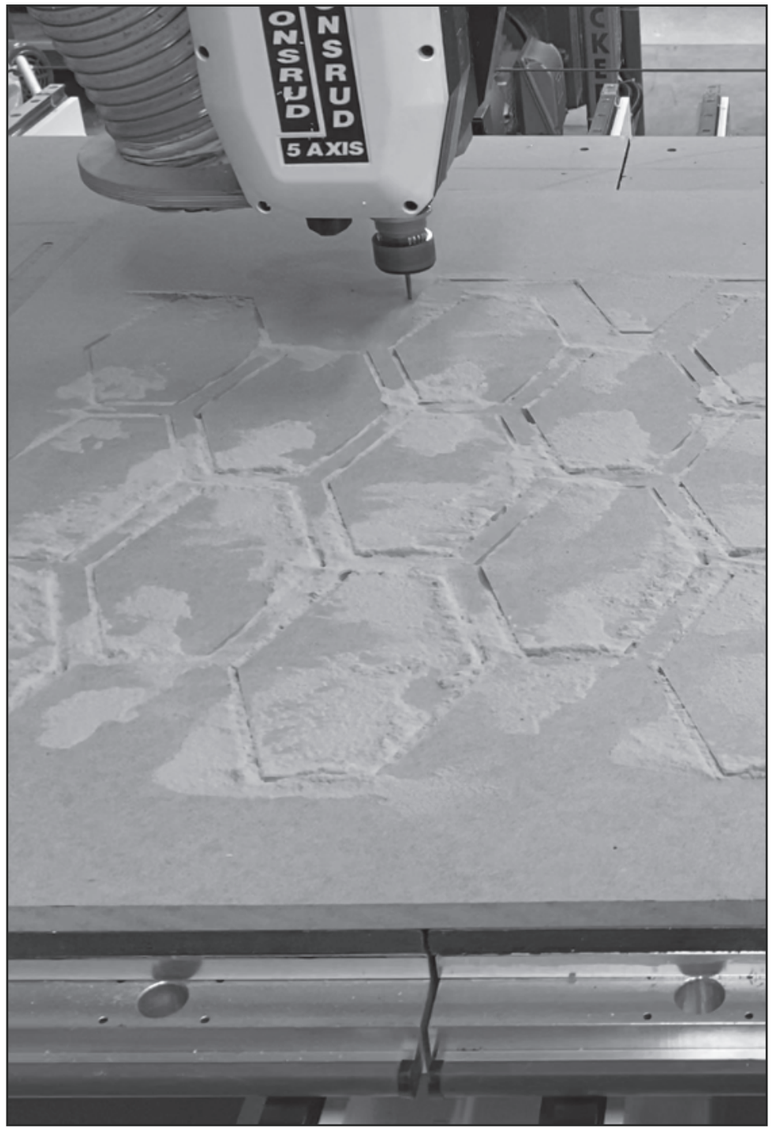
A TOTAL OF 18 MODULES WERE 3D PRINTED FOR THE COMPLETION OF THE PROJECT.



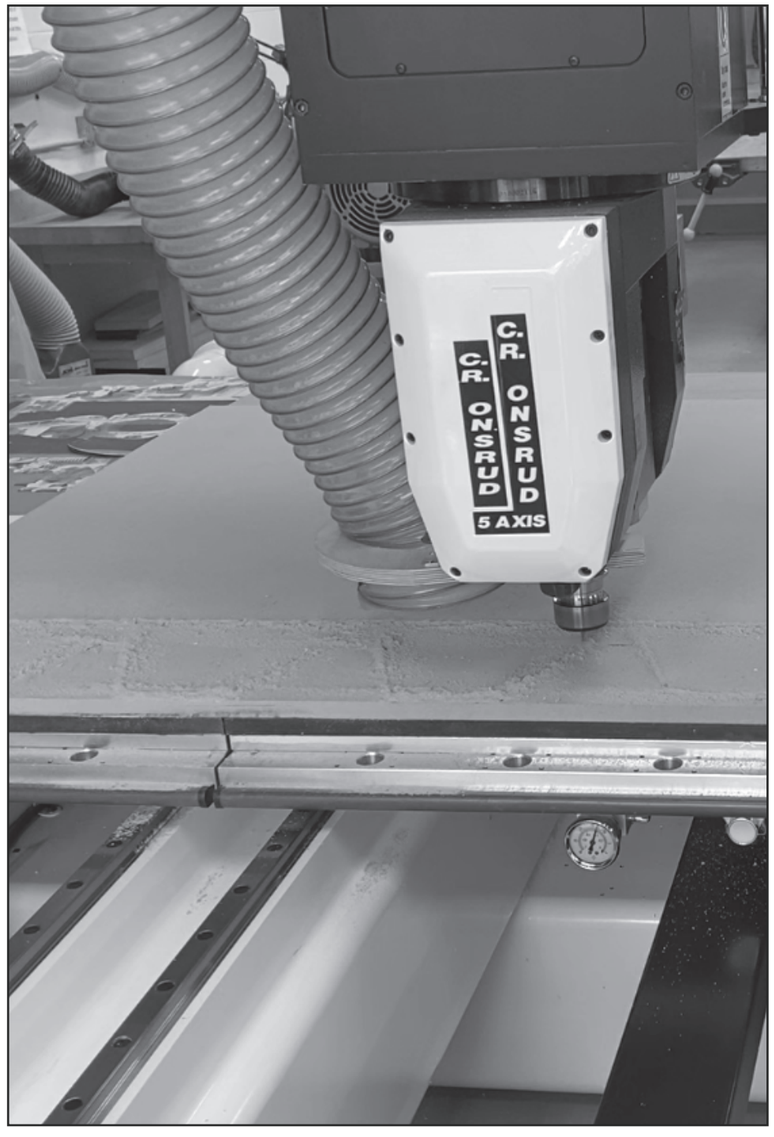
THE 18 MODULES ARE BROKEN DOWN INTO THESE 3 VARIATIONS WITH 6 BEING SMALL, 9 MEDIUM, AND 3 LARGE.

CNC ROUTER PROCESS_

CNC PROCESS OF THE MAIN FRAMING SYSTEM TO HOUSE THE 3D PRINTED MODULES [HEX-FRAME].



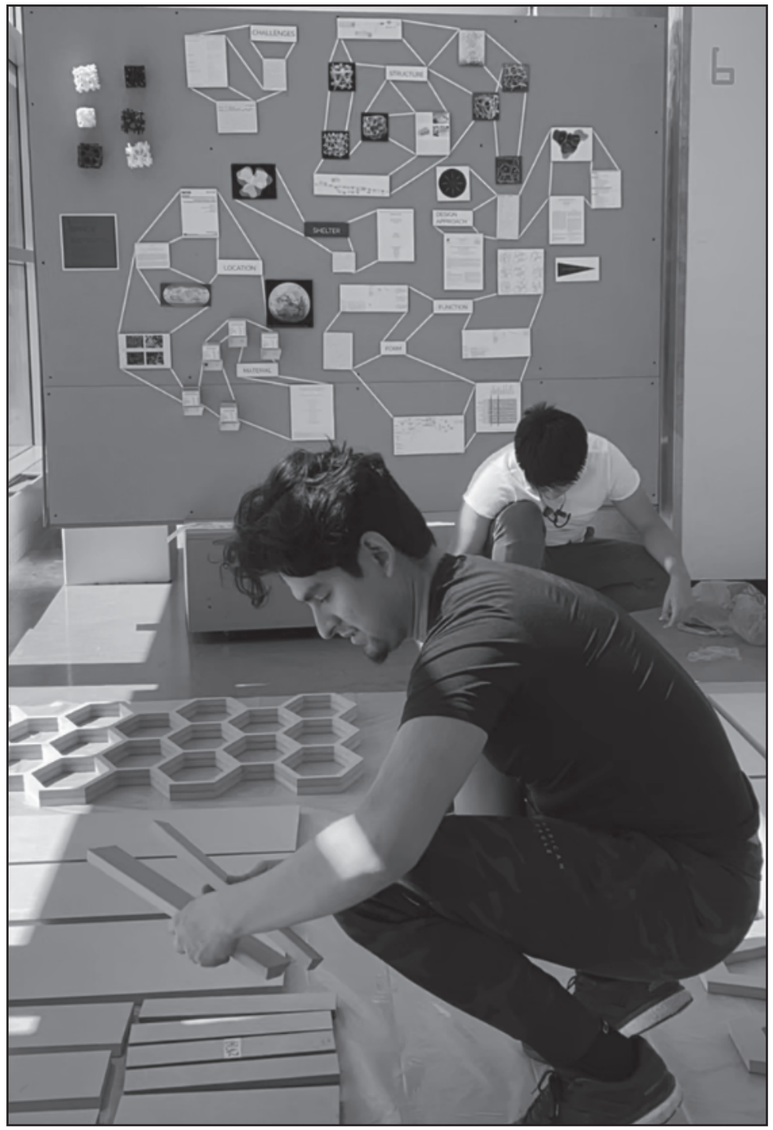
CNC PROCESS OF THE LARGE MAIN PANEL TO WHICH THE [HEX-FRAME] GETS ATTACHED TO.



CNC PROCESS OF THE BACK SIDE STRUCTURE OF THE MAIN HOUSING CONTAINER.

PAINTING PROCESS_

A COATING OF PRIMER WAS FIRST APPLIED TO ALL THE PIECES IN ORDER TO CREATE A WATERPROOF BARRIER.



THE CONTAINER PIECES WERE CATEGORIZED AND ORGANIZED DURING THE PAINTING PROCESS.

A LAYER OF WHITE PAINT WAS APPLIED AS THE FINAL FINISH FOR ALL THE CNC PIECES.

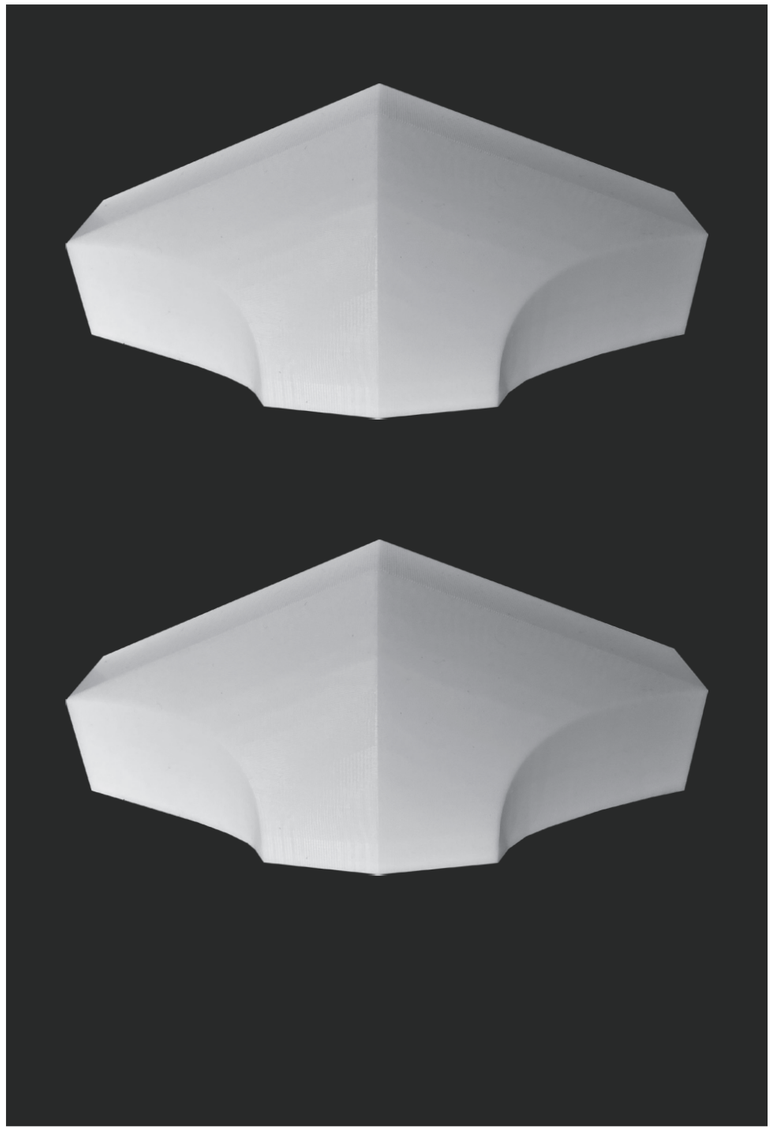
MODULE ATTACHMENT_

PRIOR TO THE CELLS GETTING INSERTED INTO THE HEX FRAME THE FRAME ITSELF HAD TO BE SCREWED TO THE MAIN FRONT PANEL.

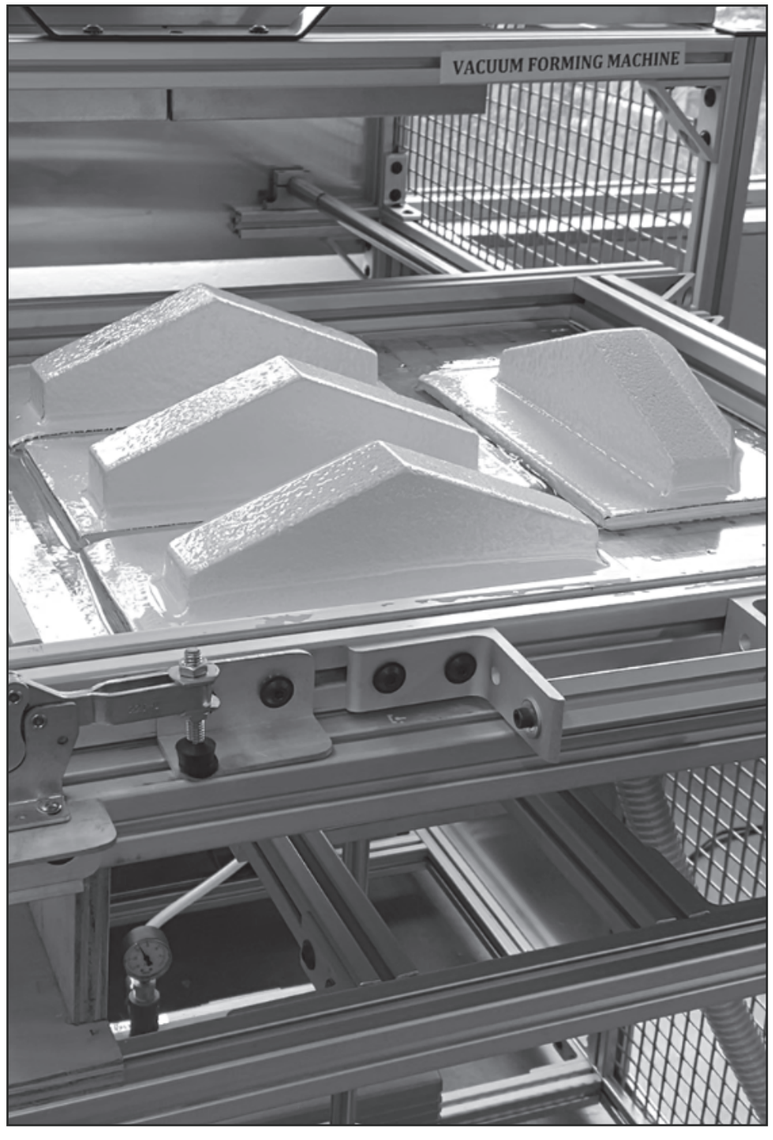
INSERTING THE MODULES INTO THE FRAME REQUIRED SPECIAL CARE AS THEY HAD TO BE FORCED INTO THE OPENINGS.

COMPLETION OF GETTING ALL THE MODULES WITHIN THE [HEX-FRAME]

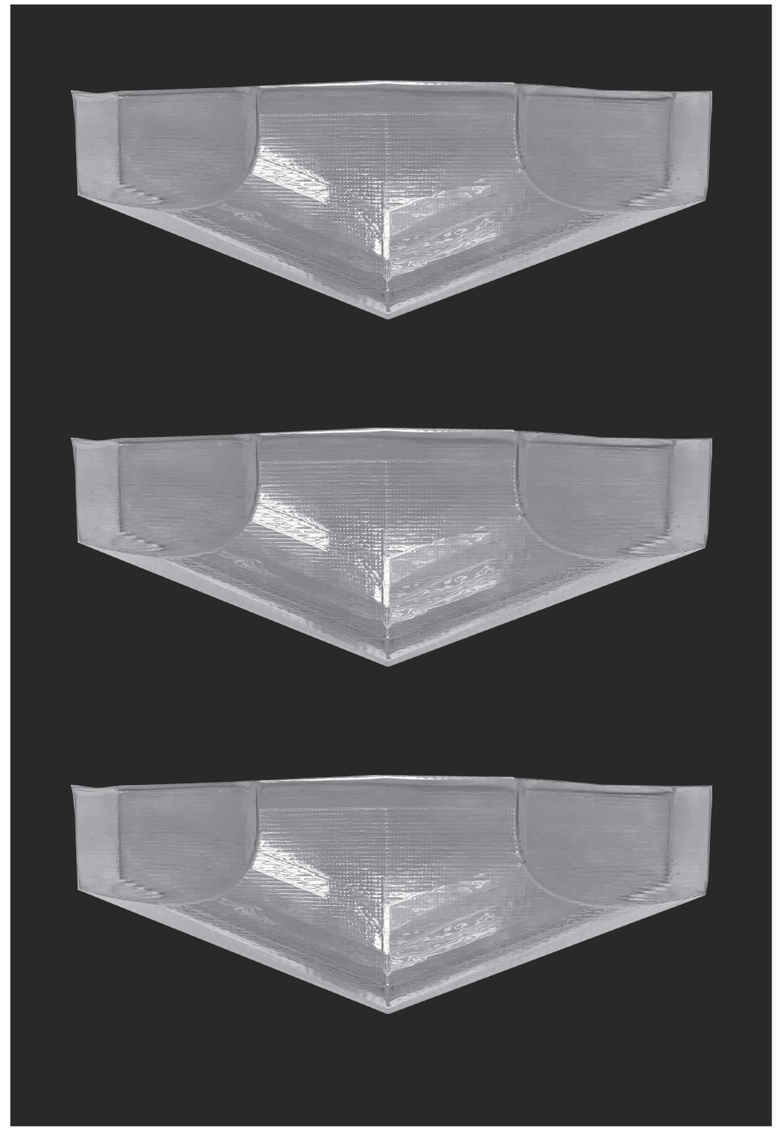
VACUUM FORMING_



SPECIAL MOLDS WERE 3D PRINTED IN ORDER TO CREATE THE PLASTIC CONTAINERS.

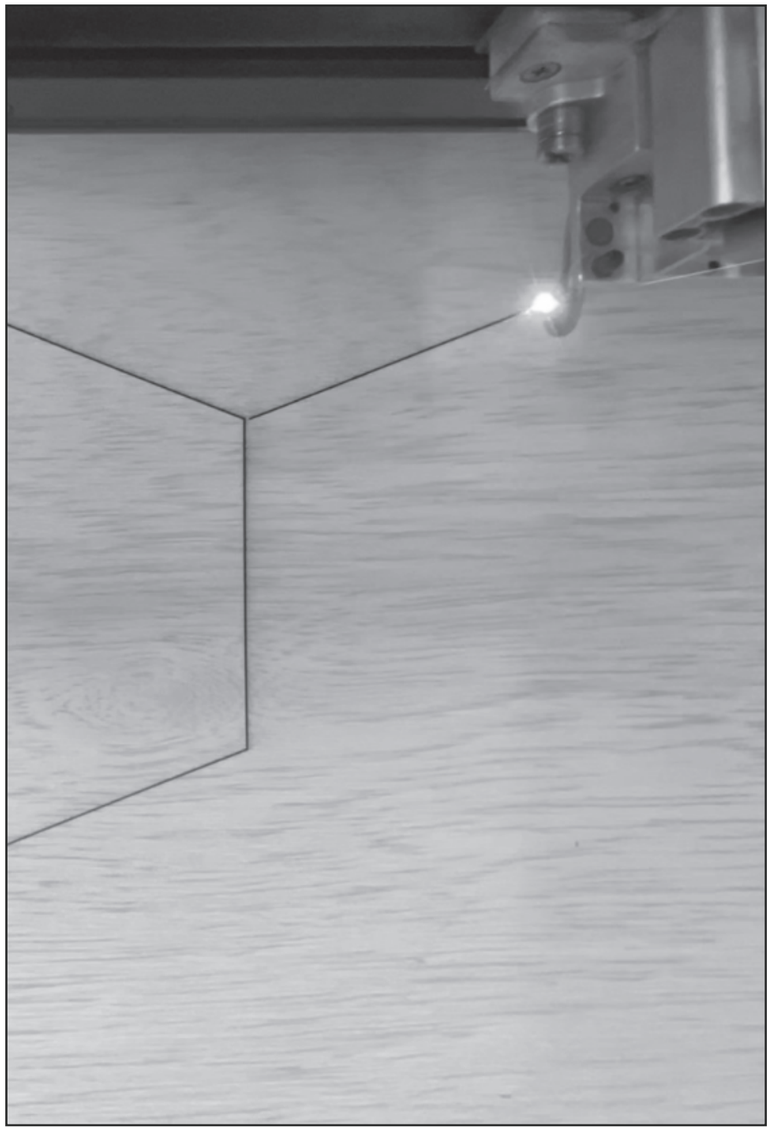


THE CUSTOM 3D PRINTED MOLDS WERE DESIGNED TO WERE THEY COULD BE REUSED, MAKING THE VACCUM FORMING PROCESS EASIER.

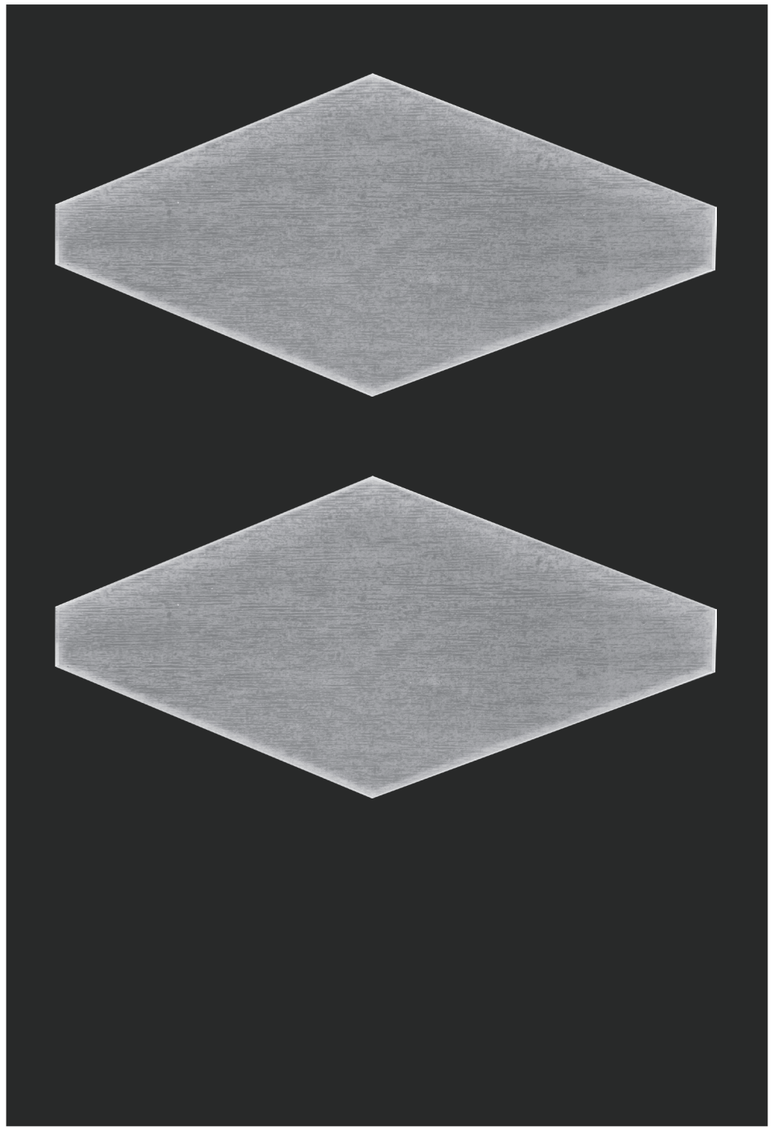


THE FINAL OUTCOME ARE CUSTOM PLASTIC CONTAINERS MEANT TO FIT WITHIN THE BACK PART OF THE CELL MODULES.

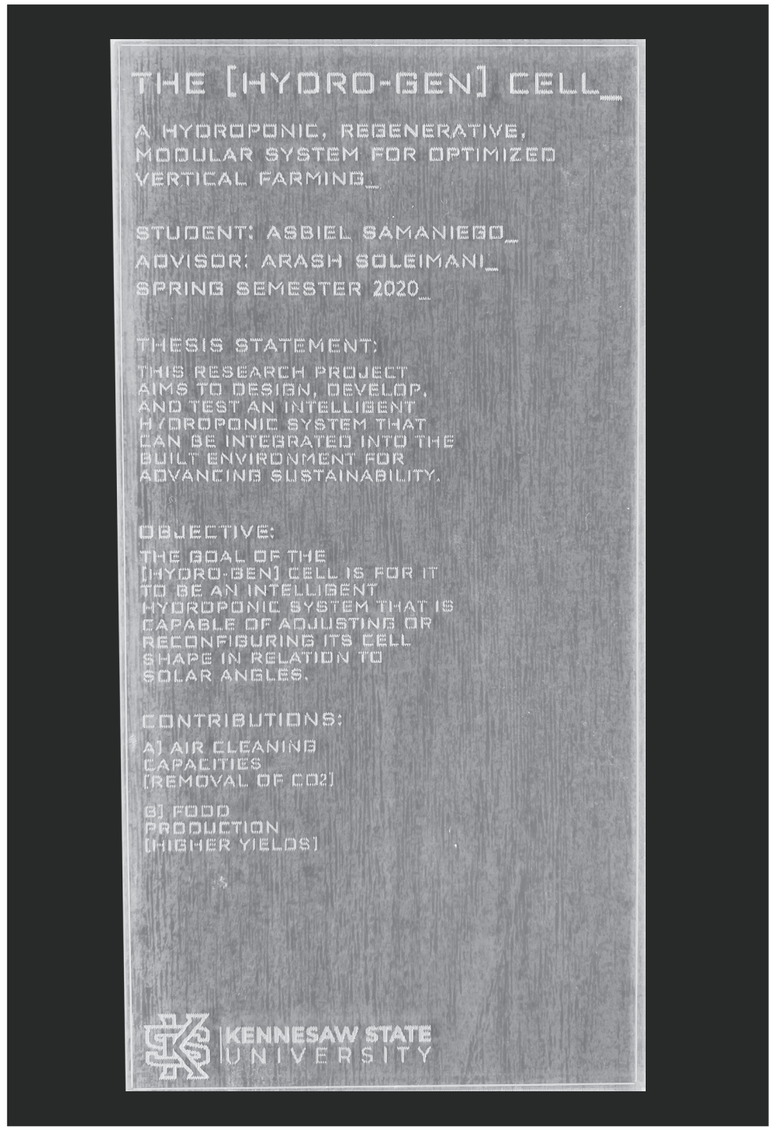
ADDITIONAL DETAILS_



HEXAGONAL PIECES ARE LASER CUT AND ARE PLACED ON THE FRONT PANEL IN ORDER TO PROVIDE ADDTIONAL DEPTH.



ORANGE ACRYLIC IS CUT IN ORDER TO FILL THE SMALL HEXAGONAL OPENINGS ON THE FRONT PANEL AND TO CREATE TRANSPARENCY.



A SPECIAL PLAQUE WAS MADE UTILIZING THE SAME ORANGE ACRYLIC.

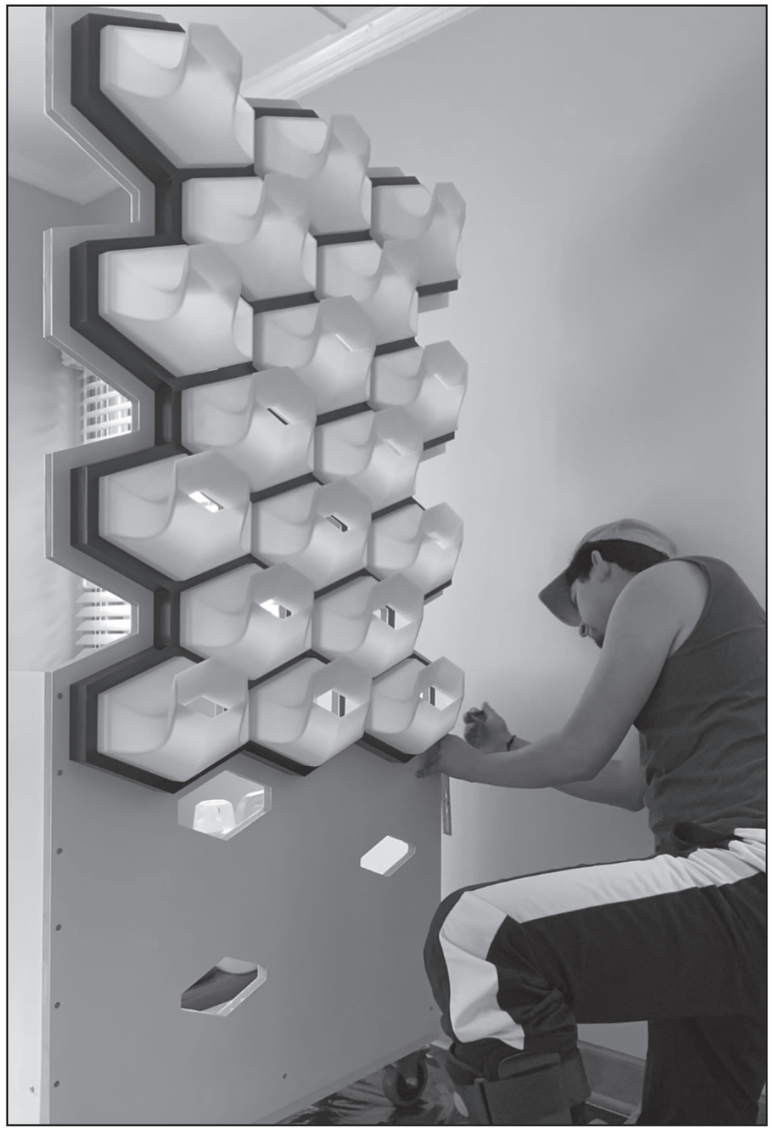
FINAL ASSEMBLY_

ASSEMBLY OF THE BASE AND THE STRUCTURAL SUPPORT PIECES FOR THE FRONT AND SIDE PANELS.

CASTERS GETTING SCREWED IN PLACE IN ORDER TO FACILITATE THE TRANSPORTATION OF THE DEVICE.

SIDE PANEL GETTING SCREWED INTO THE STRUCTURAL 2X8 WOOD STUD OF THE BASE.

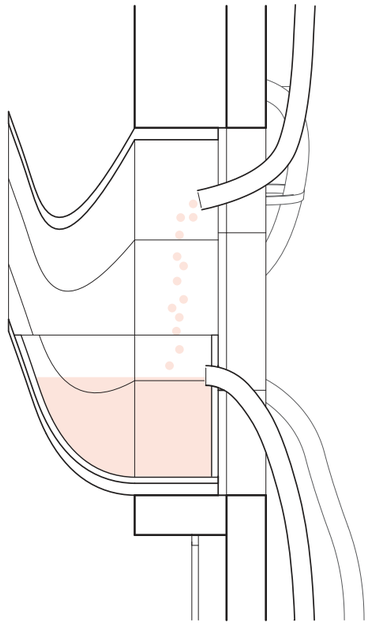
ALIGNING THE FRONT PANEL TO WHERE IT MEETS FLUSH WITH THE SIDE PANELS PRIOR TO SECURING IT.



MEASURING TO DETERMINE THE PLACEMENT AND LOCATION OF THE SCREWS.

SCREWING IN ONE OF THE SIDE PANELS IN ORDER TO PROVIDE STRUCTURAL SUPPORT BETWEEN THE FRONT AND BACK PANELS.

4.2 SCHEMATIC DIAGRAMS_



SECTION PROFILE_

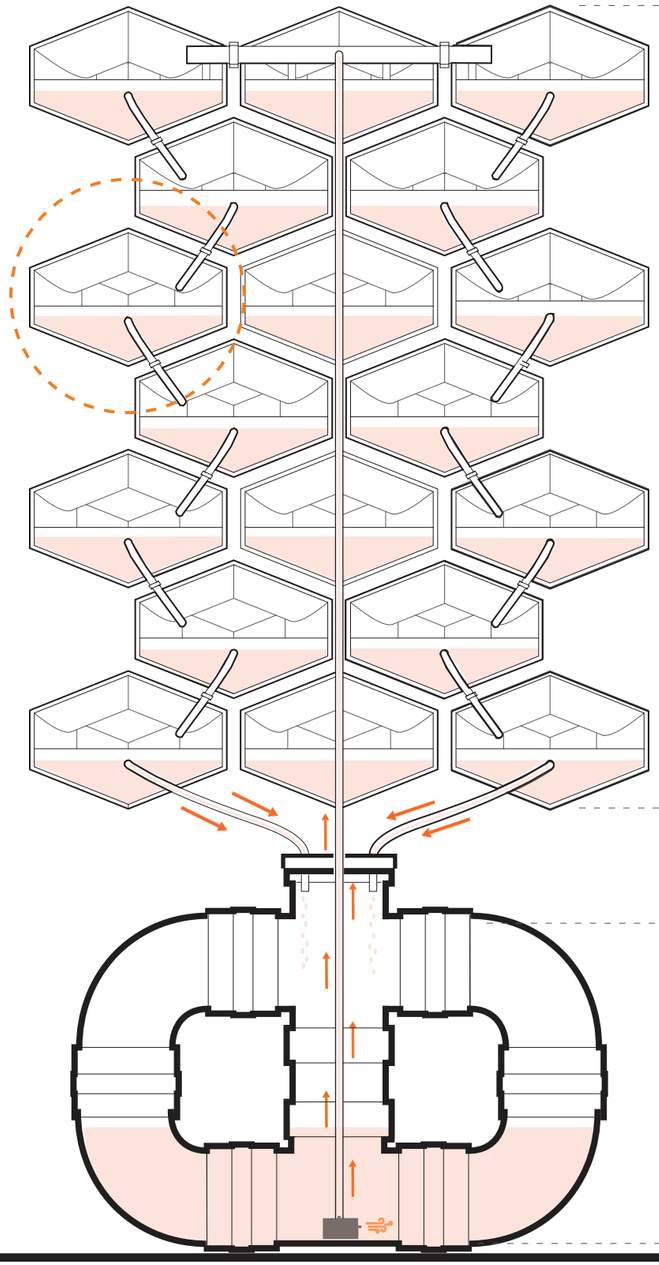
THROUGH THE USE OF GRAVITY WATER FLOWS FROM CONTAINER TO THE NEXT ONE DIRECTLY BENEATH IT.

OPERATION_

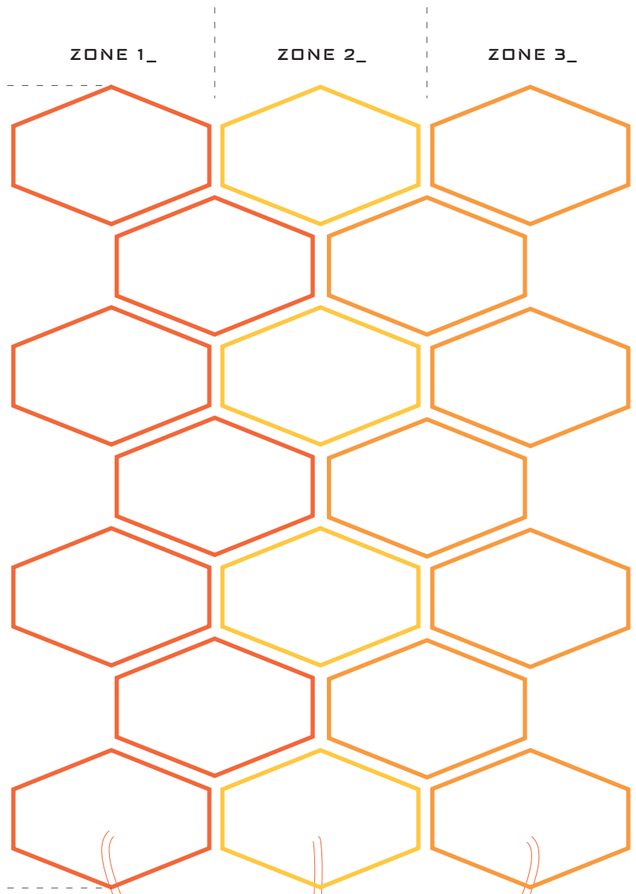
WATER FROM THE MAIN TANK IS SHOT VERTICALLY THROUGH A PLASTIC TUBE. THAT WATER THEN FILLS A HORIZONTAL PVC PIPE WITH 3 HOLES EACH ONE DISTRIBUTING WATER INTO THE 3 ZONES.

WATER THEN WORKS ITS WAY DOWN THROUGH THE 3 ZONES FLOWING FROM ONE CONTAINER TO THE NEXT UNTIL IT EVENTUALLY MAKES ITS WAY BACK INTO THE MAIN TANK.

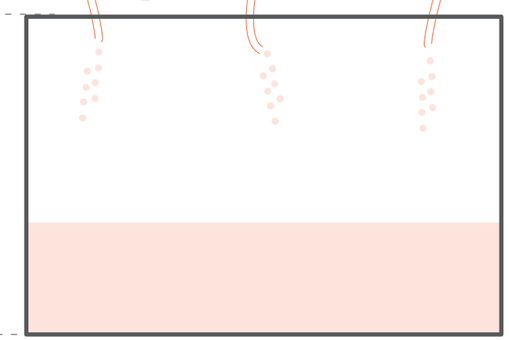
SCHEMATIC_



ZONE 1_ ZONE 2_ ZONE 3_

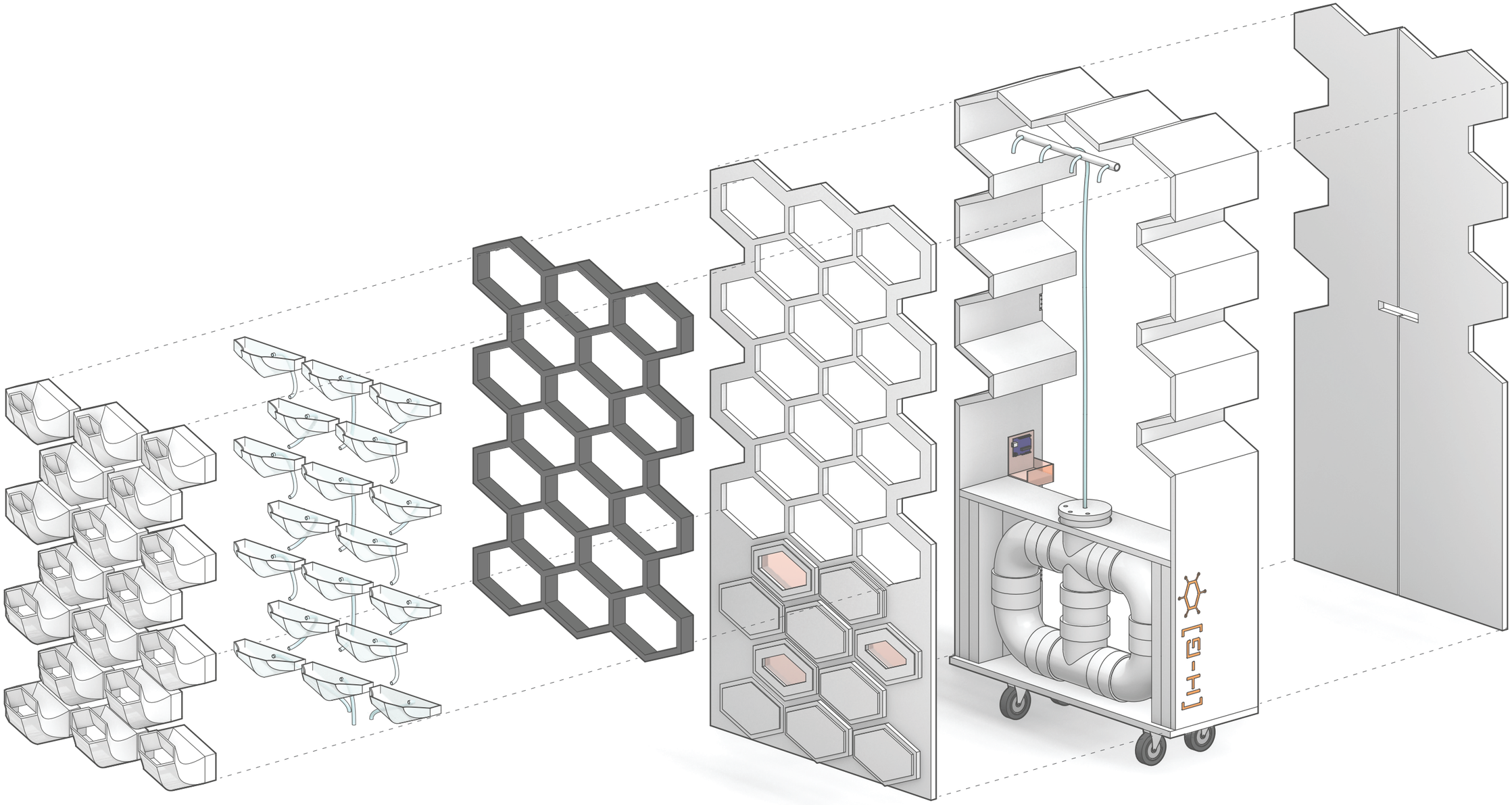


MAIN TANK_



THE WATER IN THE TANK IS ALWAYS MONITORED TO CHECK ITS TEMPERATURE.

NUTRIENT SOLUTION IS ALSO, DISSOLVED INTO IT IN ORDER TO FEED THE PLANTS.



1 CELL MODULE

3D PRINTED MODULES WITH A PARAMETRIC VARIATION IN THE SIZE OF THE APERTURES OPENINGS. GEOMETRY WAS TAILORED TO BEST SUIT ALL PLANTS BASIC NEEDS.

2 WATER CONTAINER

CUSTOMIZED PETG CONTAINERS TAILORED TO FIT THE 3D MODULES BACKSIDE. HOLDS WATER WITHIN THE MODULES AND SERVES AS A PROTECTIVE BARRIER.

3 HEX-FRAME

RESPONSIBLE FOR HOUSING THE CELL MODULES.

4 HEX-FRAME PANEL

PANEL IN WHICH THE HEX-FRAME WILL BE ANCHORED ONTO. MAKES UP THE FRONT PIECE OF THE OVERALL SYSTEM CONTAINER.

5 SYSTEM CONTAINER

HOUSES THE MAIN PVC TANK WHICH STORES ALL THE WATER. AS WELL AS THE ARDUINO CONNECTIONS FOR THE SYSTEM TO FUNCTION.

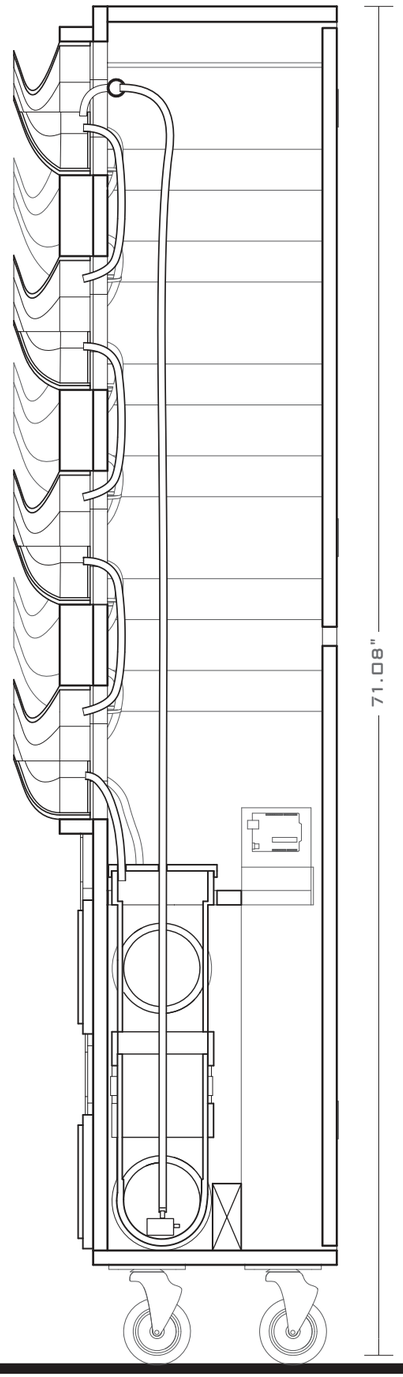
6 SYSTEM ACCESS

BACKSIDE OF THE CONTAINER HAS SWINGING DOORS MAKING IT EASIER TO ACCESS ALL THE SYSTEMS.

4.3 ORTHOGRAPHICS _

[1] SECTION A
[2] RIGHT ELEVATION
[3] FRONT ELEVATION
[4] BACK ELEVATION [CLOSED]
[5] BACK ELEVATION [OPEN]
[6] LEFT ELEVATION

[1]



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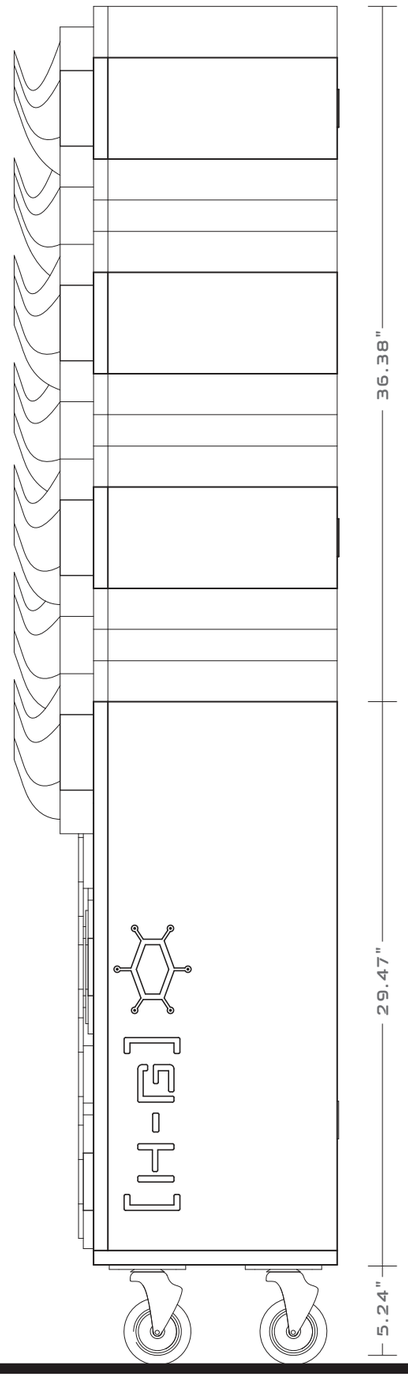

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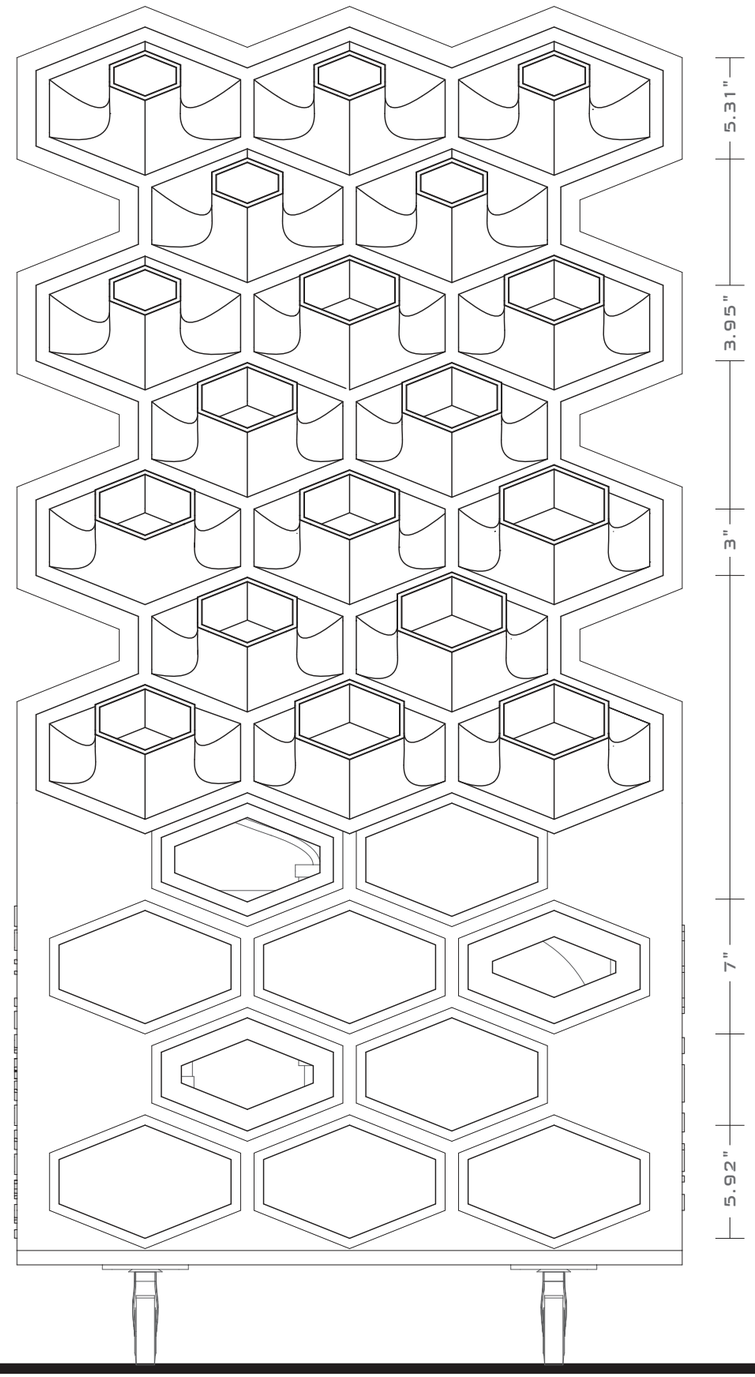

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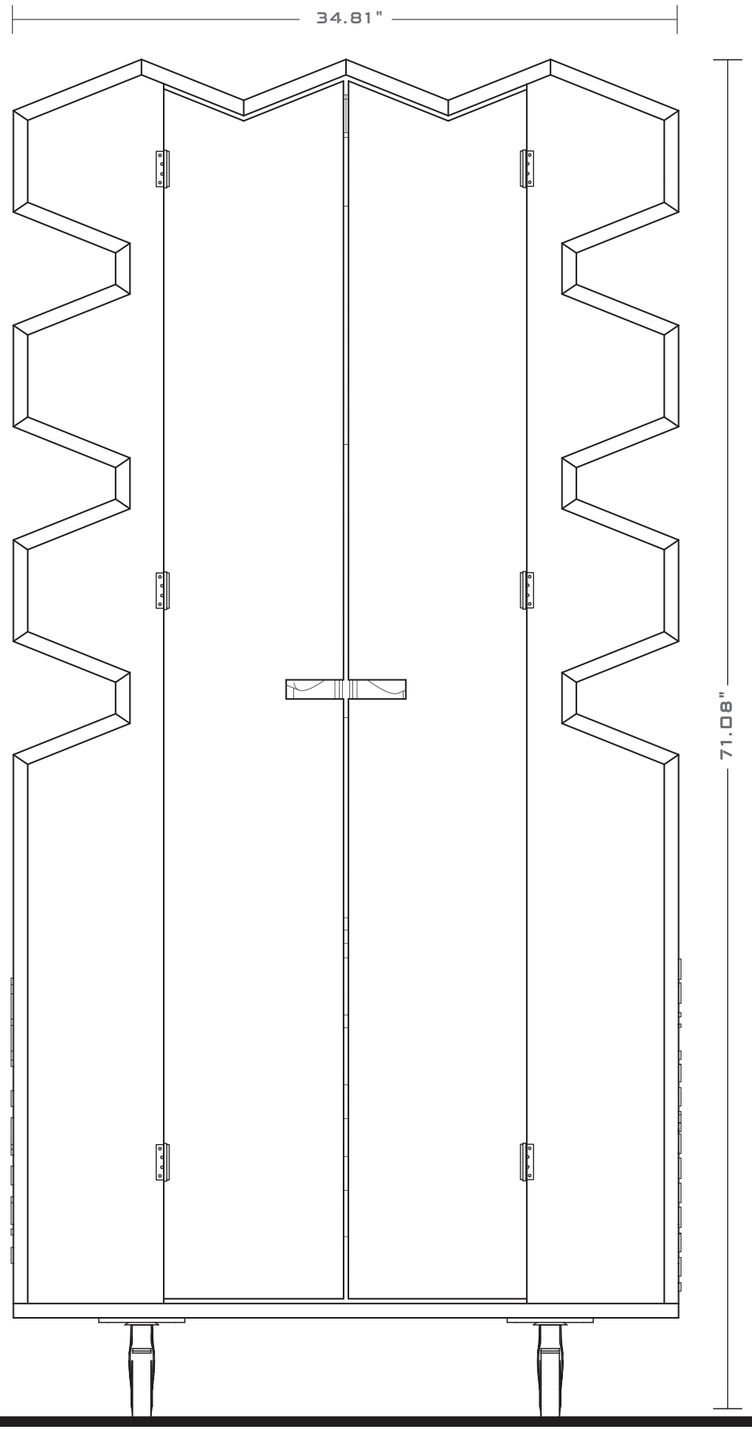

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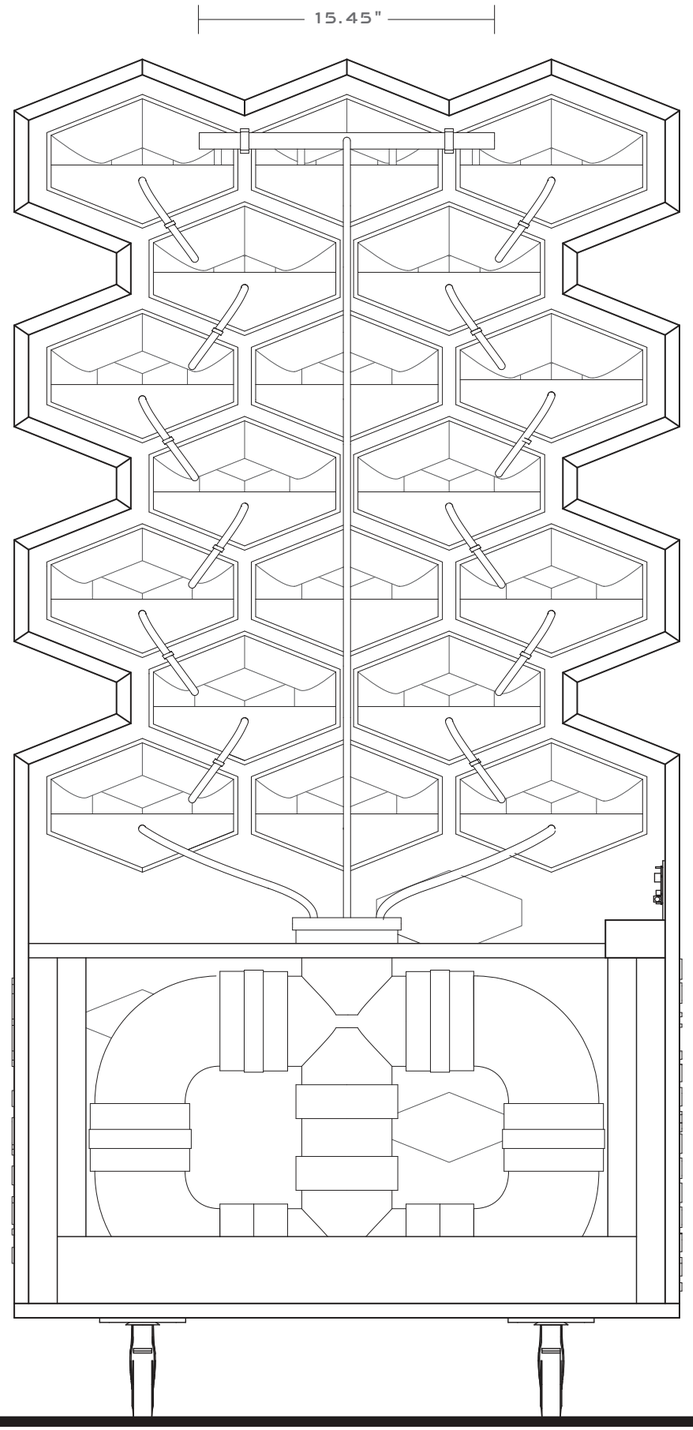

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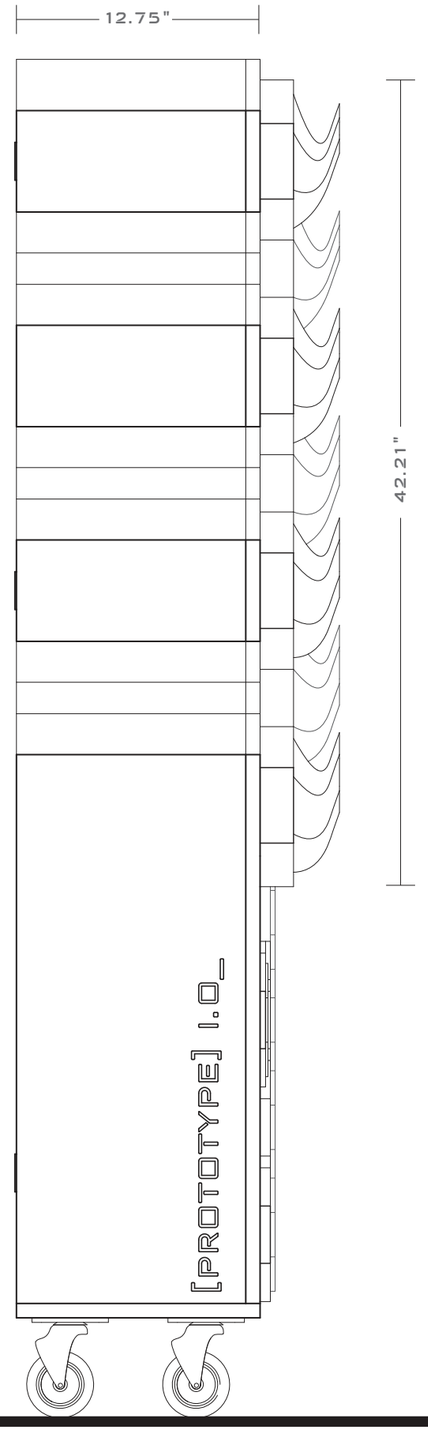
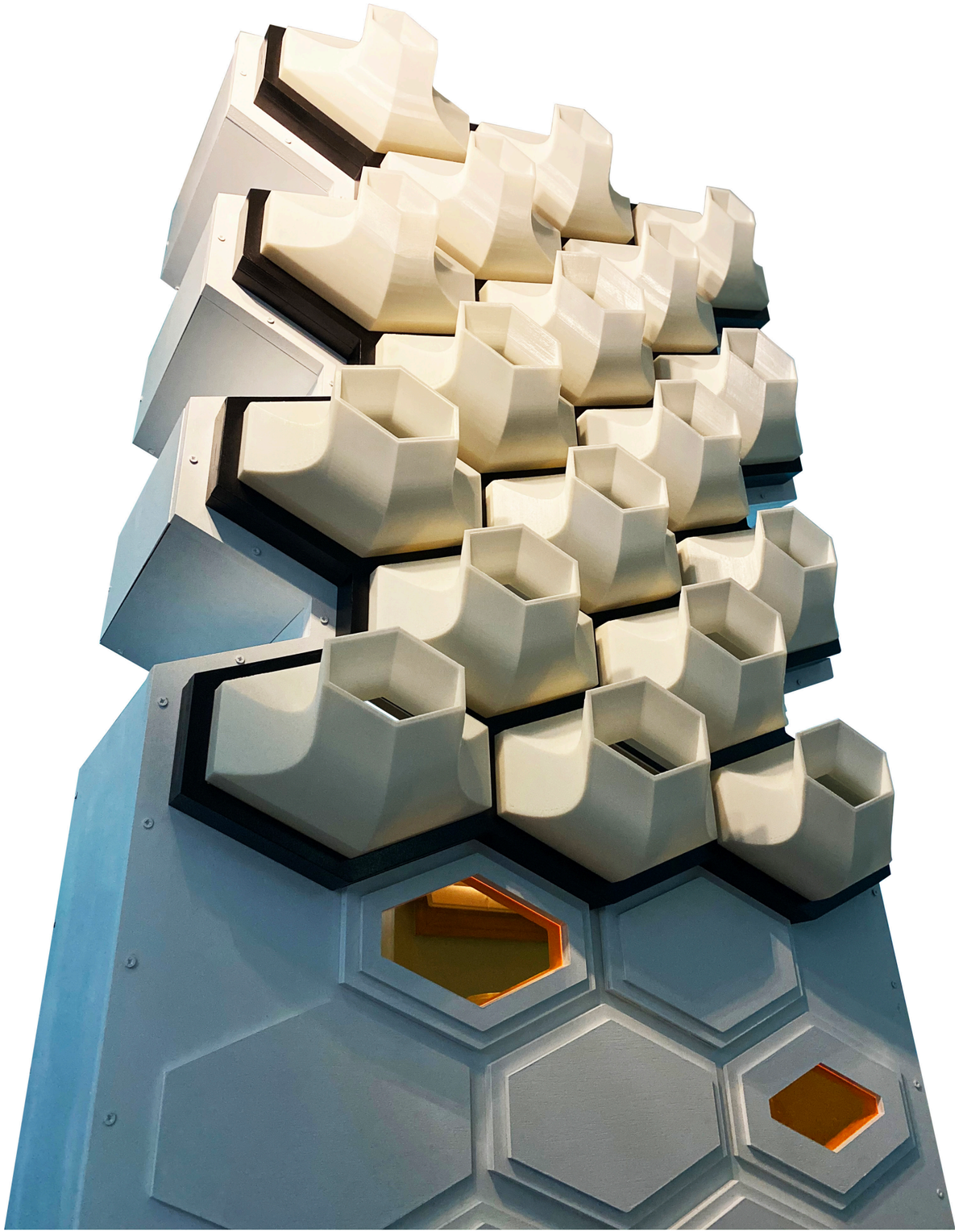
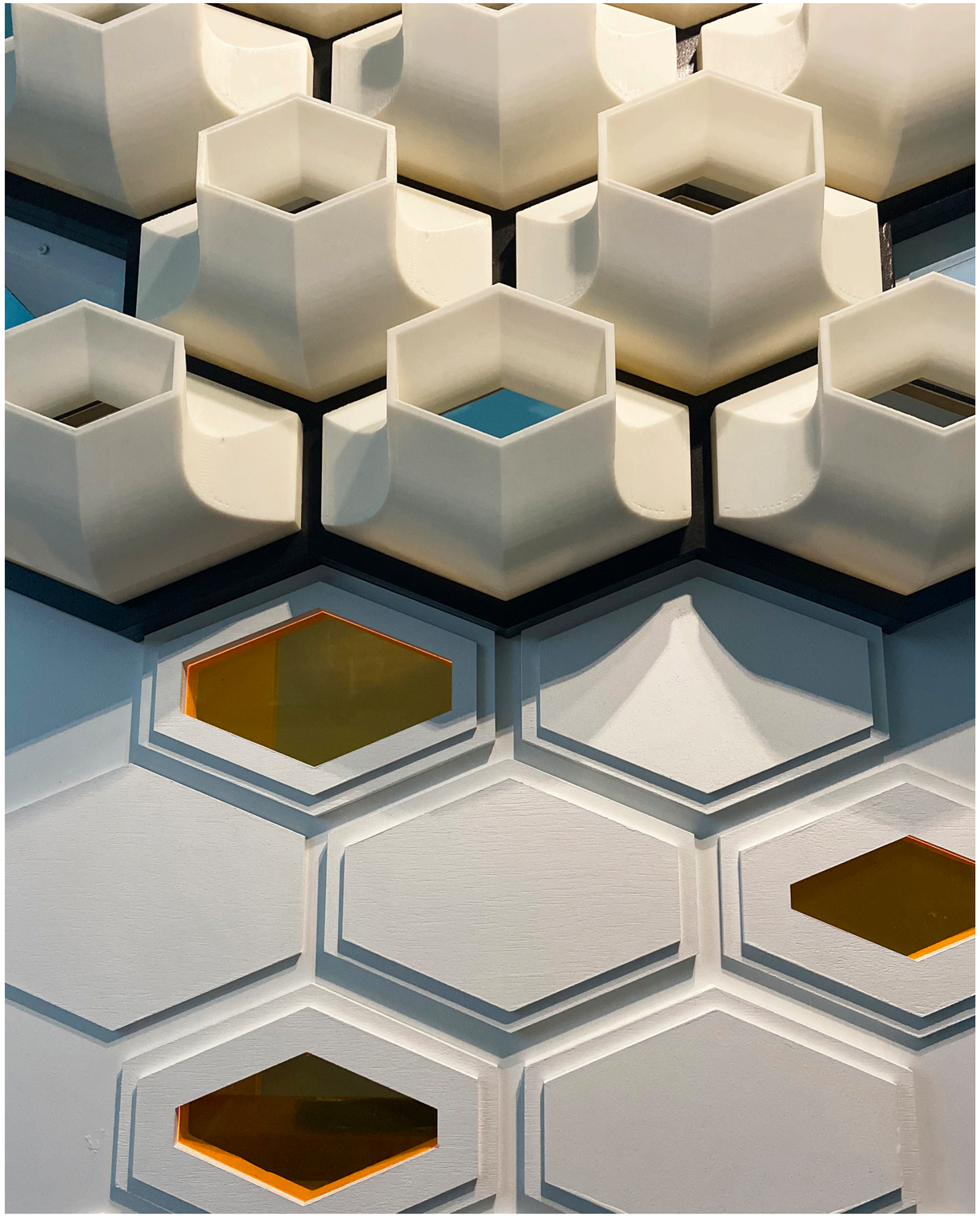
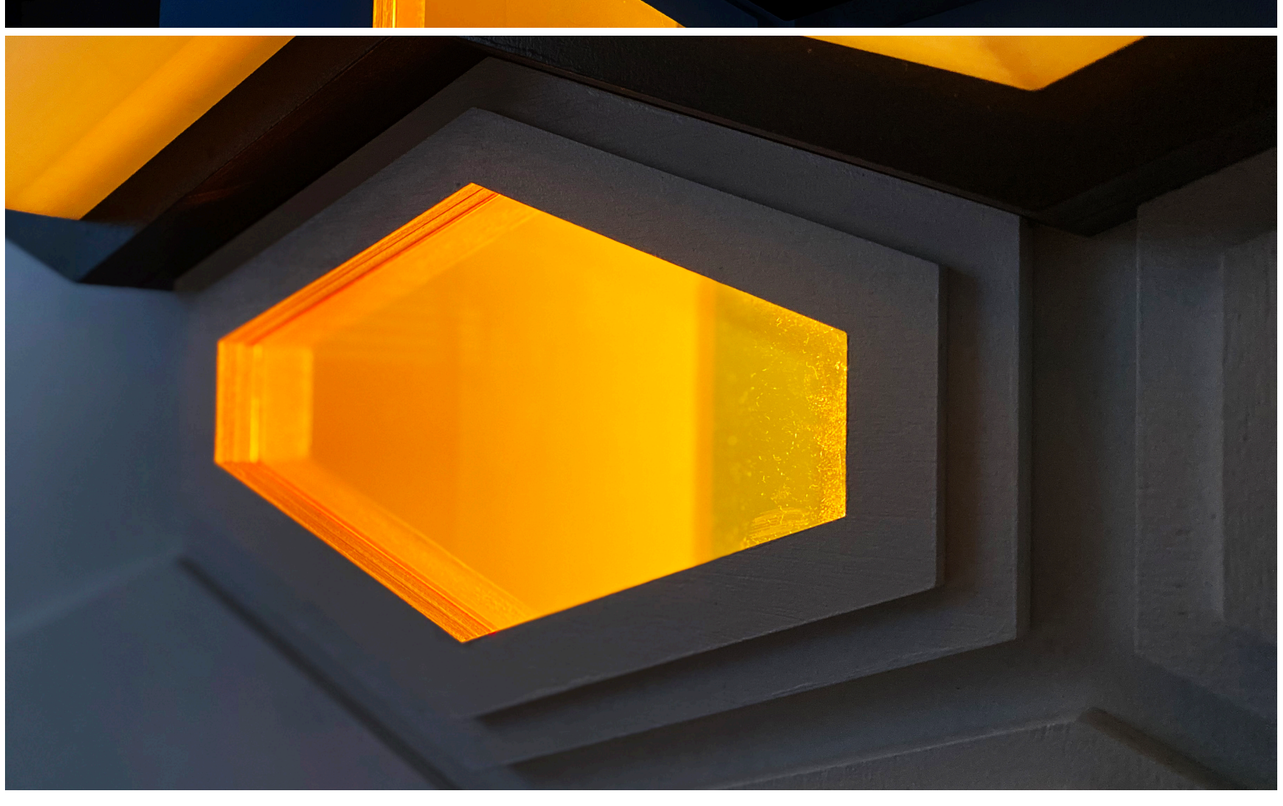


4.4 PHOTOGRAPHY _







CHAPTER 05_

"SYSTEM INTEGRATION"_

5.1 MASHAMBAS SKYSCRAPER_

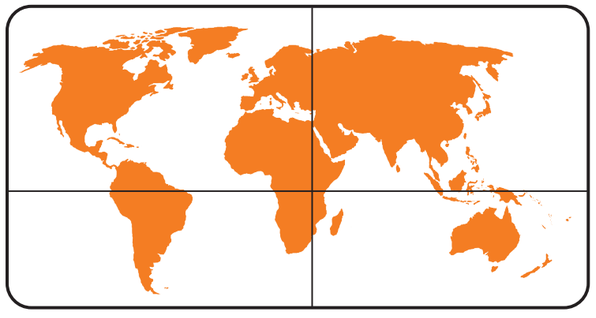
ARCHITECT: PAWEL LIPINSKI AND MATEUSZ FRANKOWSKI
LOCATION: GITEGA, BURUNDI
COMPLETION YEAR: 2017_ THEORETICAL PROJECT
PROPERTIES: MODULAR, VERTICAL LANDSCAPING, ATRIUM

THE OVERALL CONCEPT OR IDEA THAT THE TOWER EMBODIES IS THAT IT SERVES AS A MOVEABLE EDUCATION CENTER. A PLACE WHERE POOR FARMERS CAN GO AND BE TRAINED TO LEARN MORE EFFICIENT AGRICULTURAL TECHNIQUES, CREATE FERTIZLIZER, AND LEARN HOW TO USE MODERN TOOLS.

THE TOWER IS HIGHLY FLEXIBLE, IT DOESN'T REMAIN STATIONARY IN JUST ONE LOCATION, BUT CAN BE DISASSEMBLED AND TRANSPORTED TO ANOTHER SITE. THE TOWER IS RELOCATED ONCE THE COMMUNITY BEGINS TO THRIVE ON ITS OWN AND NO LONGER NEEDS THE TOWERS SERVICES. THIS ALLOWS FOR THE TOWER TO HAVE MULTIPLE LIFE-CYCLES. ITS MODULAR DESIGN COMPOSED OUT OF ARCHED TIMBER FRAMES GIVES THE MASHAMBAS THE FLEXIBILITY TO QUICKLY BE TAKEN DOWN AND BE BUILT.

THE MODULAR DESIGN CREATES A SOLID STRUCTURAL LAYOUT IN WHICH PROGRAM CAN EASILY BE INSERTED. TOWARDS THE BOTTOM THE MORE SOCIAL SPACES EXIST AND ALL THE UPPER LEVELS CONSIST OF EDUCATIONAL SPACES AND POCKETS OF OPEN SPACE FOR PLANTS AND CROPS TO GROW.

THE TOWER USES LOTS OF NATIVE VEGETATION AND ALSO TAKES ADVANTAGE OF THE LARGE OPENINGS IN ORDER TO GROW CROPS. THROUGHOUT THE BUILDING AND PERHAPS ITS MOST DOMINANT FEATURE IS THE ATRIUM SPACE THAT CARVES THROUGH EACH LEVEL BRINGING IN DAYLIGHT AND ALSO ALLOWING FOR THE BUILDING TO BE NATURALLY VENTILATED. ALONG WITH THE ATRIUM THE OTHER COMPONENT THAT GIVES THE INTERIOR SPACE A UNIQUE FEEL IS THE SPIRALING SYSTEM OF RAMPS THAT GO FROM FLOOR TO FLOOR. THE RAMPS ARE DESIGNED FOR USER EXPERIENCE ENHANCING THE WAY ONE TRAVELS AND MOVES UP IN A HIGH RISE BUILDING.



COORDINATES_ 3.3731° S, 29.9189° E

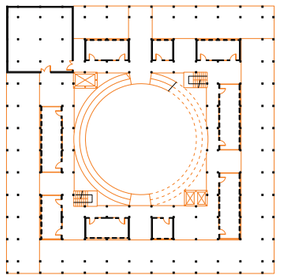
TAKEAWAYS_

UTILIZING LOCAL MATERIALS TO GIVE THE TOWER A MORE VERNACULAR LOOK

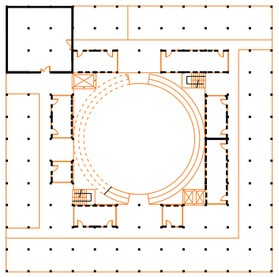
MODULAR DESIGN COMPONENT THAT CAN BE ASSEMBLED & DISSASSEMBLED WITH EASE

RAMP + ATRIUM ENHANCE THE OVERALL USER EXPERIENCE IN THE TOWER

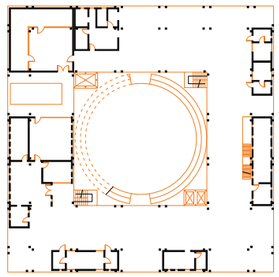
FLOOR PLANS_



GROUND LEVEL



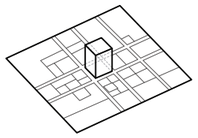
FIRST LEVEL



SECOND LEVEL

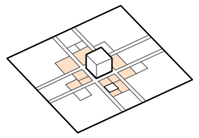
LIFE-CYCLE AXIS_

[1]



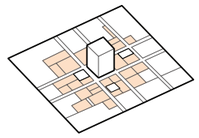
DESIGN PHASE

[2]



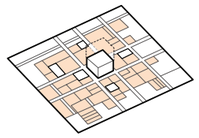
BUILD & DEVELOPMENT

[3]



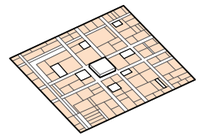
APOGEE OF THE BUILDING

[4]



TRANSPORTATION

[5]



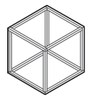
END OF LIFE-CYCLE

MODULE CONSTRUCTION_

[1]

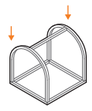
MODULE COMPONENTS

[2]



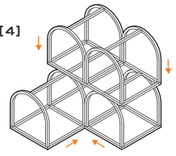
CUBIC MODULAR FRAME

[3]



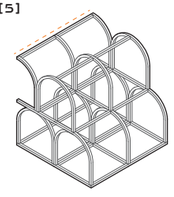
TRANSFORMATION OF MODULE

[4]



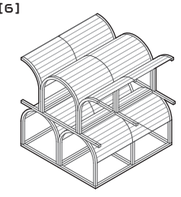
EXPANSION OF SEVERAL MODULES

[5]



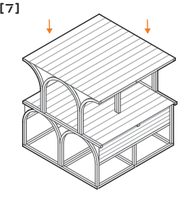
ARCHES CUT IN HALF

[6]



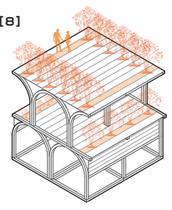
WOODEN SUBSTRUCTURE ADDED TO ARCHES

[7]

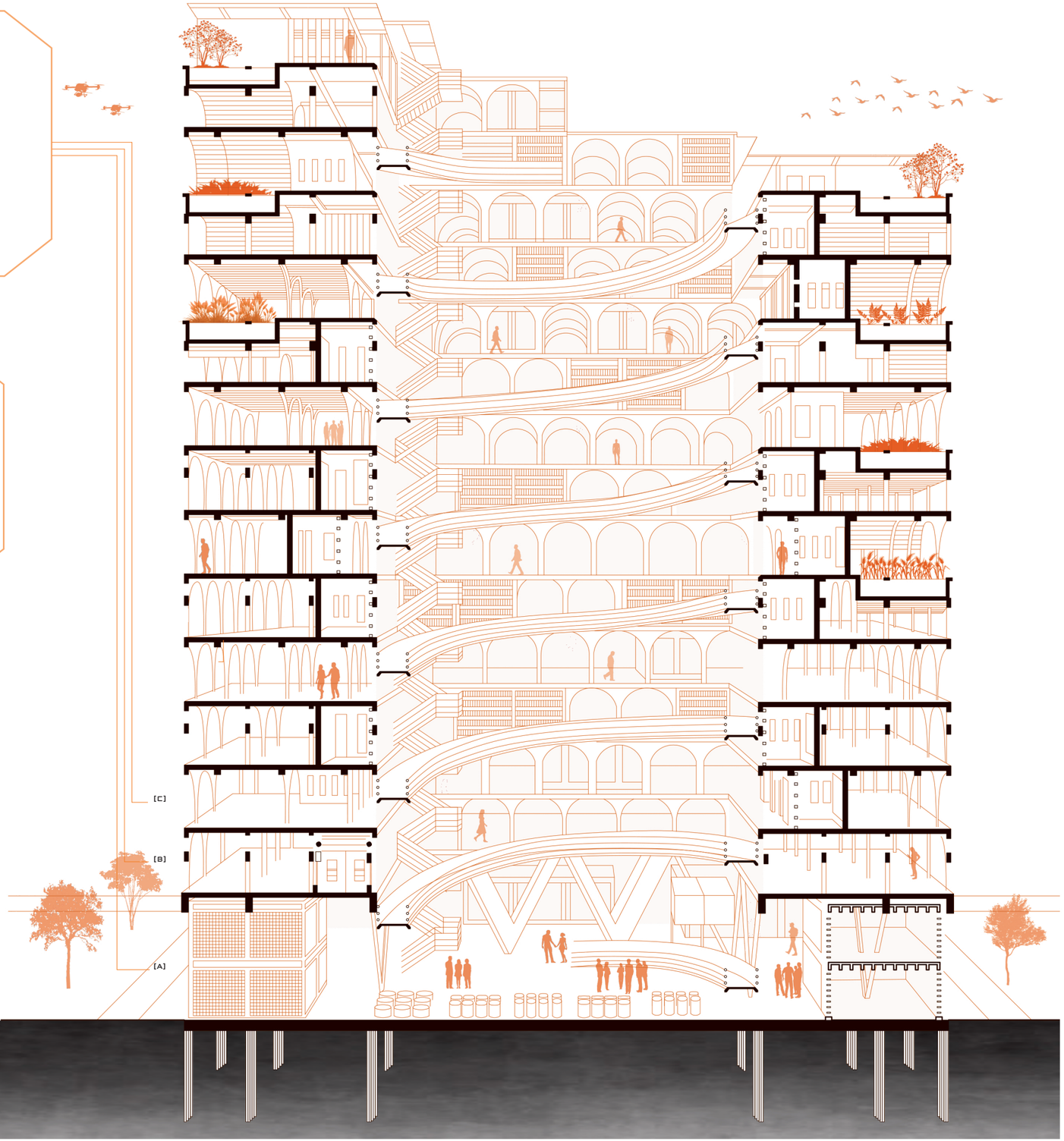


FINAL ASSEMBLY OF MODULES

[8]



PLANTS ADDED TO MODULES



SECTION A_

5.2 SHANGHAI ARMOURY TOWER_

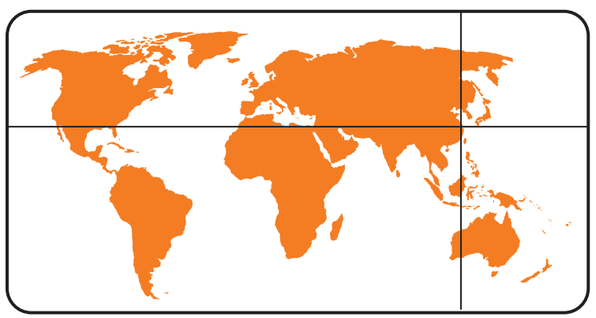
ARCHITECT: KEN YEANG
LOCATION: SHANGHAI, CHINA
COMPLETION YEAR: 1995, THEORETICAL PROJECT
PROPERTIES: SOLAR, WIND, VERTICAL LANDSCAPING, ATRIUM

THE TOWER PROPOSAL HAS A RICH DESIGN PROCESS THAT SHOWS ALL OF ITS DESIGN DECISIONS THAT WERE ALL BASED UPON THE BIOCLIMATIC INFORMATION OF SHANGHAI, CHINA. EVERYTHING WITHIN THE BUILDING IS DESIGNED ACCORDING TO THE EXTERNAL FORCES IMPOSED BY THE REGIONS LOCAL CLIMATE.

THE FLOOR PLATE RESPOND TO BOTH THE SOLAR AND WIND CONDITIONS BY CAREFULLY PINPOINTING SPECIFIC AREAS ALONG THE TOWER TO SHIELD AGAINST. THE CORES OF THE TOWER ARE POSITIONED TO WHERE THEY CAN BE UTILIZED AS SOLAR BUFFERS AGAINST THE HARSH EAST AND WEST SUNLIGHT.

IN TERMS OF RESPONDING TO THE WIND PATTERNS OF THE AREA THE BUILDING IS ORIENTATED TO WHERE THE USE OF PASSIVE STRATEGIES CAN TAKE PLACE. THE ORIENTATION OF THE TOWER TAKES ADVANTAGE OF THE WIND PATTERNS DURING THE SUMMER TO MAXAMIZE CROSS VENTILATION. THE ADDITION OF WIND BREAKERS ARE INTEGRATED IN ORDER TO DEFLECT THE HARSH COLD WINTER WIND FROM THE BUILDING.

FOR THE MAJORITY OF THE TOWER EACH LEVEL HAS SOME KIND OF GREEN SPACE THAT THE USERS OF THE BUILDING HAVE ACCESS TO. LARGE SKYCOURTS ALLOW FOR BIODIVERSITY TO THRIVE AND ALSO SERVE THE PURPOSE OF PROMOTING NATURAL VENTILATION AND A MUCH MORE HEALTHIER ENVIORNMENT FOR THE PEOPLE INHABITING THE TOWER. THE VERTICAL LANDSCAPING USED I THE PROJECT IS ALL NATIVE VEGETATION FOUND WITHIN THE LOCAL REGION WHICH ACCORDING TO YEANG BRINGS BACK SOME BALANCE WITHIN THE LOCAL ECOLOGY.



COORDINATES_ 31.2304° N, 121.4737° E

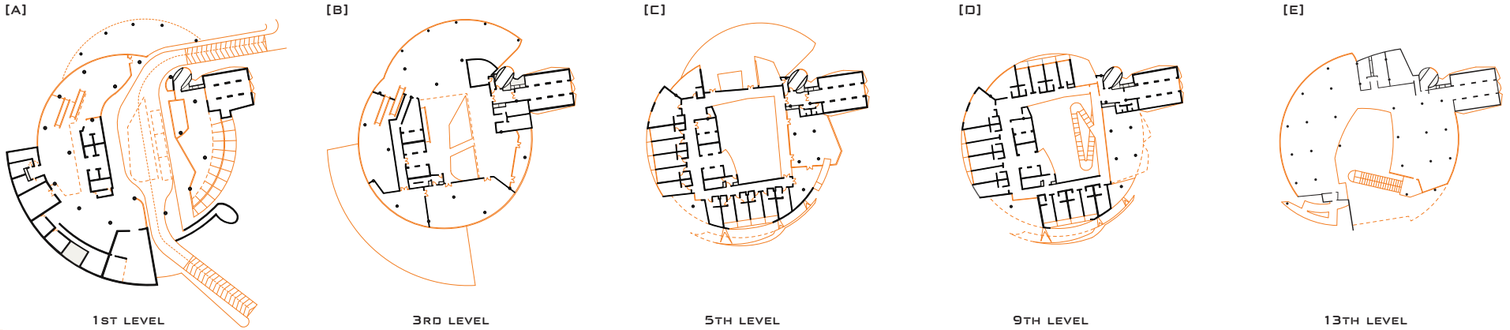
TAKE-

UTILIZING SOLAR & WIND CHARTS TO CONFIGURE THE OVERALL FORM OF THE FLOOR PLATES

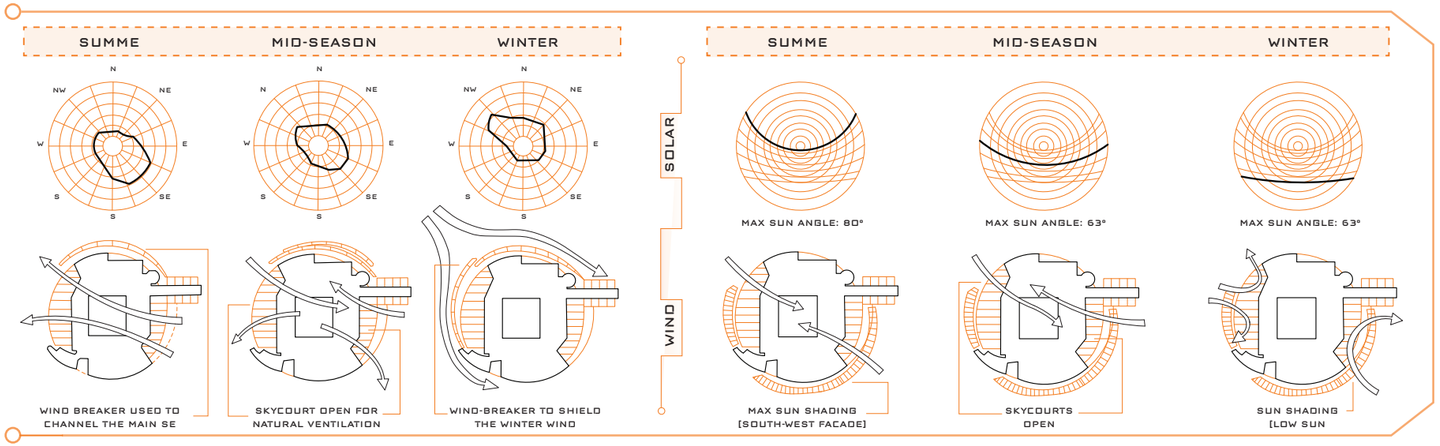
IMPORTANCE OF THE ATRIUM SPACE WHICH ALLOWS FOR NATURAL VENTILATAION TO OCCUR THROUGH-OUT THE BUILDING

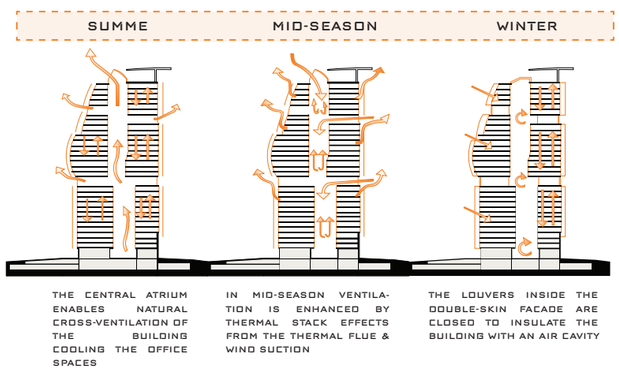
DOUBLE SKIN FACADE SYSTEM TO REGULATE NATURAL VENTILATION INTO THE BUILDING

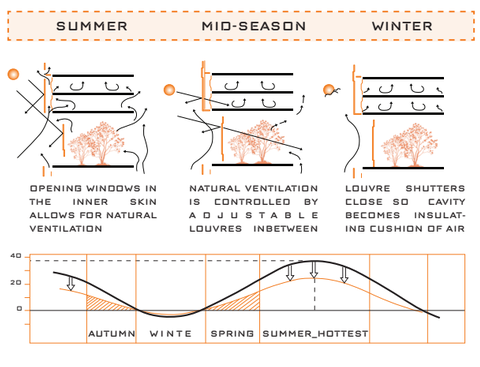
FLOOR PLANS_

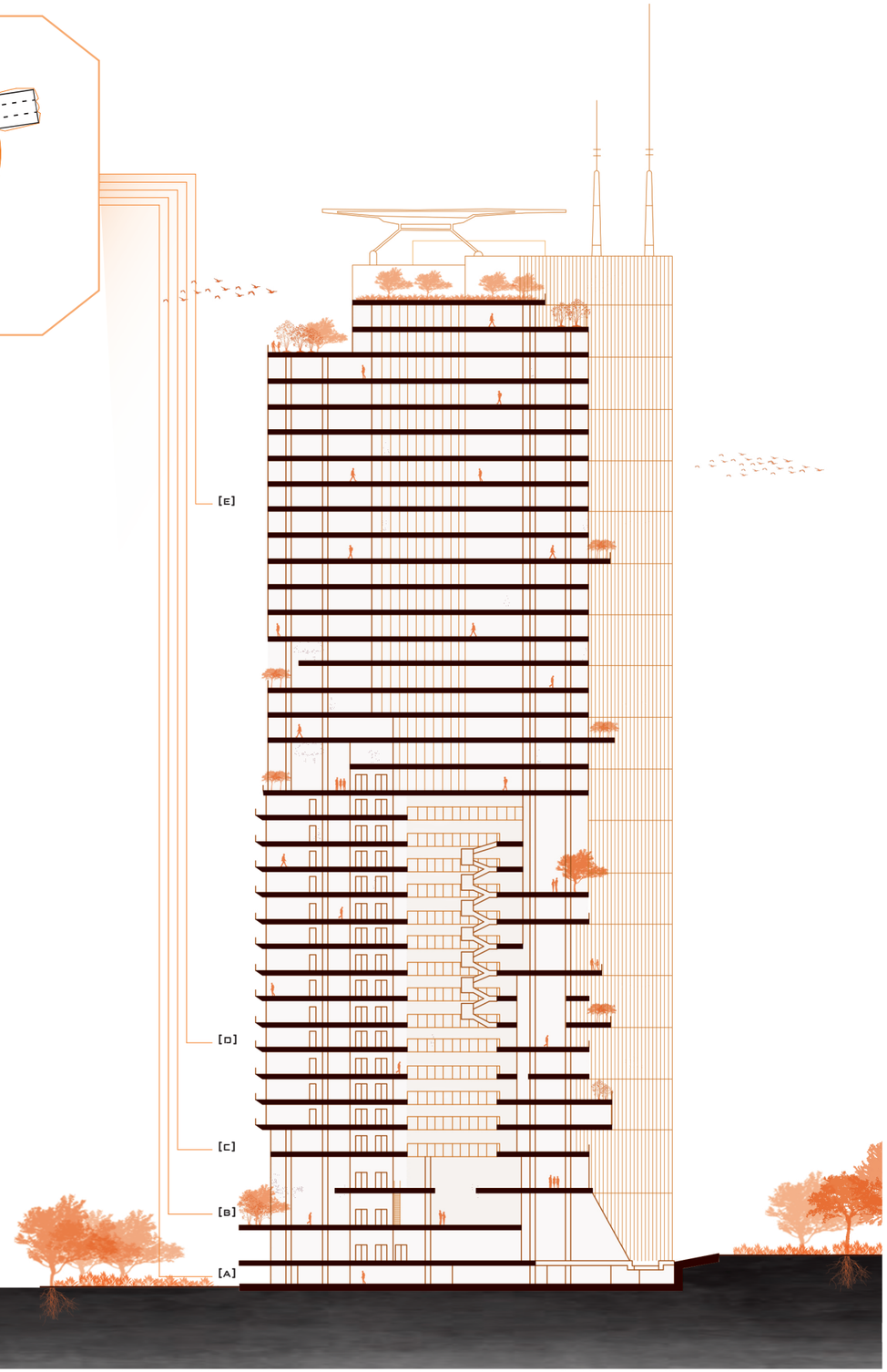


BIOCLIMATIC DIAGRAMS_









SECTION A_

5.3 MENARA MESINIAGA_

ARCHITECT: KEN YEANG
LOCATION: PETALING JAYA, MALAYSIA
COMPLETION YEAR: 1991
PROPERTIES: SOLAR, WIND, VERTICAL LANDSCAPING

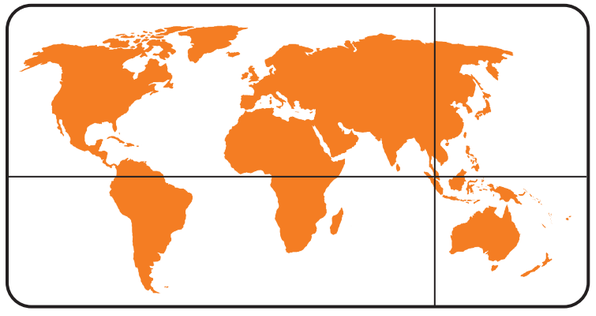
THE MENARA MESINIAGA TOWER WAS YEANG'S FIRST BIOCLIMATIC SKYSCRAPER. THE MALAYSIAN BORN ARCHITECT IS WELL KNOWN FOR HIS PHILOSOPHY ON WHAT AN ENVIRONMENTALLY FRIENDLY HIGH-RISE SHOULD BE. AFTER THE BUILDINGS COMPLETION, YEANG RECIEVED THE AGA KHAN AWARD FOR ARCHITECTURE IN 1995 FOR THE PROJECT AND HIS RESEARCH.

THE TOWER IS A BIOCLIMATIC ORIENTATED BUILDING, MEANING THAT IT IS DESIGNED BASED ON THE SPECIFIC CLIMATIC DATA OF ITS REGION. THE DESIGN INCLUDES PASSIVE FEATURES SUCH AS SOLAR SHADING AND NATURAL VENTILATION. ITS CORES ARE SHIFTED TO THE PERIPHERY OF THE BUILDING IN ORDER TO USE THEM AS SOLAR BUFFERS AGAINST THE HARSH EAST AND WEST SUN.

THE MAIN STRUCTURE CONSISTS OF EXPOSED STEEL TUBES AND ITS FLOOR PLATES ARE CONCRETE OVER STEEL TRUSSES. ALL THE WINDOWS ON THE EAST AND WEST HAVE ALUMINUM LOUVERS TO REDUCE SOLAR GAIN WHEREAS THE NORTH AND SOUTH WINDOWS HAVE DEEP INSETS ACTING AS A THERMAL BUFFER.

ONE OF ITS MOST DOMINANT FEATURES IS THE USE OF VERTICAL LANDSCAPING. IT HAS A SPIRALING SKY GARDEN THAT TWISTS AROUND THE BUILDING AS IT GOES UP WHICH CREATES SHADING FOR THE INTERIOR AND MAKES A NICE CONTRAST AGAINST THE STEEL ALUMINUM SURFACE OF THE BUILDING.

YEANG HAS STATED THAT IN ORDER TO ACHIEVE A BETTER BALANCE WITH THE SITE THAT IT IS BEST TO UTILIZE PLANT LIFE THAT IS NATIVE TO THE AREA FOR ANY PROJECT PLANNING TO INTEGRATE VERTICAL LANDSCAPING.



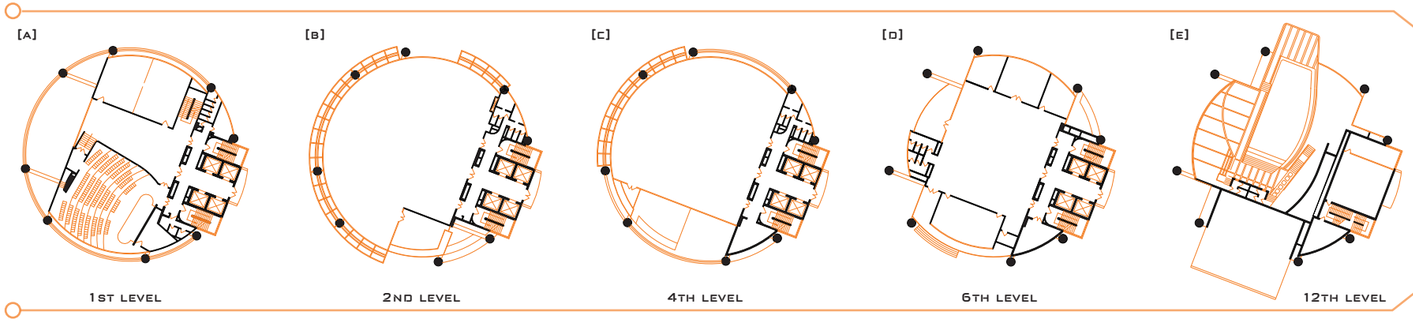
COORDINATES_ 3.0826° N, 101.5925°

TAKEAWAYS_

UTILIZING BIOCLIMATIC DATA OF A SITE TO MAKE INFORMED DECISIONS ON THE OVERALL TOWER FORM & PERFORMANCE

VERTICAL LANDSCAPING ADDED TO PROMOTE THE BIODIVERSITY OF LOCAL AREA & FOR A HEALTHIER WORKING ENVIRONMENT

FLOOR PLANS_



BIOCLIMATIC DATA_

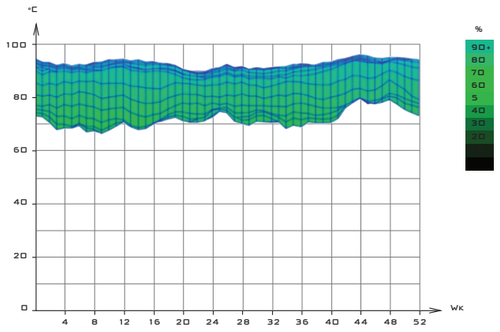


FIGURE 1: ANNUAL RELATIVE HUMIDITY FOR KUALA LUMPAR
LOCATION_ KUALA LUMPUR, MALAYSIA
COORDINATES_ [3.0826° N, 101.5925° E]

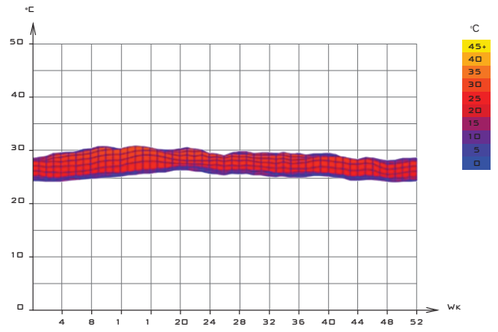
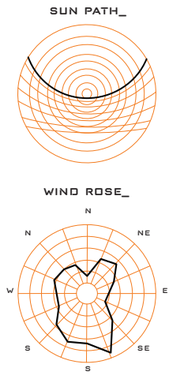
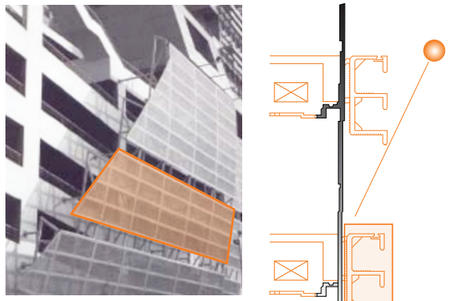


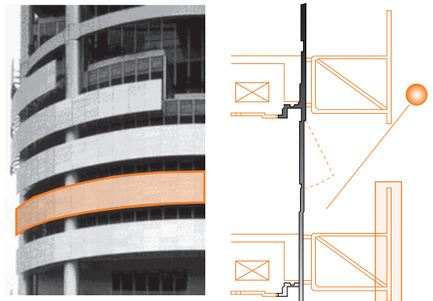
FIGURE 1: ANNUAL AVERAGE TEMPERATURE FOR KUALA LUMPAR
LOCATION_ KUALA LUMPUR, MALAYSIA





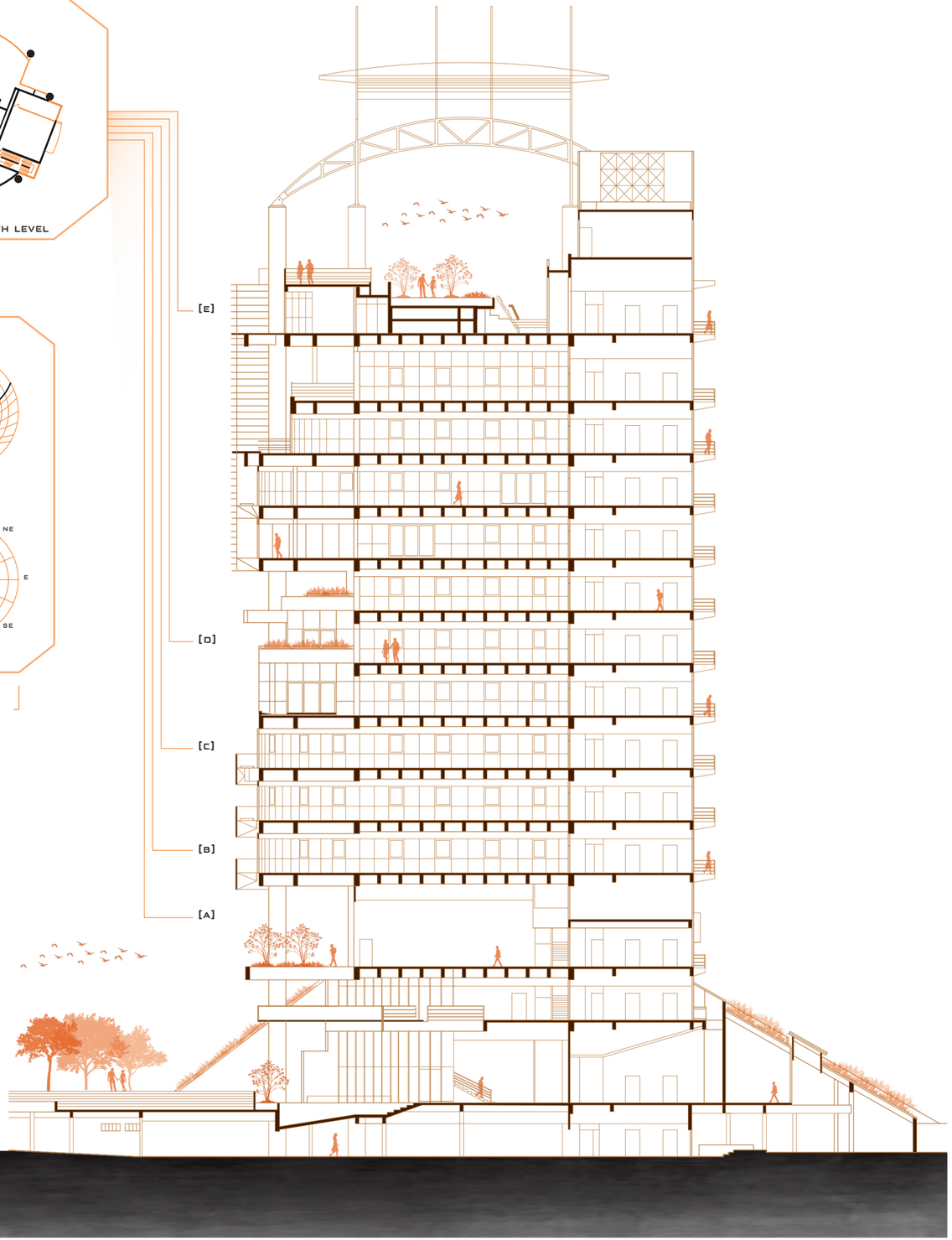
SUN SHADERS_

THE SHADES RESPOND DIRECTLY TO THE ORIENTATION OF THE BUILDING BY ALLOWING OR REDUCING SOLAR GAIN.



GARDEN INSETS_

THE DEEP INSETS ALLOWS FOR THE USE OF FULL HEIGHT CURTAIN WALLS ON BOTH THE NORTH & SOUTH SIDES OF THE BUILDING.



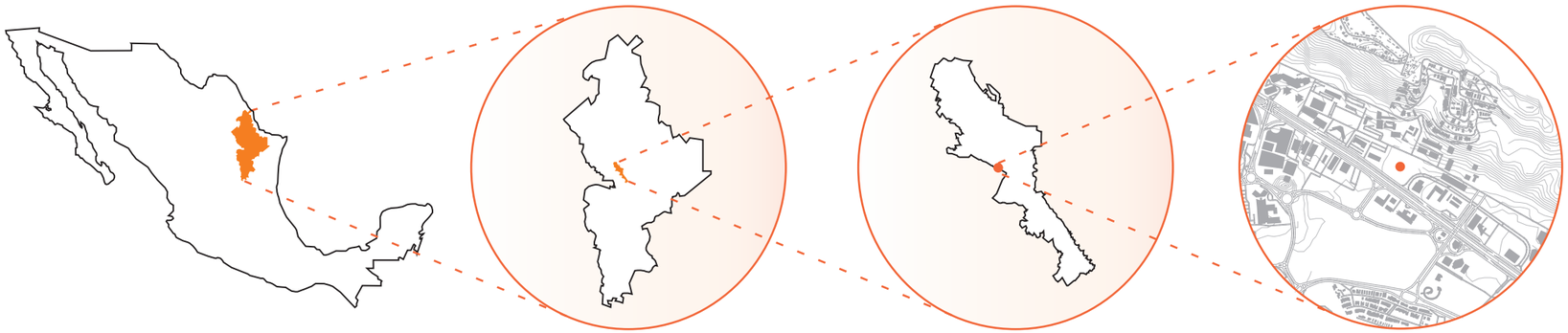
SECTION A_

[H-G] TOWER_

5.4 SITE ANALYSIS_

THE FOLLOWING SITE WAS SELECTED AS THE LOCATION FOR A MIXED-USE, HIGH-RISE BUILDING. THE CITY OF MONTERREY IS ONE OF MEXICO'S LARGEST CITIES AND IS AT THE FOREFRONT OF THE NATION'S AGRICULTURAL PRODUCTION.

THE CITY PROVIDES A LARGE DENSE URBAN FABRIC RICH WITH CULTURE AND A BOOSTING ECONOMY. THE SITE SELECTED WITHIN THE CITY ALSO OFFERS A CHANCE OF SEEING ONE OF THE MOST ICONIC MOUNTAIN RANGES IN THE COUNTRY TOWARDS THE SOUTH.



[MEXICO] [NUEVO LEON] [MONTERREY] [SITE SELECTION]

WHY MONTERREY MEXICO?_

7TH

IN THE WORLD FOR
AGRICULTURAL PRODUCTION

3RD

LARGEST STATE
ECONOMY IN MEXICO

#1

LARGEST CITY IN
NORTHERN MEXICO

66278 SAN PEDRO GARZA GARCIA: MONTERREY, NUEVO LEON_

[BUILDING TYPOLOGIES]

COMMERCIAL
RESIDENTIAL
MIXED-USE
GOVERNMEN
INSTITUTIONA

[TRANSPORTATION]

MAJOR ROADS
MINOR ROADS
AV LAZARO CARDENAS

[NODES + LANDMARKS]

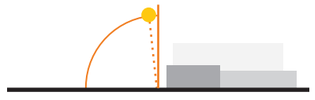
NODES/MAJOR
LANDMARKS

[ZONING/SUBDIVISIONS]

COL. VISTA REAL
SAN AUGUSTIN
CORP. PRODESA
DE LA SIERRA
VALLE ORIENTE
LAS PRIVANZAS

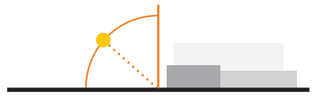
[SUMMER SOLSTICE]

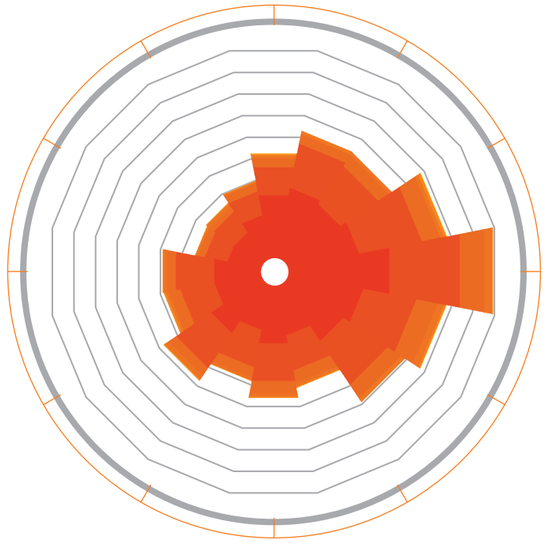
LATITUDE: 25.73
21 JUN 12:00, ALT = 85.50, AZM = 240.18
LOCATION: MONTERREY, NUEVO LEON: MEXICO



[WINTER SOLSTICE]

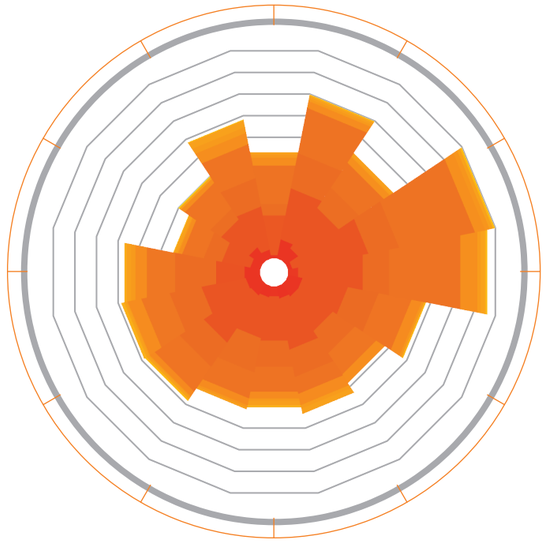
MONTERREY_NLE_MEX
LATITUDE: 25.7333333
21 DEC 12:00, ALT = 40.58, AZM = 186.26





[HOT SEASON]

MONTERREY_NLE_MEX
01 MAR 1:00 - 30 NOV 24:00
CALM FOR 3.68% OF THE TIME =243 HOURS



[COLD SEASON]

MONTERREY_NLE_MEX
01 DEC 1:00 - 28 FEB 24:00
CALM FOR 8.94% OF THE TIME =193 HOURS

5.5 PARAMETRIC FORM FINDING_

THE FOLLOWING STUDIES ARE OF CONCEPTUAL MASSES EXPLORING BUILDING FORM IN RELATION TO THE SITE'S NATURAL BOUNDARIES/FORCES. OF THESE A STRONG FOCUS WAS PLACED ON THE SOLAR ORIENTATION.

BECAUSE OF THE SITE AND ITS INTENSE SOLAR PERIOD IT WAS CRITICAL TO DETERMINE HOW MUCH SURFACE AREA IS EXPOSED AND NEEDS PROTECTION AGAINST THE SUN.

RADIATION RESULTS_

VARIATION_ 1

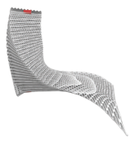
KWH/M2
2037.45<
1833.71
1629.96
1426.22
1222.47
1018.73
814.98
611.24
407.49
203.75
<0.00

VARIATION_ 2

KWH/M2
2099.27<
1889.35
1679.42
1469.49
1259.56
1049.64
839.71
629.78
419.85
209.93
<0.00

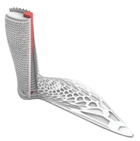
VARIATION_ 3

KWH/M2
1980.57<
1782.51
1584.45
1386.40
1188.34
990.28
792.23
594.17
396.11
198.06
<0.00



VARIATION_ 4

KWH/M2
2049.73<
1844.75
1639.78
1434.78
1229.84
1024.86
819.89
614.92
409.95
204.97
<0.00

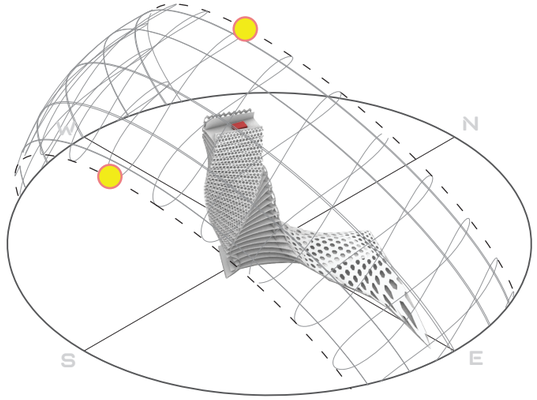


VARIATION_ 5

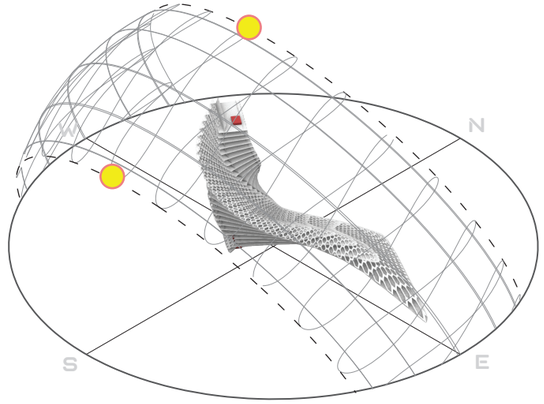
KWH/M2
2086.29<
1877.66
1669.03
1460.40
1251.77
1043.14
834.52
625.89
417.26
208.63
<0.00

VARIATION_ 6

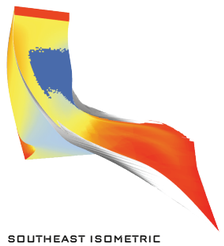
KWH/M2
2012.18<
1810.96
1609.74
1408.53
1207.31
1006.09
804.87
603.65
402.44
201.22
<0.00

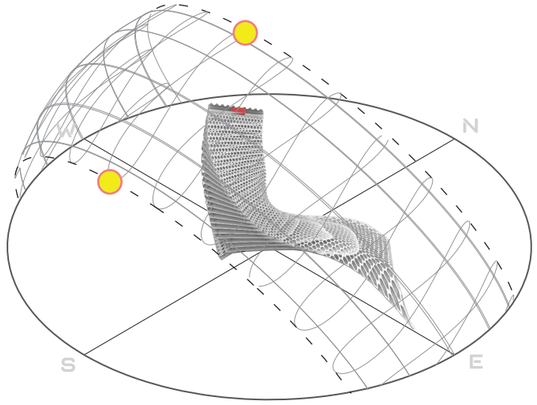


SOUTHEAST ISOMETRIC
CONCEPT VARIATION_ 1
RADIATION PERIOD: JAN 01 - DEC 31
TIMEFRAME: 9:00AM - 6:00PM



SOUTHEAST ISOMETRIC
CONCEPT VARIATION_ 2
RADIATION PERIOD: JAN 01 - DEC 31
TIMEFRAME: 9:00AM - 6:00PM





SOUTHEAST ISOMETRIC
CONCEPT VARIATION_ 3
RADIATION PERIOD: JAN 01 - DEC 31
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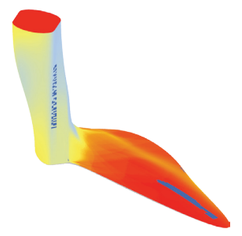
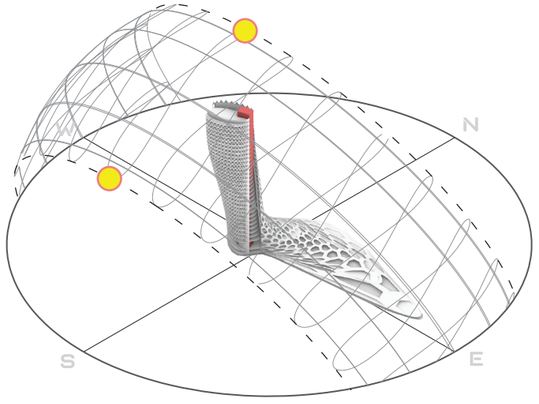
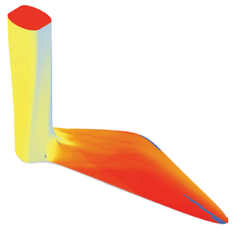
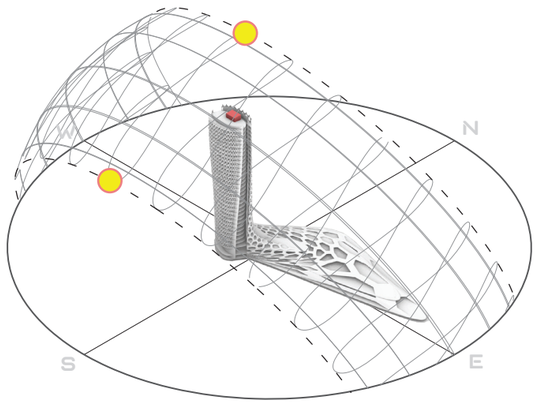


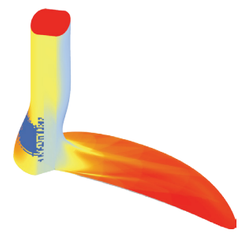


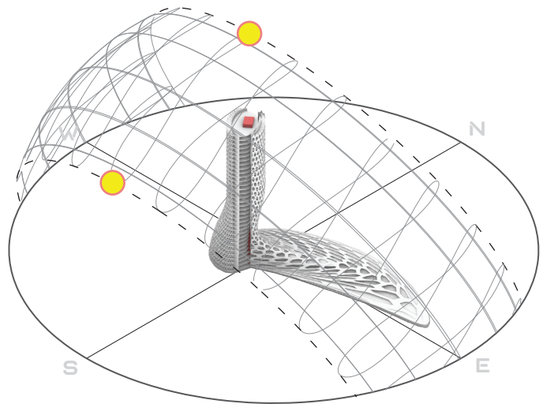
SOUTHEAST ISOMETRIC
CONCEPT VARIATION_ 4
RADIATION PERIOD: JAN 01 - DEC 31
TIMEFRAME: 9:00AM - 6:00PM





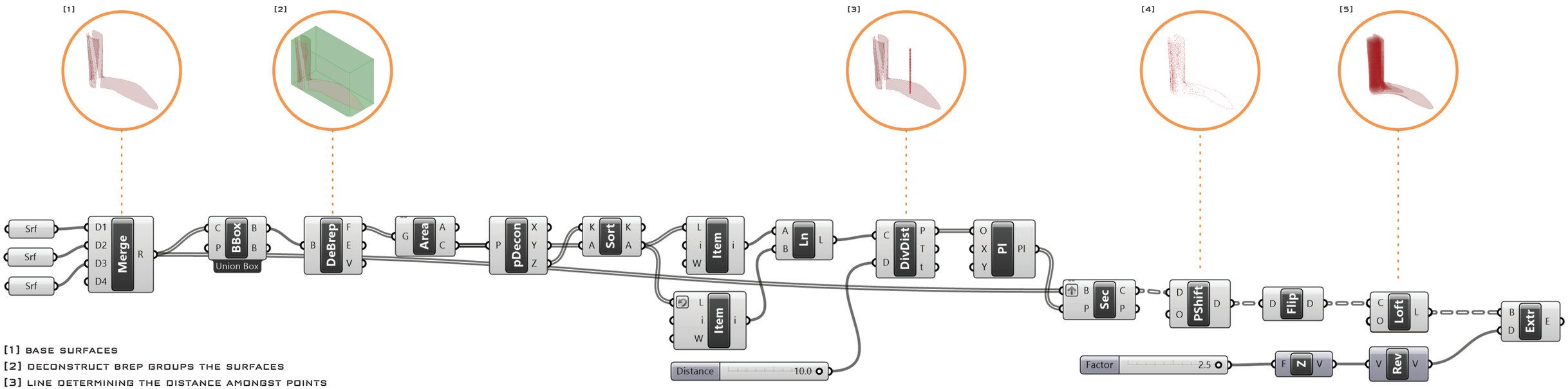
SOUTHEAST ISOMETRIC
CONCEPT VARIATION_ 5
RADIATION PERIOD: JAN 01 - DEC 31
TIMEFRAME: 9:00AM - 6:00PM





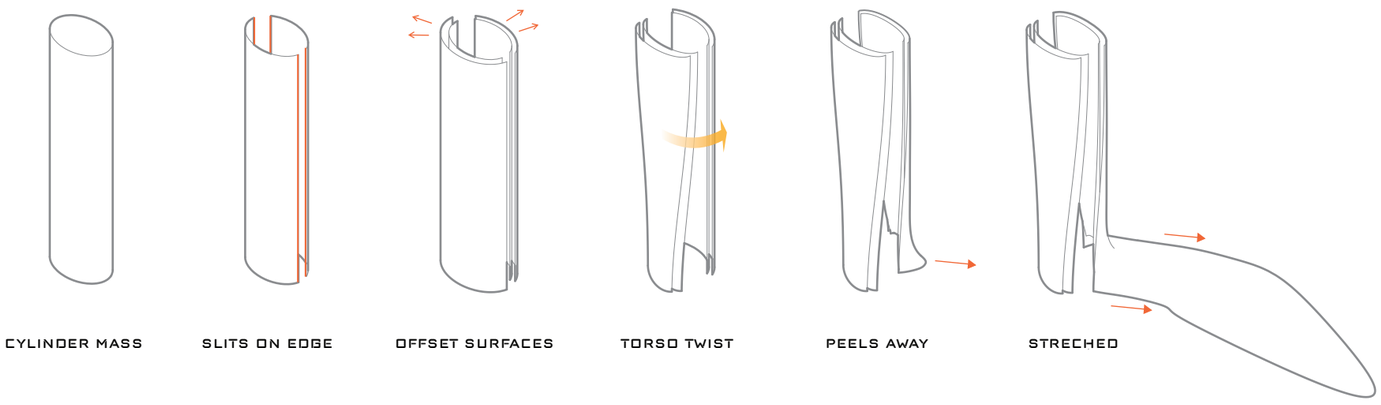
SOUTHEAST ISOMETRIC
CONCEPT VARIATION_ 6
RADIATION PERIOD: JAN 01 - DEC 31
TIMEFRAME: 9:00AM - 6:00PM

BUILDING DEFINITION_

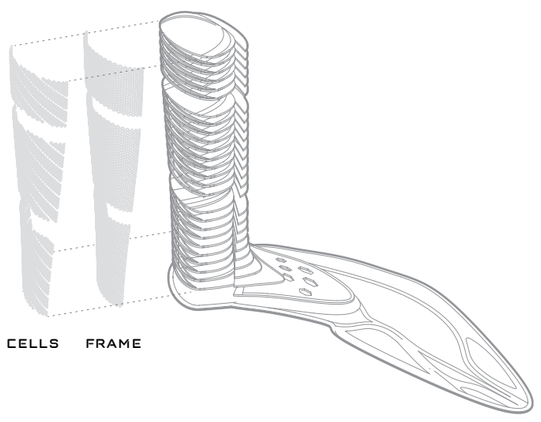


[1] BASE SURFACES
[2] DECONSTRUCT BREP GROUPS THE SURFACES
[3] LINE DETERMINING THE DISTANCE AMONGST POINTS
[4] LINES CREATED AT INTERVALS
[5] LINES ARE LOFTED TO CREATE FLOOR PLATES

FORM DEVELOPMENT_



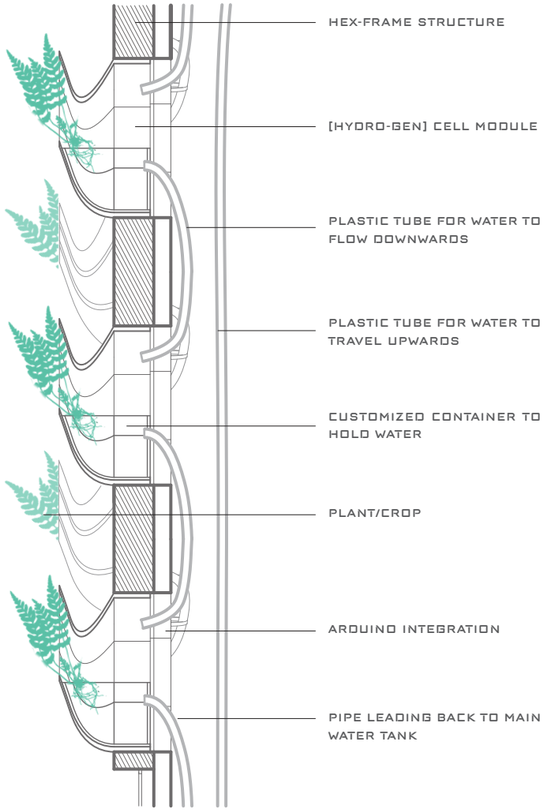
CYLINDER MASS SLITS ON EDGE OFFSET SURFACES TORSO TWIST PEELS AWAY STRECHED



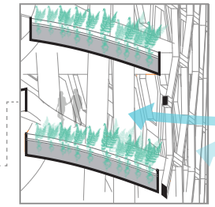
CELLS FRAME

5.6 DRAWINGS AND DIAGRAMS_

FACADE DETAIL_

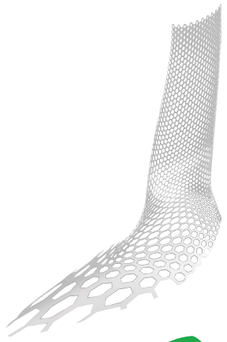


SECTION A_



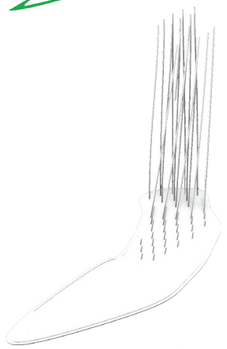
GREEN SPINE DETAIL_

CROSS VENTILATION USED AS THE DOMINANT WINDS COME FROM THE NORTHEAST DIRECTION.

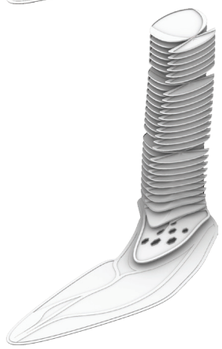


HEX FRAME
ALONG THE BACK END A STRUCTURAL SYSTEM FLOWS FROM THE GROUND TO THE TOP AND HOLDS PV PANELS.

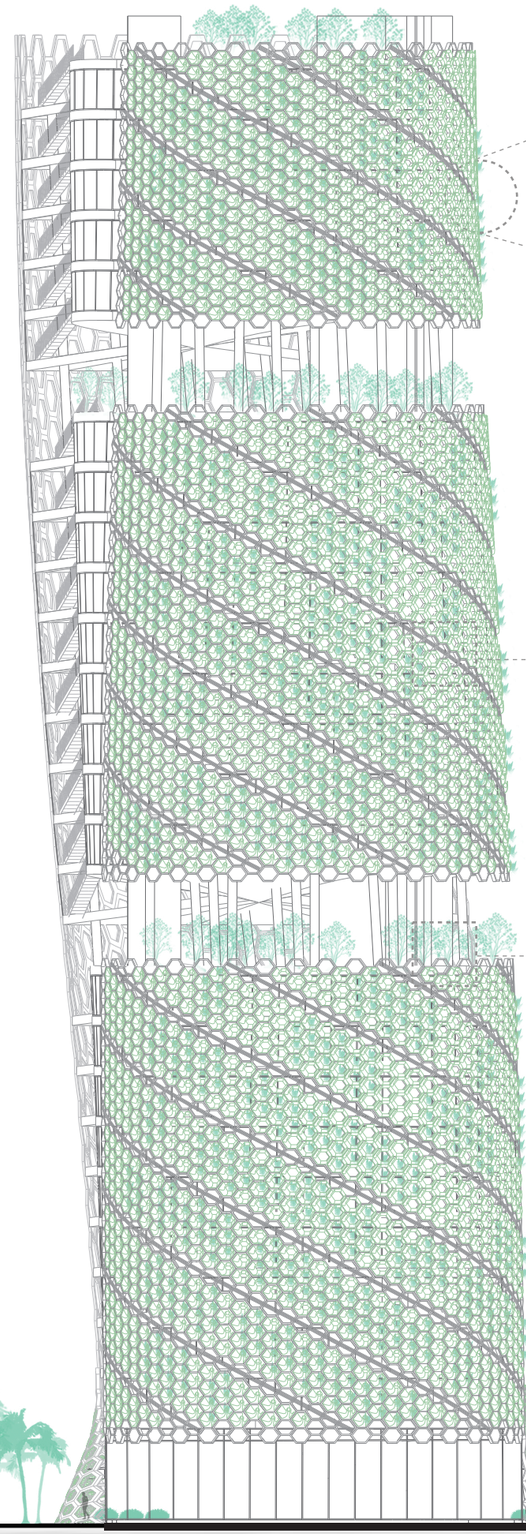
GREEN SPINE
VERTICAL LANDSCAPING ALL THROUGHOUT THE BACK END OF BUILDING IN ORDER TO PROVIDE OUTDOOR SPACE.



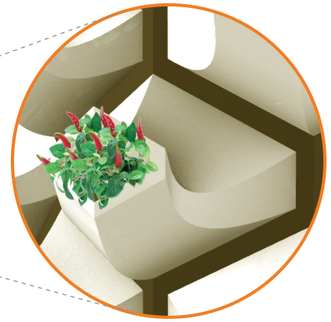
STRUCTURE
A SERIES OF TWISTED COLUMNS FROM THE BASE MAKES UP THE STRUCTURAL SYSTEM IN THE BUILDING.



FLOOR PLATES
RESPOND TO THE SITE'S BOUNDARIES AND ARE RAMPED TOWARDS THE BACK END IN ORDER TO COLLECT RAINWATER

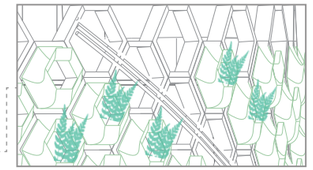


SOUTHEAST ELEVATION_



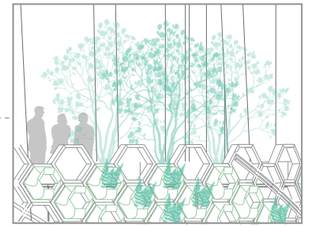
IN THE URBAN CONTEXT THE [HYDRO-GEN] CELL IS SEEN PRIMARILY AS A FUTURISTIC PARAMETRIC FACADE SYSTEM WITH KINETIC MODULES THAT CAN RESPOND TO SOLAR CONDITIONS.

HOWEVER, ITS TRUE INTENTION IN A URBAN ENVIRONMENT IS THAT THE MODULES WITH THE PLANTS HOUSED IN THEM WILL ACT AS AIR FILTRATION DEVICES TO REMOVE CO2.



ROBOTIC TRACK SYSTEM_

A ROBOTIC TRACK SYSTEM IS USED WITHIN THE FACADE AS A WAY TO HARVEST/COLLECT CROPS. TRACK SYSTEM IS ALSO BENEFICIAL FOR THE MAINTENANCE OF THE CELL MODULE



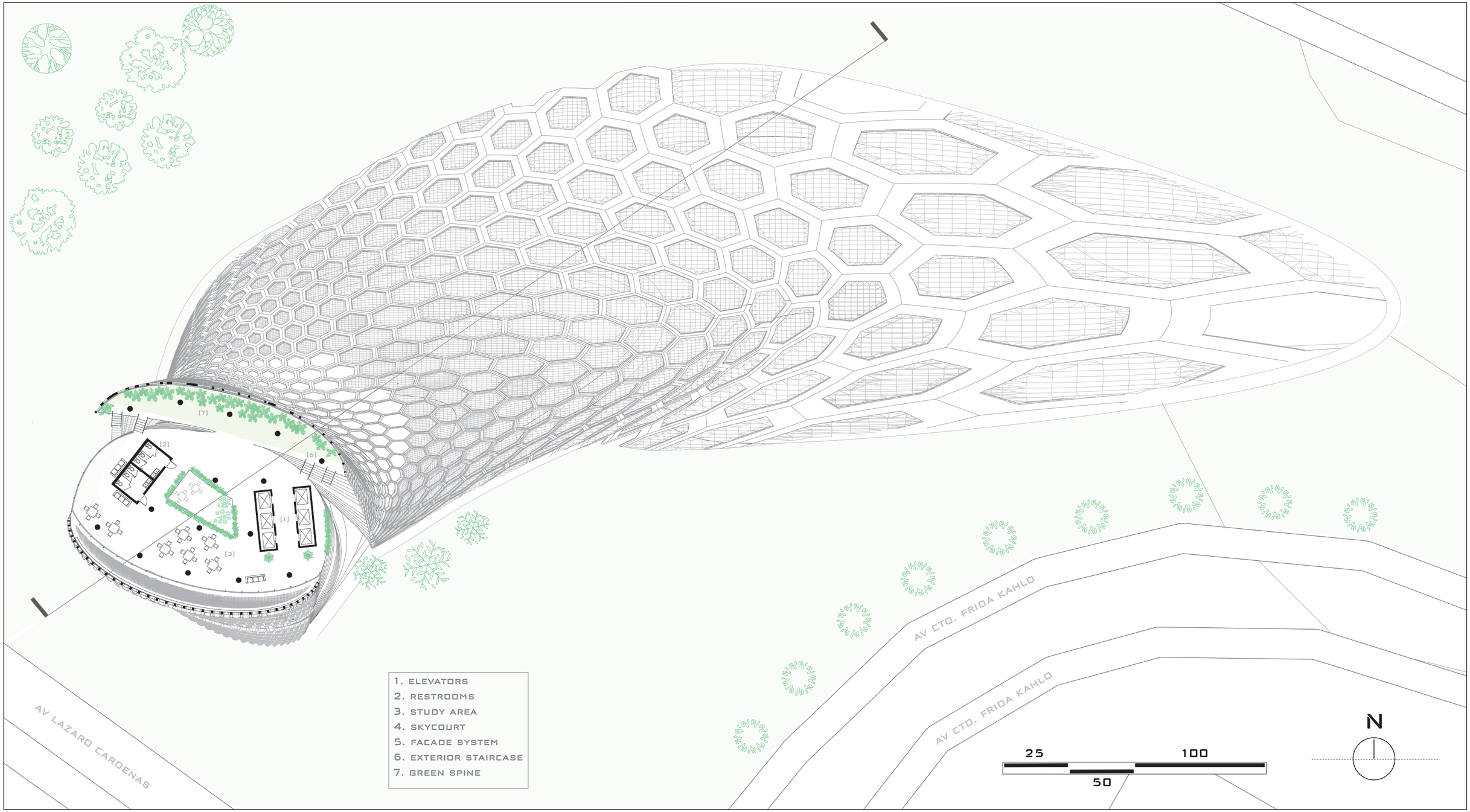
PUBLIC OUTDOOR SPACE_

SKYCOURTS IN ORDER TO PROVIDE LARGE OUTDOOR SPACES FOR THE PEOPLE IN THE BUILDING.

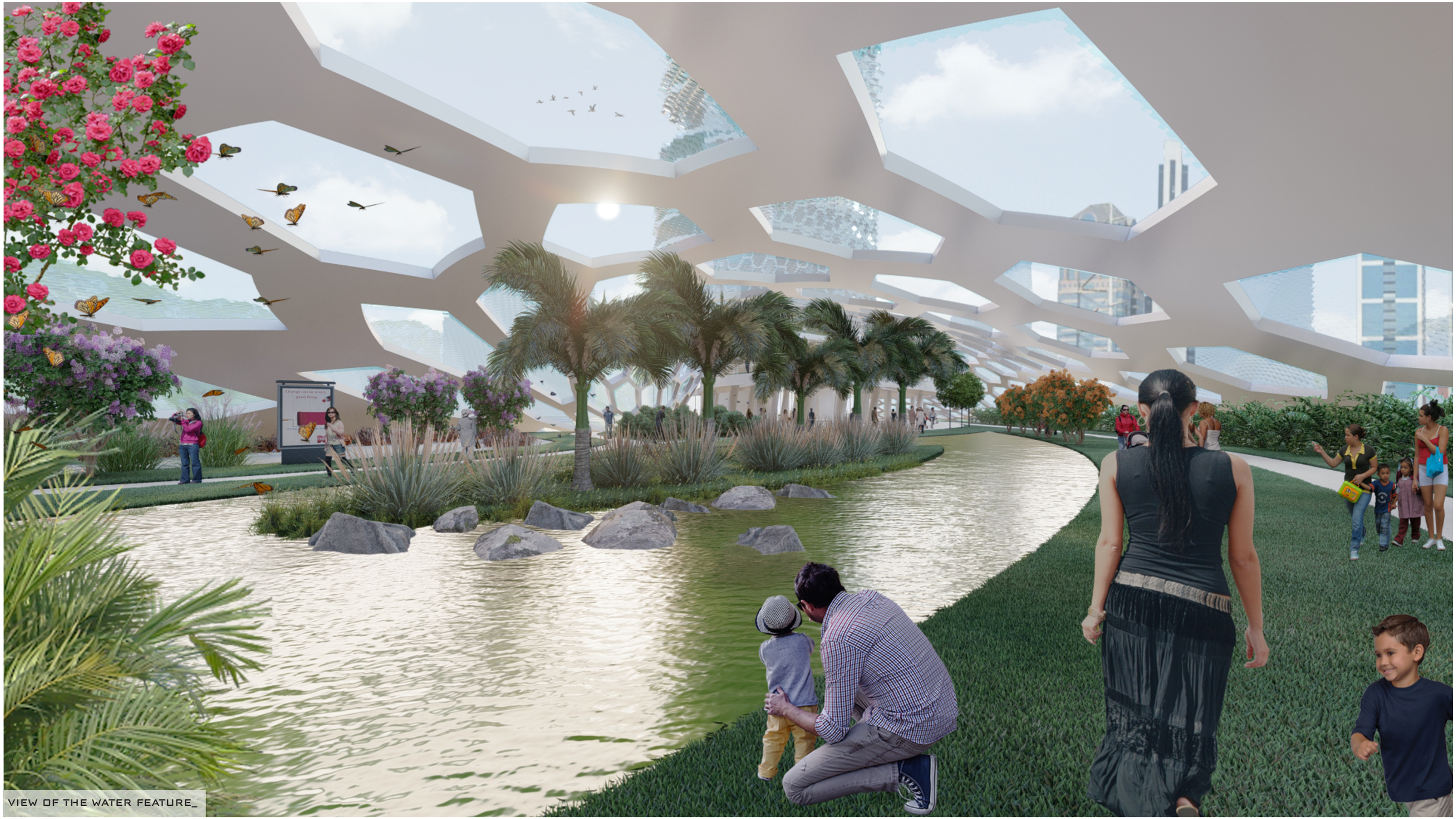
CREATES A PLACE OF GATHERING AND ALLOWS FOR ADDITIONAL CROSS VENTILATION THROUGHOUT THE BUILDING WHILE PROMOTING ECOLOGY WITH NATIVE VEGETATION.

GROUND FLOOR PLAN_

16TH LEVEL FLOOR PLAN_

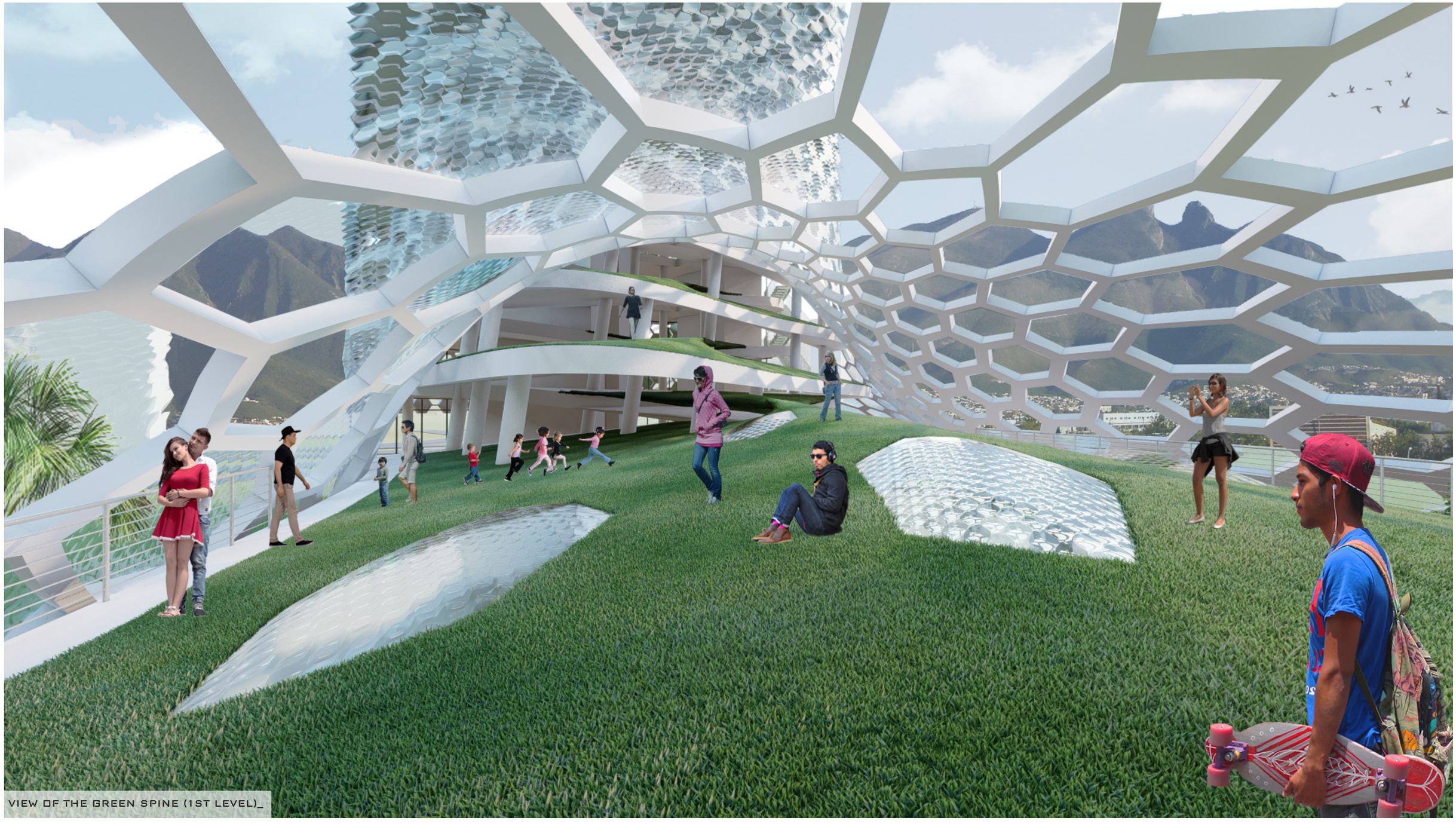


5.6 EXPERIENCE_

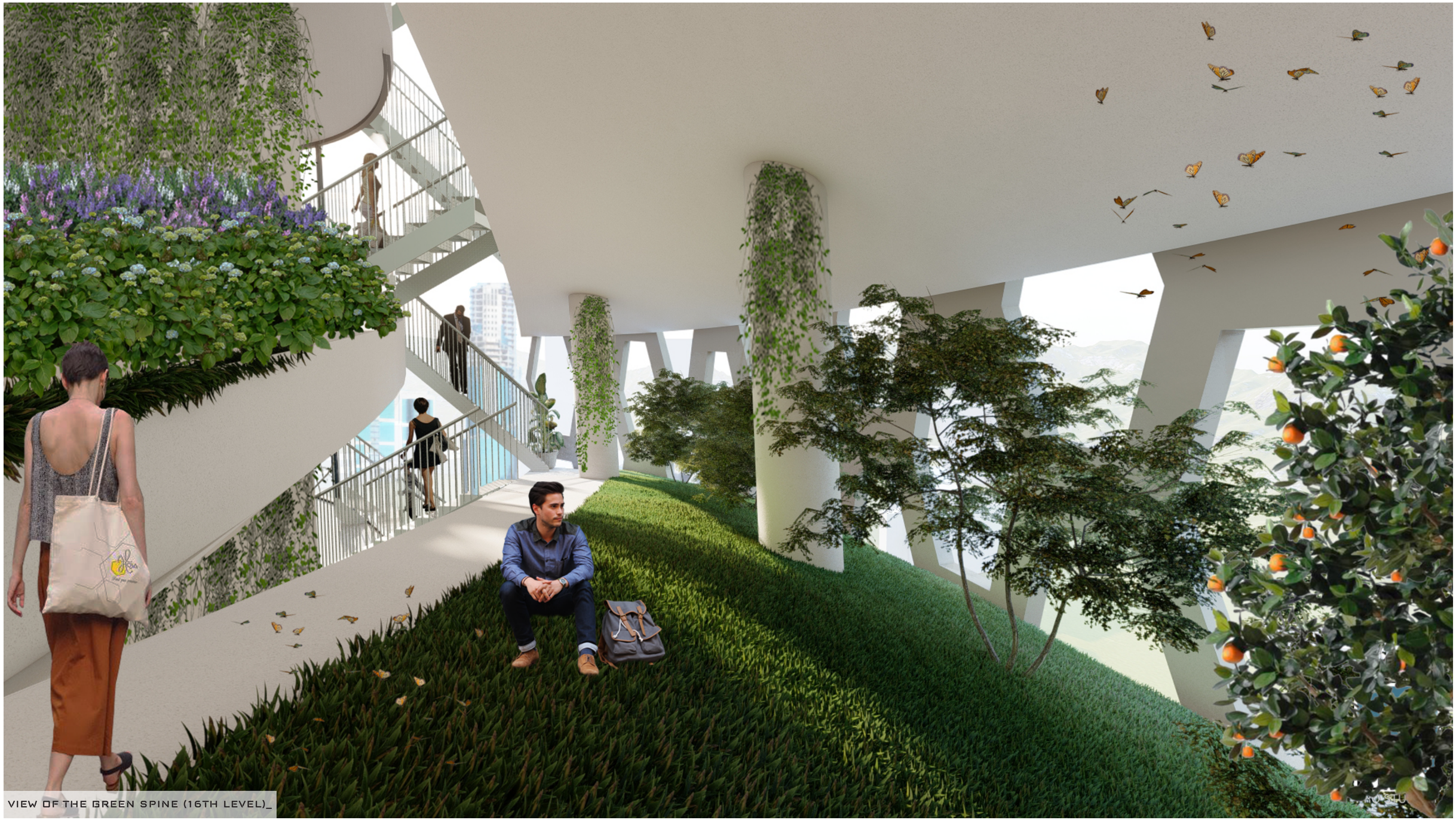


VIEW OF THE WATER FEATURE_

VIEW OF THE GARDENS_



VIEW OF THE GREEN SPINE (1ST LEVEL)_



VIEW OF THE GREEN SPINE (16TH LEVEL)_

EXTERIOR VIEW OF BUILDING AND CONTEXT_

SKYCOURT VIEW OUT TO THE CITY_

INTERIOR OF RESEARCH LABS_

SPACE BETWEEN FACADE AND INTERIOR_

CHAPTER 06_

"AWARDS AND CONFERENCES"_

6.1 [NAPH] CONFERENCE_

THE NORTH AMERICAN PASSIVE HOUSE CONFERENCE [NAPH] HELD ITS 14TH ANNUAL CONFERENCE IN WASHINGTON D.C. IN THE HYATT REGENCY HOTEL IN CRYSTAL CITY. I RECIEVED FUNDING FROM THE SOCIETY OF BUILDING SCIENCE EDUCATORS [SBSE] TO ATTEND THE CONFERENCE FROM DECEMBER 6-7.

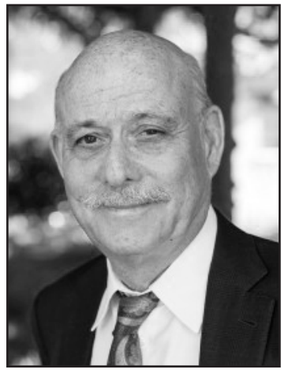
WHAT THE CONFERENCE PRIMARILY FOCUSES ON IS PASSIVE HOUSE DESIGN AND HOW TO PROMOTE THE IDEA SO THAT THE BUILDING INDUSTRY BECOMES MORE SUSTAINABLE. THE [NAPH] IS THE LEADING PASSIVE HOUSE CONFERENCE IN THE COUNTRY THAT TARGETS CLIMATE-SPECIFIC ZERO ENERGY DESIGN, CONSTRUCTION, AND BUILDING SCIENCE EXPERTISE.

PASSIVE HOUSE IS DEFINED AS A VOLUNTARY STANDARD FOR ENERGY EFFICIENCY IN A BUILDING, WHICH REDUCES THE BUILDING'S ECOLOGICAL FOOTPRINT. IT RESULTS IN ULTRA-LOW ENERGY BUILDINGS THAT REQUIRE LITTLE ENERGY FOR SPACE HEATING OR COOLING. THE ROLE OF THE ARCHITECT AND OTHER PROFESSIONALS SUCH AS ENGINEERS, DEVELOPERS AND CONSTRUCTION PROFESSIONALS IS TO MAKE SURE THEY TARGET AND MEET CERTAIN CRITERIA, SUCH AS SUPERB COMFORT AND INDOOR AIR QUALITY, COST-EFFICIENCY, AND AFFORDABILITY, CARBON REDUCTION IN THE BUILT ENVIRONMENT AND RESILIENCY.

AT THE CONFERECE MANY PROJECTS THAT HAVE SUCCESSFULLY MANAGED TO MEET PASSIVE HOUSE CRITERIA ARE SHOW-CASED. THESE PROJECTS RANGE FROM SINGLE FAMILY HOMES TO HIGH RISES. ALONG WITH BUILT PROJECTS EMERGING TECHNOLOGIES ARE ALSO DISPLAYED, SUCH AS MECHANICAL SYSTEMS, BUILDING SCIENCE, AND CONSTRUCTION MATERIALS. MANY OF THE EMERGING TECHNOLOGIES FOCUSED ON BUILDING ENVELOPES.

PASSIVE HOUSE INSTITUTE US_

KEY NOTE SPEAKERS_



[JEREMY RIFKIN]

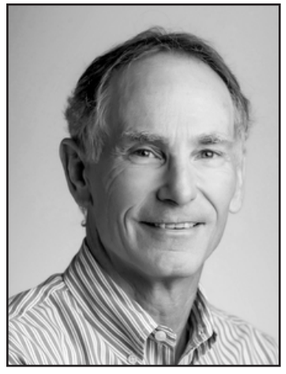
THE FIRST KEY-NOTE SPEAKER WAS JEREMY RIFKIN WHO IS A WELL KNOWN SOCIAL THEORIST, WRITER, PUBLIC SPEAKER, AND ACTIVIST. HIS TALK ON THE FIRST DAY OF THE CONFERENCE WAS VERY MOTIVATIONAL AS HE BROUGHT UP THE TOPIC OF CLIMATE-CRISIS. HE SPECIFICALLY TALKED ABOUT THE DANGERS THAT WE'RE GETTING OURSELVES INTO IF ACTION ISN'T TAKEN FROM GLOBAL GOVERNMENTS.

HE BROUGHT UP GOOD POINTS IN TERMS OF ALTERNATIVE METHODS THAT WE CAN PURSUE FOR A MORE SUSTAINABLE MODEL IN THE BUILDING INDUSTRY. HE MENTIONED THE USE OF NATURAL RESOURCES MORE SPECIFICALLY TURNING AWAY FROM CARBON AND INSTEAD LOOKING AT HYDROGEN.

[JOE LSTIBUREK]

SECOND KEY-NOTE SPEAKER JOE LSTIBUREK IS A BUILDING SCIENCE CONSULTANT AND AUTHOR. HIS EXPERTISE LIES ON BUILDING MOISTURE CONTROL AND INDOOR AIR QUALITY. HE IS WELL KNOWN FOR HIS "PERFECT WALL" CONCEPT WHICH IDENTIFIES 4 KEY CONTROL FACTORS WITHIN THE BUILDING ENVELOPE; RAIN, AIR, VAPOR, AND THERMAL.

AT THE CONFERENCE HE BROUGHT UP THE IMPORTANCE OF THE BUILDING ENVELOPE AND HOW THROUGH NEW SYSTEMS ITS BECOMING MORE EFFICIENT IN TERMS OF CONTROLLING THE 4 KEY FACTORS. HIS PERFECT WALL CONCEPT IS SOMETHING THAT BEGAN TO LOOK UP AND LEARN MORE ABOUT AS IT DIRECTLY RELATED TO MY THESIS PROJECT.



[SAM RASHKIN]

THE FINAL KEY-NOTE SPEAKER AT THE CONFERENCE WAS SAM RASHKIN WHO IS THE FOUNDER OF RETOOLING THE U.S. HOUSING INDUSTRY. HE DEDICATES HIMSELF AS A CONSULTANT THAT HELPS OTHERS IN THE INDUSTRY PREPARE FOR CLIMATIC DISRUPTIONS IN THE NEAR FUTURE.

HE IS ALSO THE CHIEF ARCHITECT OF BUILDING TECHNOLOGIES OFFICE, WHERE THEY DEVELOP HIGH-PERFORMANCE HOME INNOVATIONS AND PROMOTE THEM TO THE U.S HOUSING INDUSTRY. AT THE CONFERENCE HE TALKED ABOUT HIS COMPANY AND PRESENTED SOME THEIR PREVIOUS WORKS AS WELL AS WHAT THEY ARE CURRENTLY WORKING ON.

TAKEAWAYS_

THE [NAPH] CONFERENCE WAS AN AMAZING OPPORTUNITY IN WHICH I FELT THAT I TRULY BENEFITED FROM. FOR ME TO BE AROUND SUCH INNOVATIVE AND EXPERIENCED PROFESSIONALS THAT CARE ABOUT OUR IMPACT ON THE ENVIRONMENT WAS VERY INSPIRATIONAL.

WHAT I GOT OUT OF THIS CONFERENCE WAS A BETTER UNDERSTANDING OF WHAT'S CONSIDERED TO BE A PASSIVE HOUSE. MORE SPECIFICALLY ON HOW AS A DESIGNER I CAN FOCUS ON VERY SPECIFIC COMPONENTS THAT MAKE UP A BUILDING AND APPLY PASSIVE HOUSE STRATEGIES.

AS PREVIOUSLY MENTIONED SOME OF THE NEW EMERGING TECHNOLOGIES THAT WERE DISPLAYED FOCUSED ON MAKING THE BUILDING ENVELOPE TO KEEP COOLING AND HEATING COSTS AT A MINIMUM. I WILL BE APPLYING SOME OF THE THINGS THAT I LEARNED FROM CERTAIN TECHNOLOGIES WITHIN THE DESIGN OF THE PROPOSED [HYDRO-GEN] CELL. AS A BUILDING SKIN IT WILL REQUIRE STRATEGIC DESIGN MOVES IN ORDER TO PROPERLY ADJUST THE SYSTEM TO ITS SITE CONTEXT.

[JONATHAN Y. BEAN, PH.D.]
ASSISTANT PROFESSOR AT THE UNIVERSITY OF ARIZONA.

[WALTER GRONOZIK]
ASSISTANT PROFESSOR AT BALL STATE UNIVERSTIY.

[ALISON KWOK, PH.D]
ASSISTANT PROFESSOR AT THE UNIVERSITY OF OREGON.

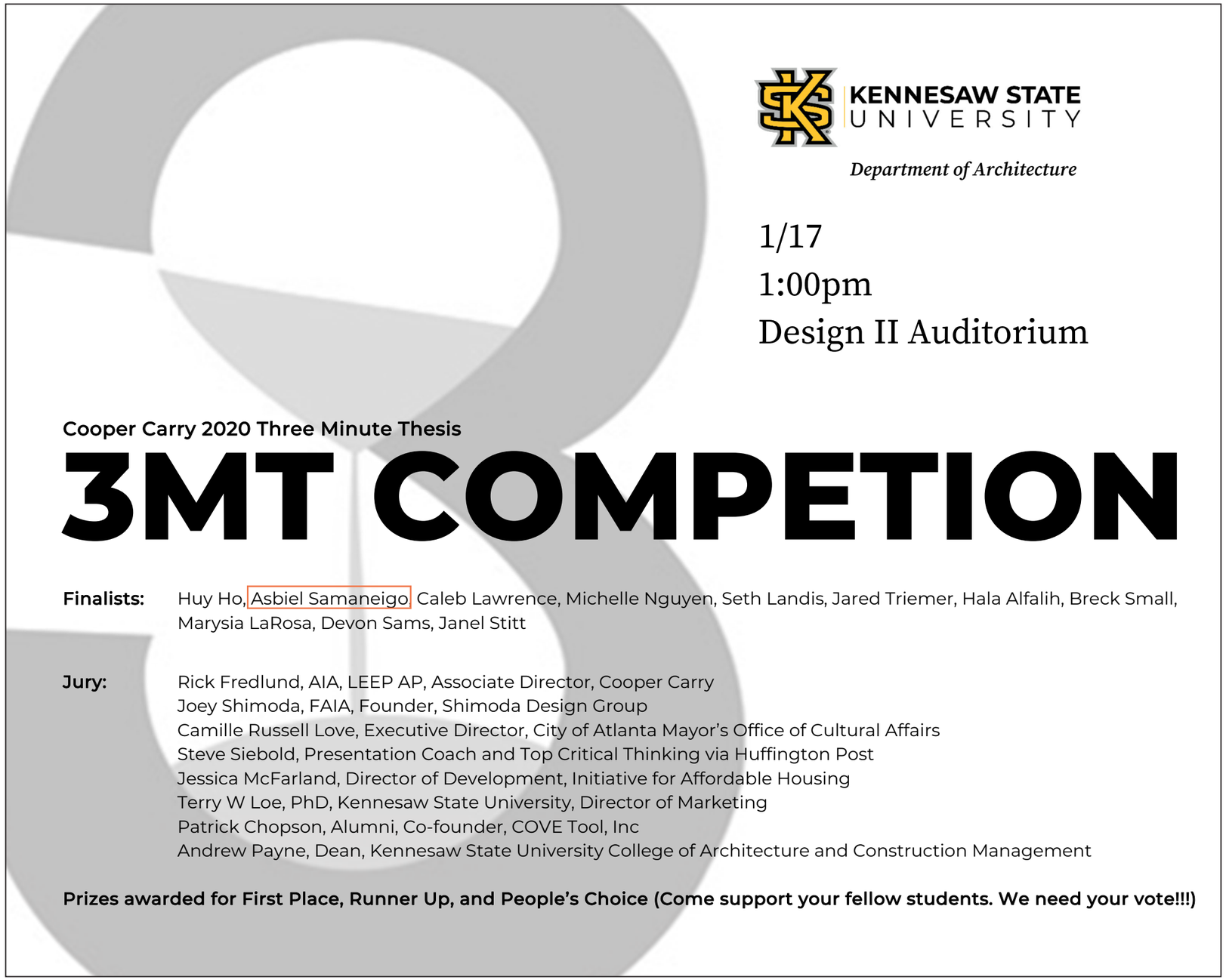
6.2 COOPER CARRY 3MT COMPETITION_

I WAS HONORED TO BE ONE OF 11 STUDENTS WHO WERE SHORTLISTED AND PARTICIPATED IN THIS YEAR'S COMPETITION.

THE COOPER CARRY THREE MINUTE THESIS COMPETITION IS HELD EACH YEAR AND ONLY A HANDFUL OF PROJECTS ARE SELECTED BY THE FACULTY TO PRESENT IN FRONT OF THE ENTIRE DEPARTMENT.

THE STUDENTS SELECTED ARE TO PRESENT VERBALLY AND EXPLAIN THE INTENT OF THEIR THESIS PROJECT'S WITHIN A THREE MINUTE TIME-FRAME.

PLACED: FINALIST [HONORABLE MENTION]



THE [HYDRO-GEN] CELL_

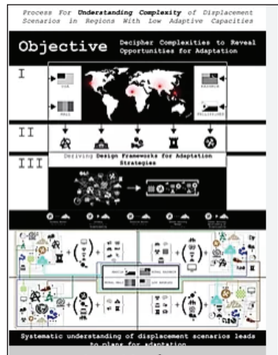
A HYDROPONIC, REGENERATIVE, MODULAR SYSTEM
FOR OPTIMIZED VERTICAL FARMING_

6.3 CRITICAL+MASS 2020_

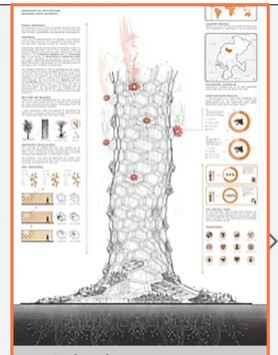
CRITICAL+MASS IS AN ANNUAL AND PRESTIGIOUS SYPOSIUM IN WHICH THE MASTER'S OF ARCHITECTURE STUDENT SOCIETY [MASS] FROM THE UNIVERSITY OF NORTH CAROLINA, CHARLOTTE, HOSTS OTHER SCHOOL'S OF ARCHITECTURE TO SHOWCASE SELECTED GRADUATE WORK.

THIS YEAR I WAS HONORED TO BE SELECTED BY THE DEPARTMENT OF ARCHITECTURE AND TO BE THE SOLE REPRESENTATIVE OF KENNESAW STATE UNIVERSITY.

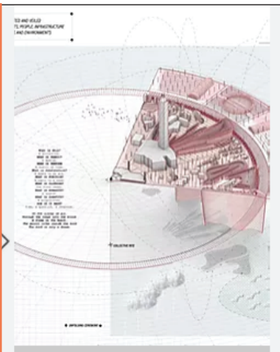
DUE TO THE COVID-19 VIRAL OUTBREAK THE EVENT WAS TRANSITIONED TO A DIGITAL PLATFORM, WHICH REQUIRED EACH OF THE PARTICIPANTS TO SEND TWO 24" X 36" BOARDS ALONG WITH OTHER DOCUMENTS.



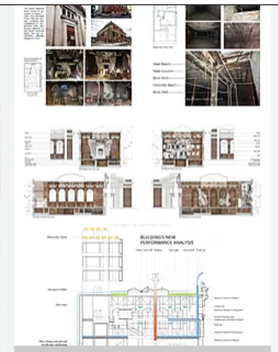
Joe Koslow
Ball State University



Asbiel Samaniego
Kennesaw State University



Zherti Jasa
University of Tennessee, Knoxville

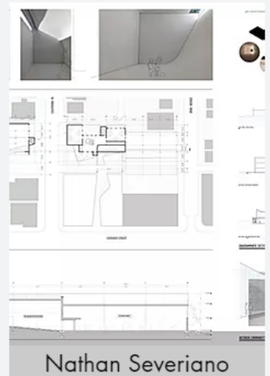


Mahsa Hedaya
Virginia Tech

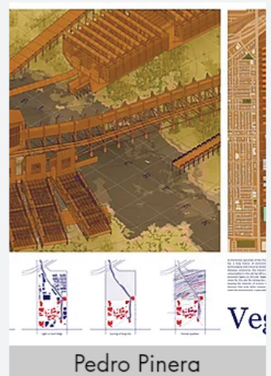
Jerome Tryon
Yale School of Architecture

Diego Zubizarreta Otero
University of Texas at Austin

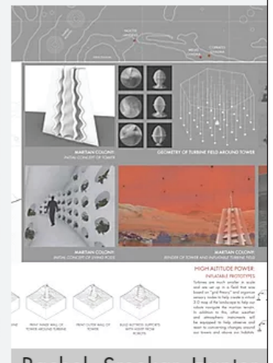
Mariel Hamer
University of North Carolina at Charlotte



Nathan Severiano
Washington University-St. Louis



Pedro Pinera
University of North Carolina at Charlotte



Rachel, Sreekar, Hunter
Clemson State University

THE [HYDRO-GEN] CELL_

[A HYDROPONIC, REGENERATIVE, MODULAR SYSTEM FOR OPTIMIZED VERTICAL FARMING]

DEPARTMENT OF ARCHITECTURE_
KENNESAW STATE UNIVERSITY_

THESIS STATEMENT_

THIS RESEARCH PROJECT AIMS TO DESIGN, DEVELOP, AND TEST AN INTELLIGENT HYDROPONIC SYSTEM THAT CAN BE INTEGRATED INTO THE BUILT ENVIRONMENT FOR ADVANCING SUSTAINABILITY.

PROPOSAL_

" THE LAND WAS SOMETHING YOU LEFT BEHIND. IN THE MINDS OF MANY OF OUR RELATIVES AND ANCESTORS, THE MORE DISTANT YOU WERE FROM THAT PAST, THE BETTER" -MAJORA CARTER

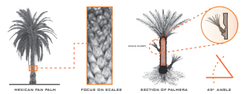
HYDROPONIC SYSTEMS ARE METHODS OF GROWING PLANTS IN A WATER-BASED SOLUTION, WHICH ARE CURRENTLY USED IN VERTICAL FARMING PRACTICES FOR FOOD PRODUCTION. IN THIS RESEARCH, THE **HYDROPONIC-REGENERATIVE** OR **[HYDRO-GEN] CELL** IS ENVISIONED AS **BIOMECHANICAL HYBRID MACHINERY** THAT, WHILE DESIGNED TO BE USED IN MID-TO HIGH-RISE BUILDINGS IT WOULD ADDRESS SUSTAINABLE ASPECTS SUCH AS FOOD PRODUCTION, ENHANCEMENT OF AIR CLEANING CAPACITY, AND REDUCTION OF ENERGY CONSUMPTION.

THE PROJECT SPECIFIALLY AIMS AT ADDRESSING THE IMPACT CLIMATE-CRISIS HAS HAD ON THE AGRICULTURE IN THE COUNTRY OF MEXICO. THROUGH TESTING AND GROWING CROPS IN A CONTROLLED ENVIRONMENT BY MICROMANAGING DIFFERENT VARIABLES THAT AFFECT A CERTAIN TYPE OF PLANTS GROWTH. ALSO, THROUGH THE THE APPLICATION OF **ARDUINO** SOFTWARE THE **[HYDRO-GEN] CELL** WILL BE AN INTELLIGENT SYSTEM WITH MULTIPLE APPLICATIONS THAT WILL OPTIMIZE THE WAY IT PERFORMS BASED ON THE PLANT(S) ITS GROWING AND ITS SURROUNDINGS. THE PROTOTYPE WILL EVENTUALLY BE INTEGRATED WITHIN THE MID TO HIGH-RISE BUILDING TYPOLOGY IN MEXICO.

REVIVING THE PALMERA_

THERE WAS A MAJOR DEFORESTATION ACT THAT TOOK PLACE IN THE 1930'S WHICH PERMITTED THE CLEARANCE OF THOUSANDS OF ACRES AND DESTROYING NATURAL ECOSYSTEMS SUCH AS THE MEXICAN FAN PALM OR "PALMERA".

I TOOK INSPIRATION FROM THE SPECIES TO INFLUENCE THE DESIGN OF A MODULAR HYDROPONIC SYSTEM. THE SCALES ON THE TRUNK WAS WHERE THE FOCUS FELL UPON.

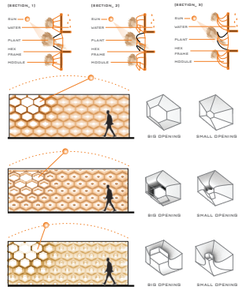


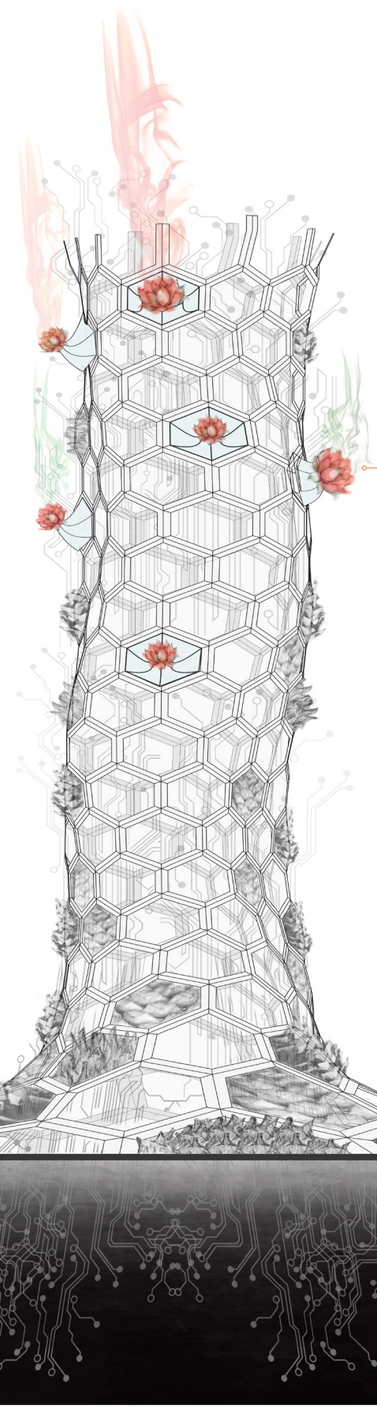
PARAMETRIC DEVELOPMENT_

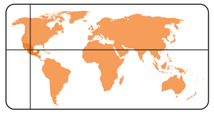
THE PROCESS OF GENERATING THE CELL MODULE IS BY UTILIZING THE PARAMETRIC PLUGIN FOR RHINO [GRASSHOPPER]. FROM THERE 3 VARIATIONS WHERE DERIVED EACH EXPLORING THE QUALITIES NEEDED FOR A HYDROPONIC SYSTEM.

THE MODULES CAN ALSO BE DESIGNED TO WHERE THEY RESPOND TO AN ATTRACTOR POINT WHICH IN THE REAL WORLD COULD BE THE MOVEMENT OF THE SUN.

CELL VARIATIONS_





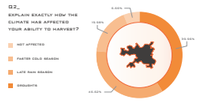


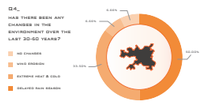
COUNTRY: MEXICO_
MEXICO WAS SELECTED AS THE COUNTRY OF FOCUS DUE TO ITS GEOGRAPHIC VULNERABILITY TO CLIMATE-CRISIS.

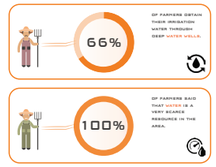
RIO GRANDE, ZACATECAS_
MUNICIPALITY CHOSEN DUE TO ITS HIGH RADIATION LEVELS AND HIGH ALTITUDE ABOVE SEA LEVEL.

QUESTIONNAIRE RESULTS_

A QUESTIONNAIRE WAS CONDUCTED TARGETING THE LOCAL FARMERS OF THE AREA TO SEE WHAT THEIR EXPERIENCES ARE LIKE. QUESTIONS WERE ASKED REGARDING THEIR ABILITY TO GROW CROPS.







THE VERTICAL FARM_

AS LAND BECOMES LESS SUITABLE FOR FARMING DUE TO NUTRIENT LOSS, AGRICULTURE HAS TO TAKE A NEW APPROACH AND MUST GO VERTICAL. THE VERTICAL FARM COULD PROVIDE THE SOLUTION AND WOULD ADDRESS MULTIPLE GLOBAL ISSUES.

ADVANTAGES_

SYSTEM INTEGRATION_

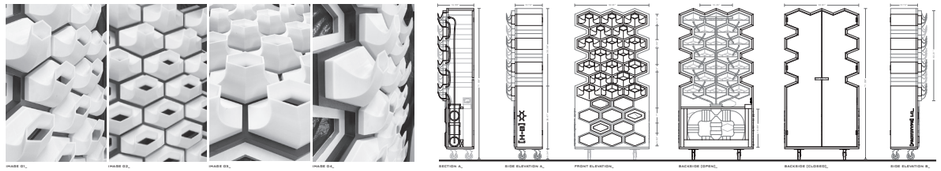
[HYDROPONICS VIA ARDUINO SOFTWARE]

MICRO PROTOTYPE_

THE SYSTEM AS A WHOLE ALLOWS FOR CERTAIN VARIABLES TO BE MEASURED AND ADJUSTED IF NEEDED. ONCE THE ENTIRE SYSTEM IS CONNECTED PROPERLY THE ARDUINO SOFTWARE ON ANY COMPUTER IS ABLE TO READ ALL THE SENSORS DATA AND IS ABLE TO RECORD IT EVERY SECOND. BY READING THE OUTPUTS OF THE SENSORS ONE IS THEN ABLE TO MAKE INFORMED DECISIONS ON CONTROLLING THE AMOUNT OF LIGHT THE PLANT MAY RECIEVE OR INCREASE/DECREASE THE ROOM TEMPERATURE.

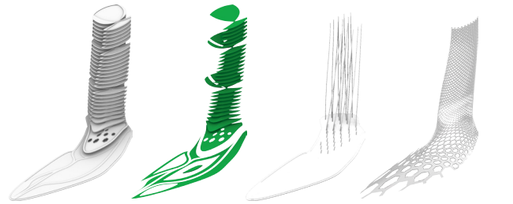
WITH IT BEING A CLOSED-LOOP SYSTEM THE PRESERVATION OF WATER IS RETAINED AND CYCLED BACK INTO THE SYSTEM. CONTROL OF THE VARIABLES AFFECTING THE PLANTS GROWTH IS WHAT MAKES HYDROPONICS A BETTER ALTERNATIVE TO OUTDOOR FARMING WHERE ONE HAS LITTLE TO NO CONTROL.

MACRO PROTOTYPE_

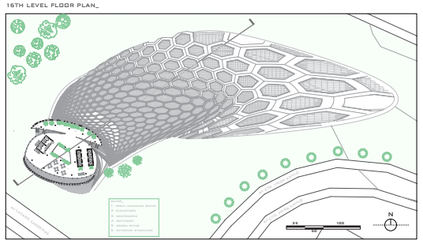


[H-B] TOWER_

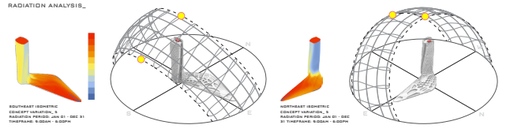
GREEN SPINE RENDER_



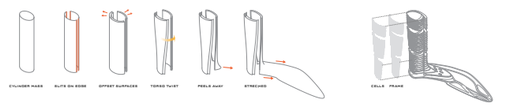
16TH LEVEL FLOOR PLAN_

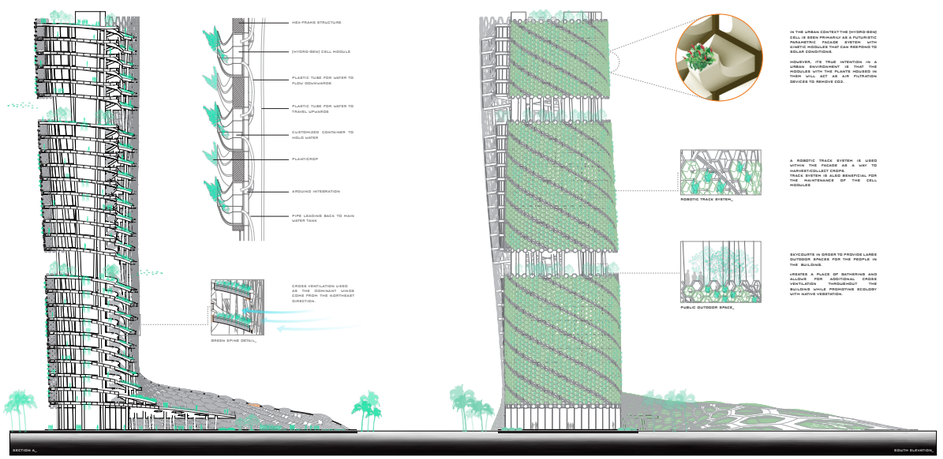


RADIATION ANALYSIS_



FORM DEVELOPMENT_





COMPETITION BOARDS_

6.4 [REAL] THESIS COMPETITION 2020_

FOR THIS YEAR'S ANNUAL THESIS COMPETITION I HAD THE PRIVILEGE TO BE SHORTLISTED ALONG WITH 5 OTHER COLLEAGUES AND GOT TO PRESENT MY FINAL THESIS PROJECT.

DUE TO THE COVID-19 OUTBREAK OUR PRESENTATIONS WERE DONE THROUGH THE REMOTE ELECTRONIC ARCHITECTURE LAB [REAL] ONLINE PLATFORM. WE EACH HAD A TOTAL OF 12 SLIDES TO PRESENT OUR PROJECTS TO A DISTINGUISHED JURY PANEL WHICH INCLUDED:
[1] ROBERT HALVERSON [COMPETITION CHAIR], AIA, NCARB
[2] NORRIS HUNT [COMPETITION CHAIR]
[3] CARYN BRAUSE, AIA
[4] TODD ERLANDSON, AIA, LEED AP
[5] HANS C. HERRMANN, AIA, LEED GREEN ASSOC., NCARB
[6] BLAKE JACKSON, AIA,LEED-WELL

THE 6 OF US COMPETED FOR NUMEROUS PRIZES THAT INCLUDED:
[1] THE PORTMAN PRIZE FOR OUTSTANDING THESIS 2020
[2] ARCHIPRIX NOMINEE 2020
[3] FACULTY BEST THESIS AWARD
[4] STUDENT'S PEOPLES CHOICE AWARD

Remote Electronic Architecture Lab

THE PORTMAN PRIZE FOR OUTSTANDING THESIS 2020_
FINISH: [HONORABLE MENTION]

ARCHIPRIX NOMINEE 2020_
FINISH: [WINNER]

FACULTY BEST THESIS AWARD_
FINISH: [JOINT - WINNER]

STUDENT'S PEOPLES CHOICE AWARD_
FINISH: [WINNER]

COMPETITION SLIDES_

THE [HYDRO-GEN] CELL_

A HYDROPONIC, REGENERATIVE, MODULAR SYSTEM FOR OPTIMIZED VERTICAL FARMING_

THESIS STATEMENT_
This research project aims to design, develop, and test an intelligent hydroponic system that can be integrated into the built environment for advancing sustainability.

PROPOSAL_
The project specifically aims at addressing the impact climate-crisis has had on the agriculture in the municipality of Rio Grande in Zacatecas, Mexico. By testing and growing crops in a controlled environment by micromanaging different variables that affect a certain type of plants growth.

Through the application of the **ARDUINO** software the **[HYDRO-GEN] CELL** will be an intelligent system with multiple applications that will optimize the way it performs based on the plant(s) its growing and its surroundings. The prototype will eventually be integrated within the mid-to high-rise building typology in an urban setting.

The **HYDROPONIC-REGENERATIVE** or **[HYDRO-GEN] CELL** is envisioned as **BIO-MECHANICAL HYBRID MACHINERY** that, while designed to be used in mid-to high-rise buildings it would address sustainable aspects such as food production, enhancement of air cleaning capacity, and reduction of energy consumption.

RESEARCH CONTEXT_
This thesis will explore the advancements in hydroponic technology and AI integration within the field of agriculture and analyze how these systems work. By understanding how the systems function the development of a new hydroponic system **[HYDRO-GEN] CELL** will be made using 3D parametric modeling software to produce **CELLULAR ORGANIC MODULES**. The system will be comprised of the special modules that will be designed for various solar configurations. The modules will attach and detach from a hexagonal structure.

The integration of the **ARDUINO** software will be applied within the hydroponic system as it will allow for easy monitoring of the immediate surroundings via specific sensors. The final prototype will be a **VERTICAL PARAMETRIC HYDROPONIC SYSTEM** that will resemble and pay homage to the **MEXICAN FAN PALM**; a native species of palm that has been eradicated in the region in order for farmers to have more space to grow their crops.

RESEARCH QUESTIONS_
1) **CHANGE IN MEXICO**: How are farmers in the municipality of Rio Grande, Zacatecas dealing with the issue of water scarcity and how has it affected their ability to grow crops?

2) **THE [HYDRO-GEN] CELL**: How does the **[HYDRO-GEN] CELL** enhance the food production and air cleaning capacities in the context of built and natural environments?

3) **BUILDING INTEGRATION**: How can the **[HYDRO-GEN] CELL** be integrated into mid and high-rise buildings throughout Mexico to optimize cultivation practices?

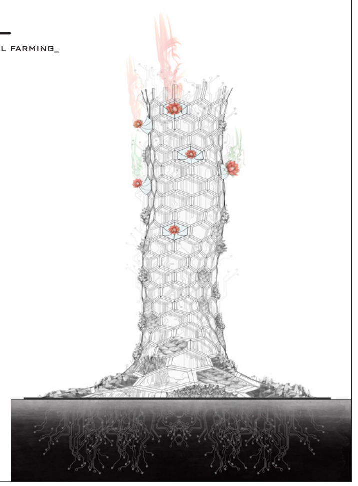
METHOD OF INQUIRY_
1) **SURVEY/QUESTIONNAIRE**: A disperse survey study and questionnaire will be conducted in the region asking both the older and newer generations questions regarding their ability to harvest crops in response to the changing climatic conditions.

2) **RESEARCH THROUGH DESIGN**: The **[HYDRO-GEN] CELL** will be designed, built, tested, and modified to meet certain food production and air cleaning criteria.

3) **RESEARCH THROUGH DESIGN**: The **[HYDRO-GEN] CELL** system will be integrated within the mid-to high-rise building typology and based on specific parameters such as; plant species used, natural lighting and atmospheric pressure will determine the strategic placement and location of the [HYDRO-GEN] cell system.

OBJECTIVE_
The goal of the [HYDRO-GEN] cell is for it to be an intelligent hydroponic system that is capable of adjusting or reconfiguring its shape in relation to solar geometry.

CONTRIBUTIONS_
1) Air cleaning capacities (removal of CO_2 emissions)
2) Food production capacities (higher yields)
3) Land use efficiency (less space to grow crops)

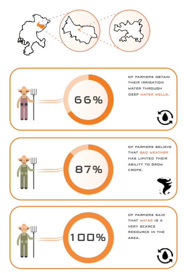


01

QUESTIONNAIRE AND RESULTS_

This past summer I decided to visit my parents hometown in Rio Grande, Zacatecas to interview and speak with the local farmers of that area to see what their hardships were in relation to producing crops.

A disperse survey study and questionnaire was conducted targeting the local farmers of the area to see first hand what their experiences are like. Several questions were asked regarding their ability to grow crops within the region. The following are the questionnaire results.



02

[MICRO] PROTOTYPE_

The project consists of 3 main components; pipe assembly, container assembly and Arduino integration. The pipes serve to not only contain water, but to house plants and other sensors as well. The container mainly made up from poplar and MDF serves as the main housing unit for the pipes and the electrical components. Arduino acts like the brain behind the entire systems functionality.

The main components are the Arduino Uno R3 which is the microcontroller. Water and air pumps which are key in keeping the flow of water oxygenated and circulated throughout the pipes. Finally, a wide range of sensors are integrated such as light, humidity, temperature, etc. in order to keep record of the interior environment in which the plants will grow.

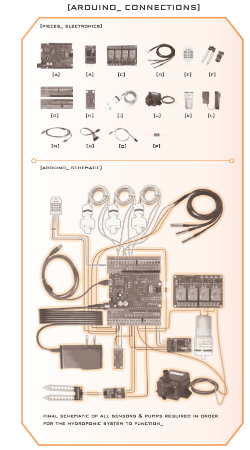
The system as a whole allows for certain variables to be measured and adjusted if needed. Once the entire system is connected properly the Arduino software on any computer is able to read all the sensors data and is able to record it at every second. By reading the outputs of the sensors one is then able to make informed decisions on controlling the amount of light the plant may receive or increase/decrease the room temperature.

With it being a closed-loop system the preservation of water is retained and cycled back into the system. Control of the variables affecting the plants growth is what makes hydroponics a better alternative to outdoor farming where one has little to no control.

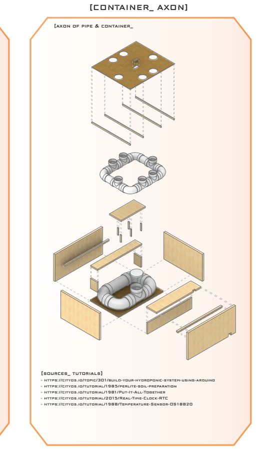
PIECES_ELECTRONICS

[A] Arduino Uno R3 x 1
[B] IIC RTC x 1
[C] 4-Channel Relay x 1
[D] Water Temp. Sensor x 1
[E] DHT22 x 1
[F] Hygrometer x 1
[G] Skrew Shield V2 x 1
[H] BH1750FVI x 1
[I] Float Switch x 3
[J] Water Pump x 1
[K] Air Pump x 1
[L] 9V Plug-in x 1
[M] Printer Cable x 1
[N] Male-Female Pins x 20
[O] Female-Female Pins x 2
[P] 4.7K Ohm Resistor x 2

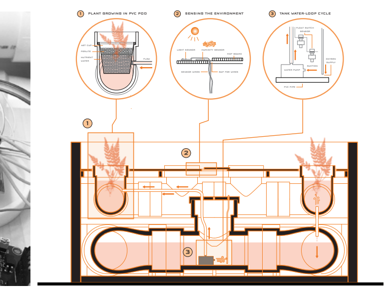
[ARDUINO_ CONNECTIONS]



[CONTAINER_ AXON]



03



04

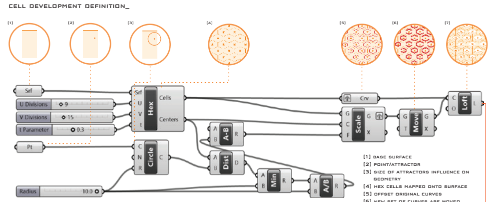
CELL DEVELOPMENT_

The [HYDRO-GEN] cell is a cellular module designed for a vertical farming system and was created in a way that allows for the module to be reconfigured in different forms due to its hexagonal base. Inspiration was drawn from the trunk of a Mexican fan palm [Palmera] as the scales also have a hexagonal base and they tend to grow upwards at an angle. It is recommended that for plants growing in any vertical system that the pods housing the plants are angled at 45°.

The process of generating a [HYDRO-GEN] cell module is by utilizing the parametric modeling plugin for Rhino [Grasshopper]. From there 5 variation where derived each exploring the qualities needed for a hydroponic system to function. Lighting, wind, stability, function, and fabrication were the main driving forces in determining the final outcomes for the 5 variations of the [HYDRO-GEN] cell module.

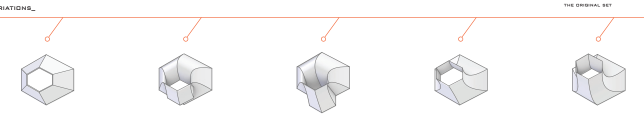
Each variation is able to be reconfigured in any way regardless of its appearance and can easily be attached or detached from a hexagonal structural system. The modules can also be designed to where they respond to an attractor point which in the real world could be the movement of the sun.

CELL DEVELOPMENT DEFINITION_

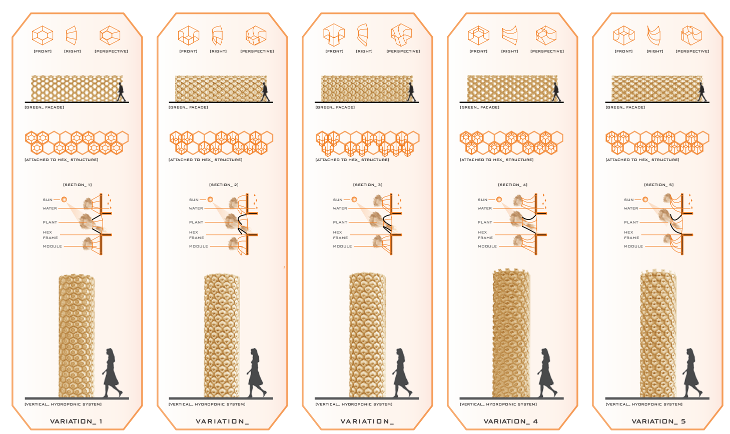


[1] Base surface
[2] Point/attractor
[3] Size of attractors influence on geometry
[4] Hex cells mapped onto surface
[5] Offset original curves
[6] New set of curves are moved along X,Y,Z coordinates
[7] Loft the new set of curves with the original set

CELL VARIATIONS_



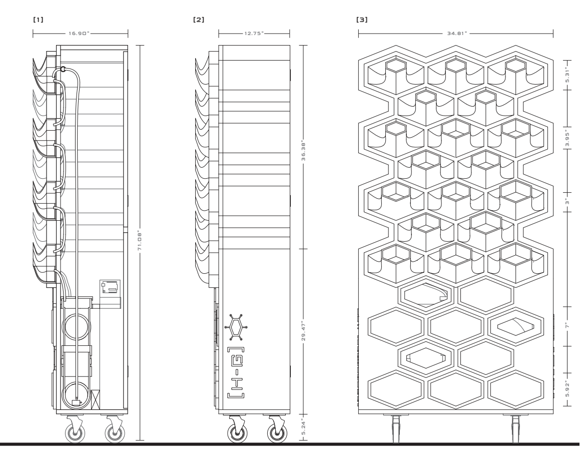
05



06

THE PROTOTYPE _

[1] SECTION A
[2] RIGHT ELEVATION
[3] FRONT ELEVATION



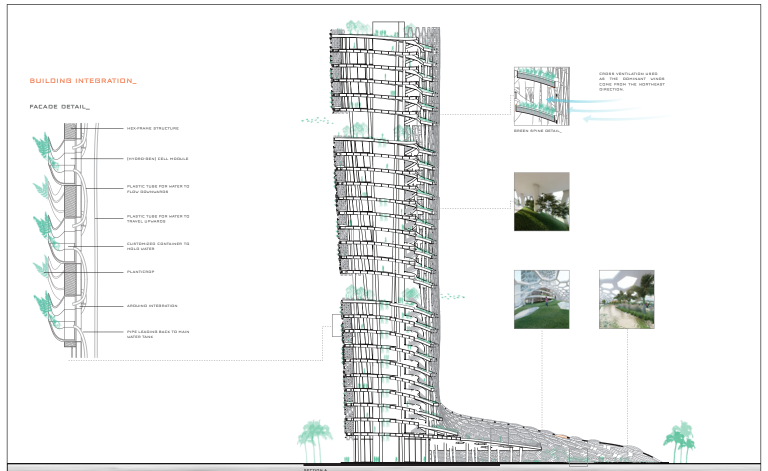
07

FABRICATION_

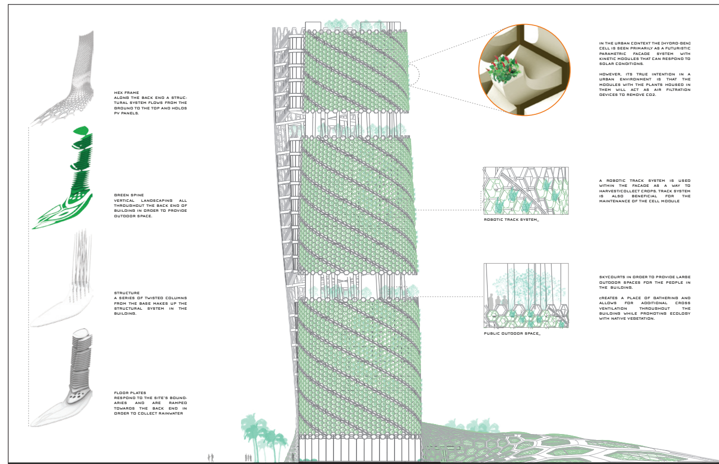
08

BUILDING INTEGRATION_

FACADE DETAIL_



09



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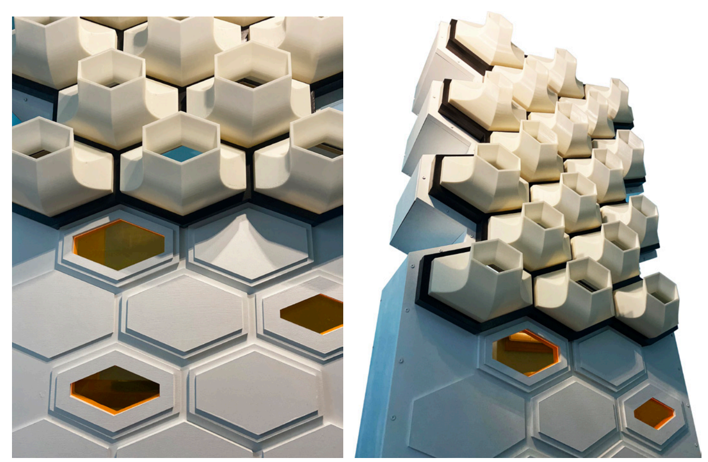

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