GEJIN ZHU

Selected Works 2021-2022

Columbia GSAPP

INTRODUCTION

This portfolio contains architecture design works from Gejin Zhu in GSAPP.

Rensselaer Polytechnic Institute SoA
Bachelor of Architecture

Columbia University GSAPP
Master of Science in Advanced Architecture Design

My thirteen semesters of architecture design studies in RPI and GSAPP exploit between architecture methodology, spatial framework, and spiritual conditions, that exist between the historically and the contemporarily, the perceived environment and the imaginative space, the ideal visions and material realities.

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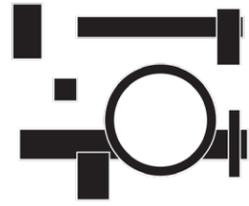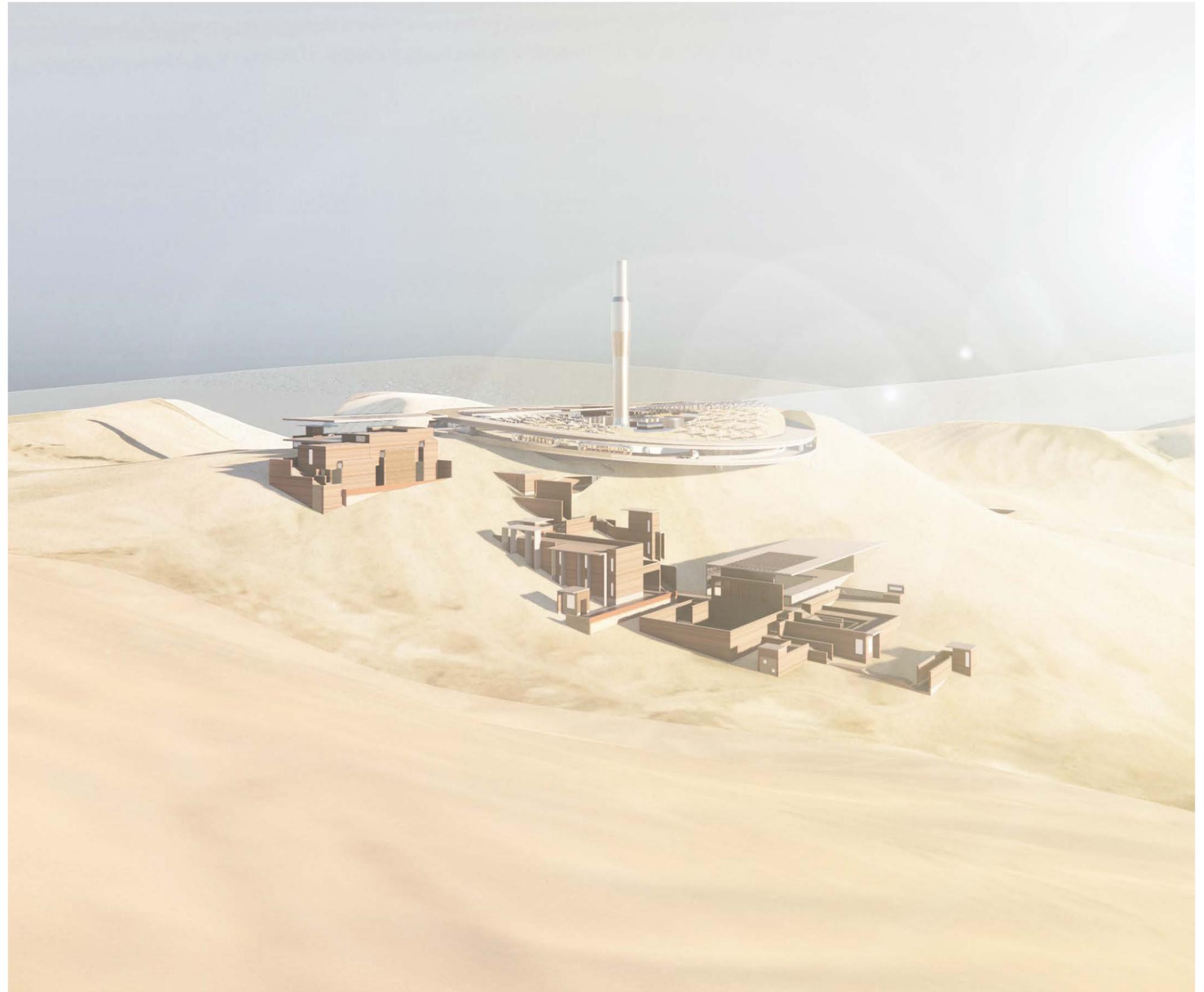# Subterranean District One
Death Valley Micro City Prototye

Advanced Design Studio
Columbia University
Instructor: David Benjamin
Site: Zabriskie Point, Death Valley, CA
Team: Gejin Zhu, Ana Hernandez

Average temperatures above 125 °F like those in Death Valley seem unusual, however according to recent climate data, northern cities will soon experience similar temperatures to southern cities, and many southern cities will reach extremely hot temperatures like those in Death Valley by 2050. Additionally, recent projections from the United Nation predict that while world population will increase by 50 percent in the next 30 years, current farm yields will decrease by 50 percent due to climate change.

Subterranean District One aims to transform current solar farm communities or the lack thereof, by creating a city that harmoniously merges people's daily lives, with good jobs, energy, food and water production. The project centers around an agro-voltaic farm and a climate data center, while integrating common city program, such as apartments, restaurants, plazas, shops, and retail. As a prototype city, the Subterranean District One is not a monumental object but a project with progessive effort for a "green revolution" in clean energy and farming practices under the environmental pressure of extreme heat.

Persoective Rendering

USA West Side Solar & Energy Map

Site Plan

1. Water Facility Room
2. Water Heating System Room
3. Climate Research Lab
4. Apartments
5. Individual Apartment
6. Hotel
7. Reception House
8. Visitor Center
9. Water Pool
10. Commercial Plaza
11. Agriculture Plaza
12. Mobile Retail
13. Agri-voltaic Farm
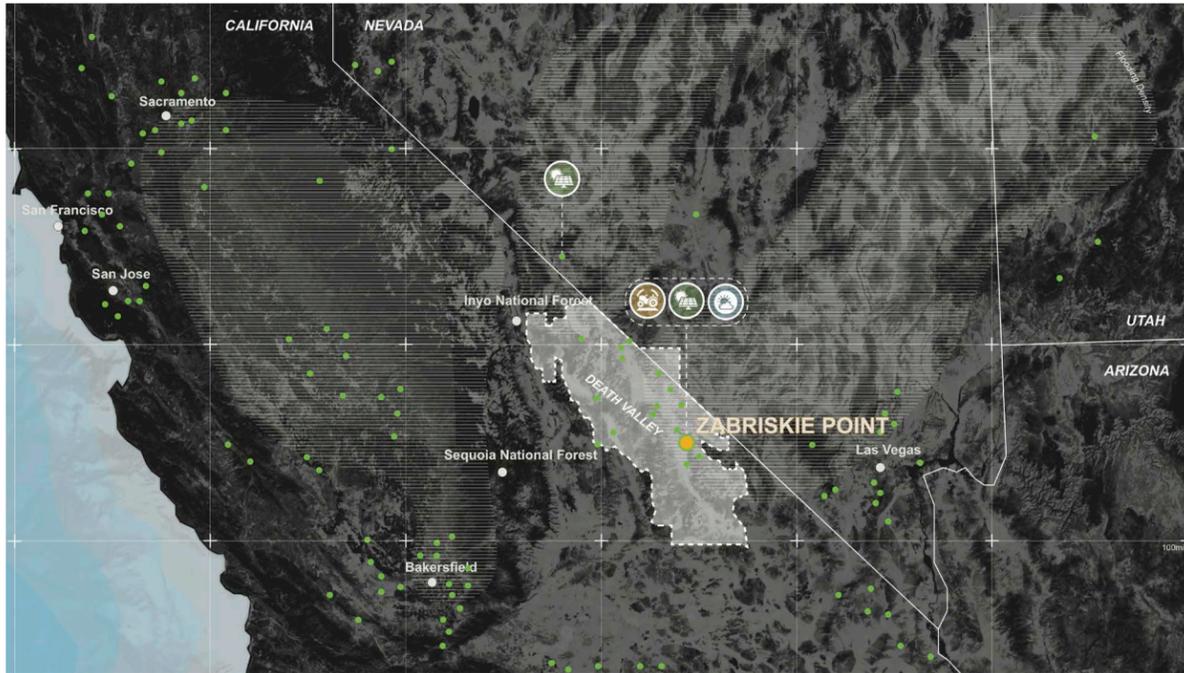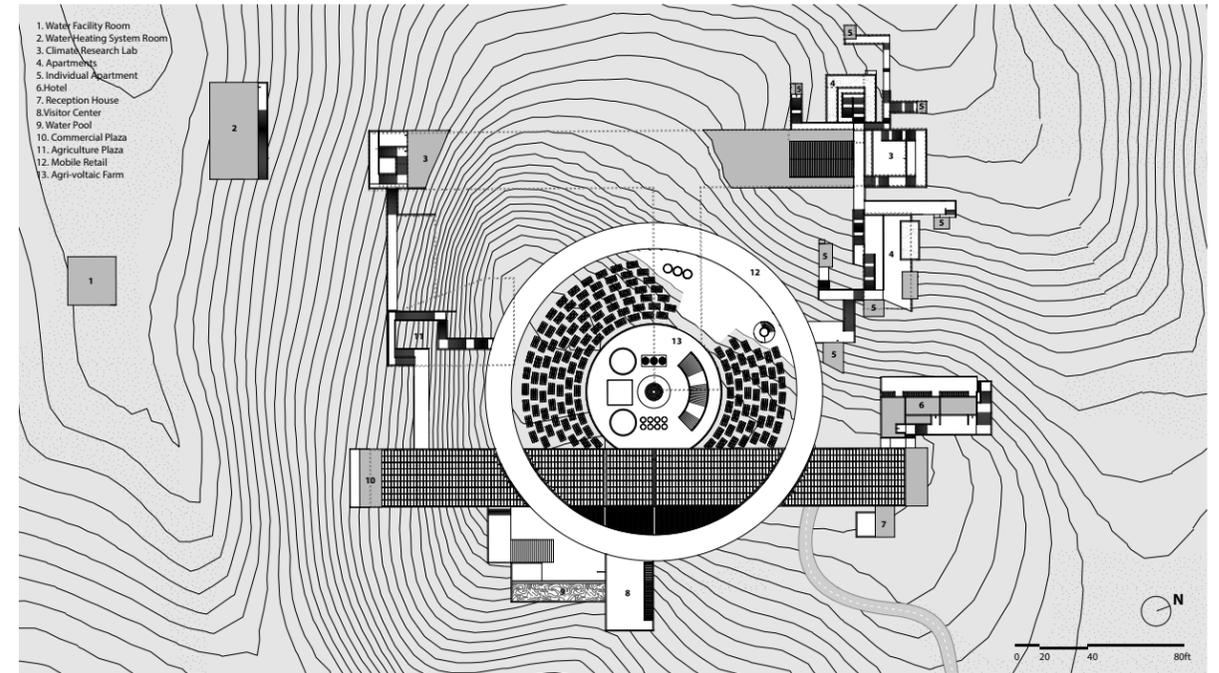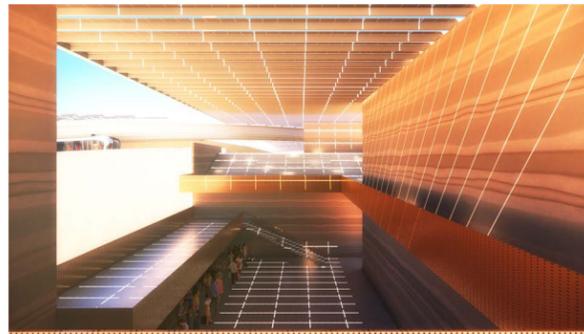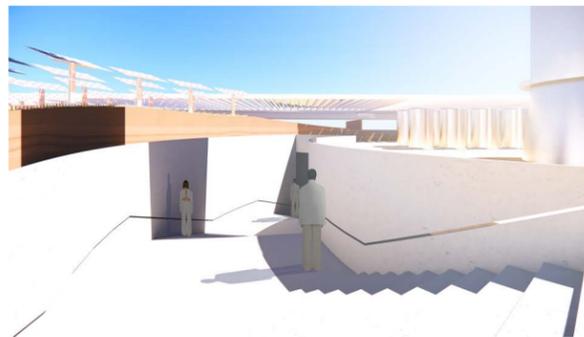
Rendering of Daily Life

4 am - residential apartment

10 am - plaza

6 am - pathway to solar farm

12 pm - facility room

Rendering of Daily Life

12 pm - residential apartments
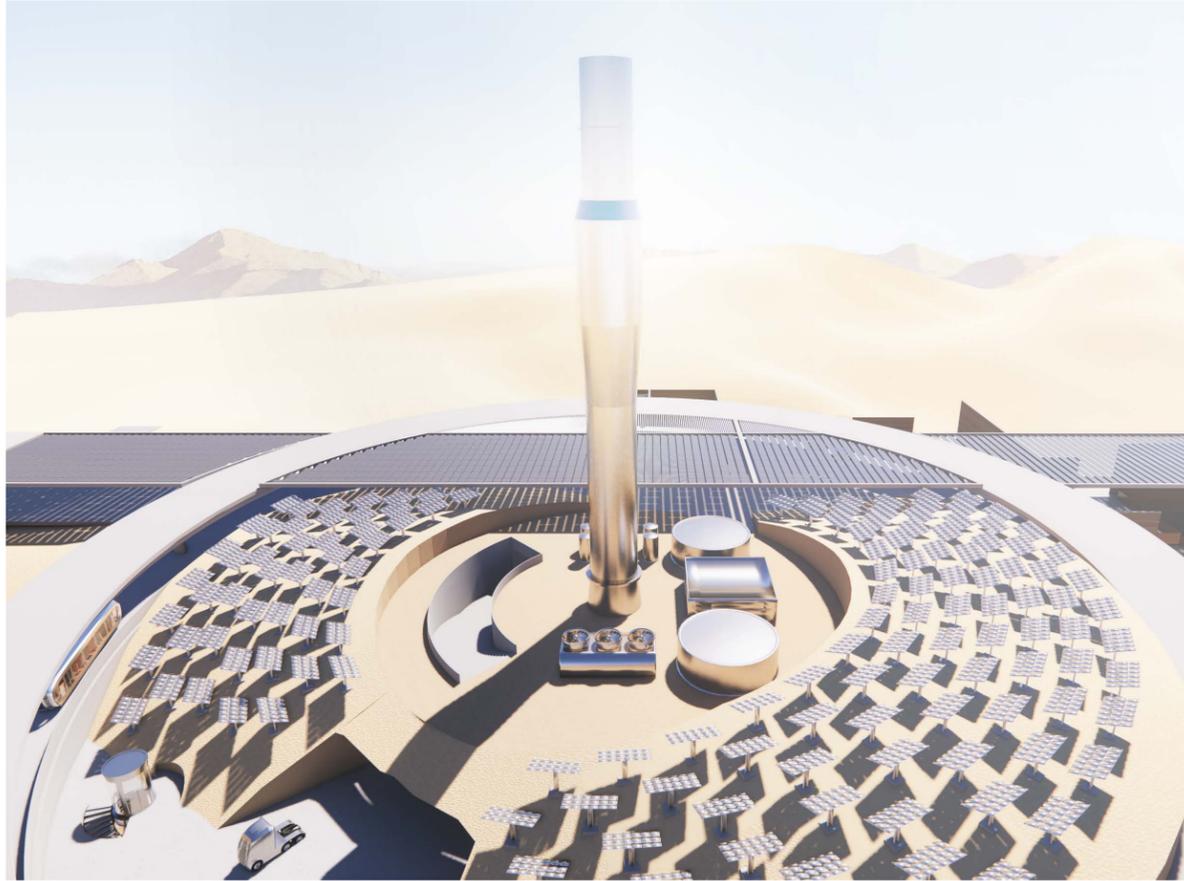

4 pm - plaza

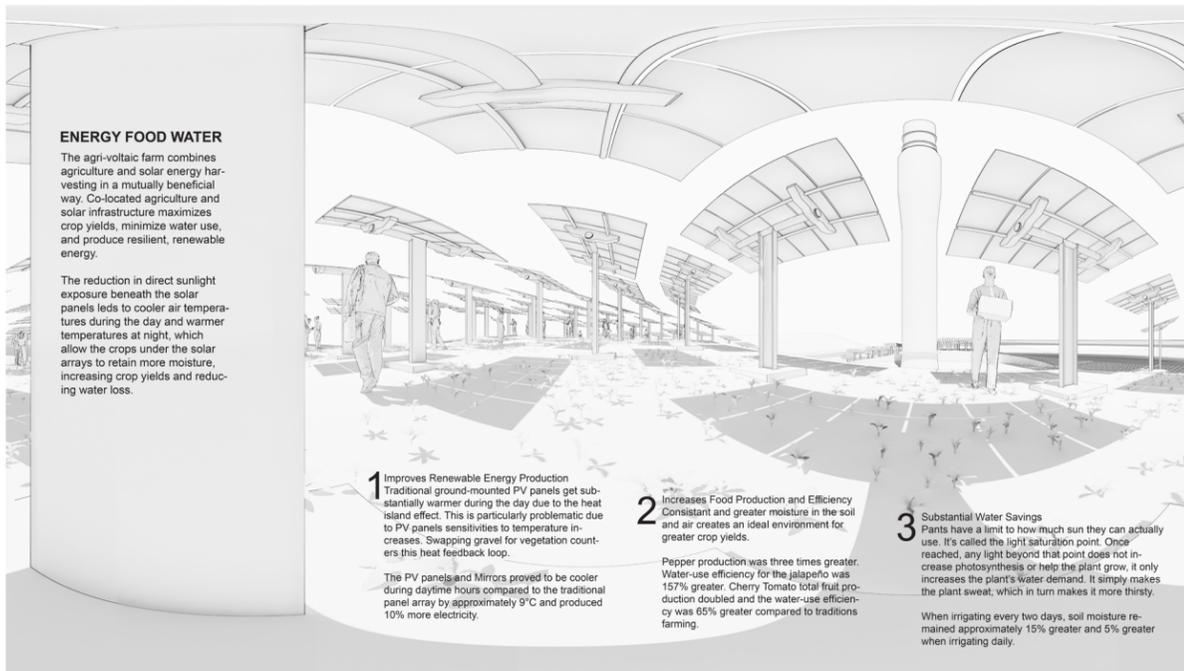

2 pm - visitor center

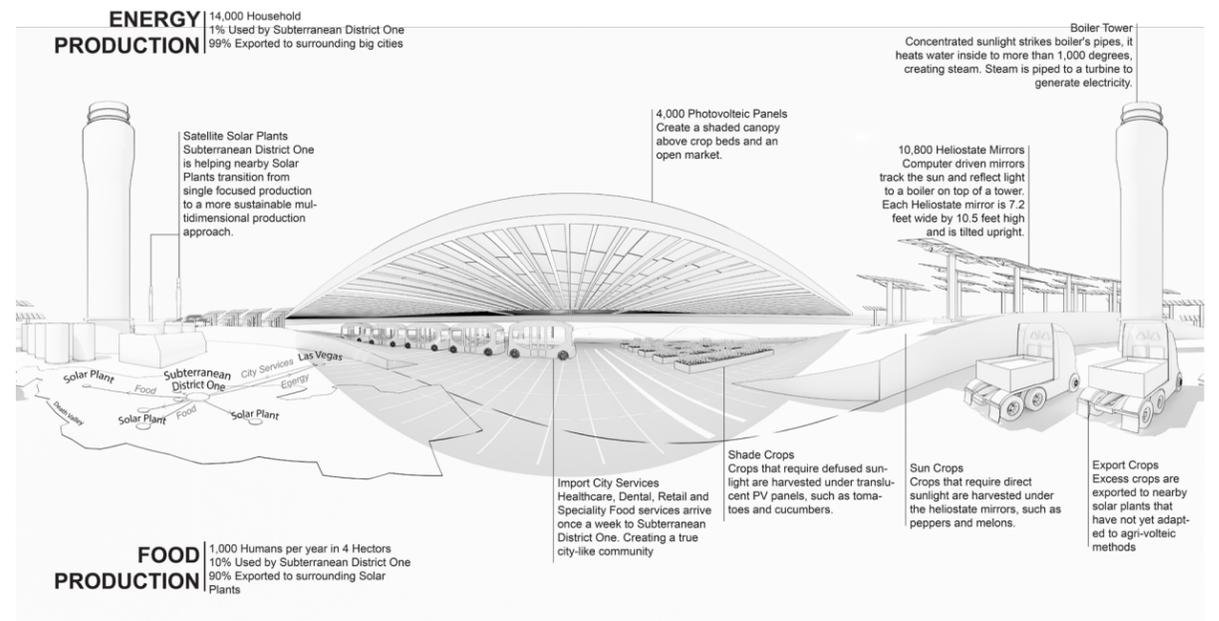6 pm - lab

Perspective Rendering - Solar Farm
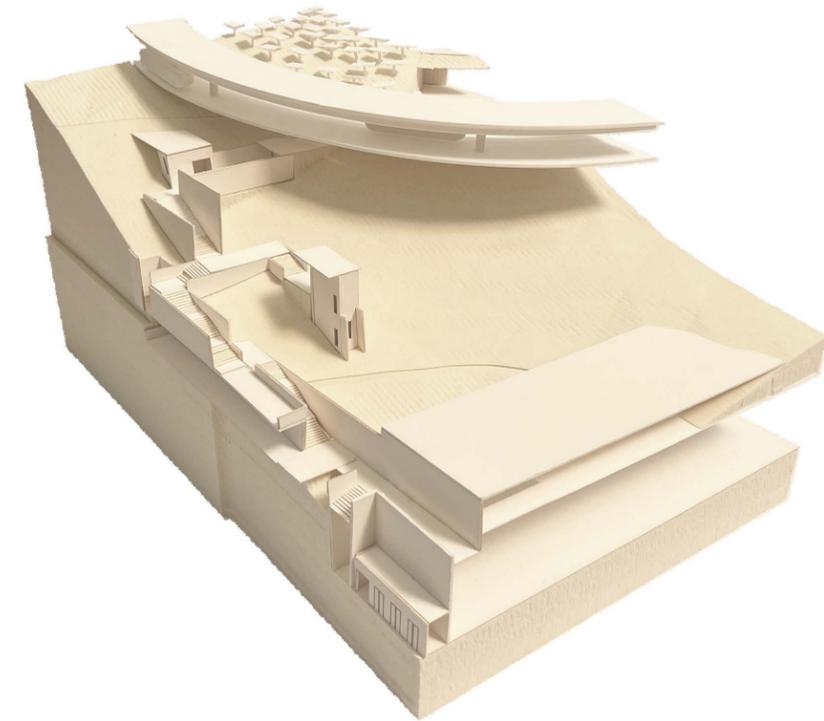

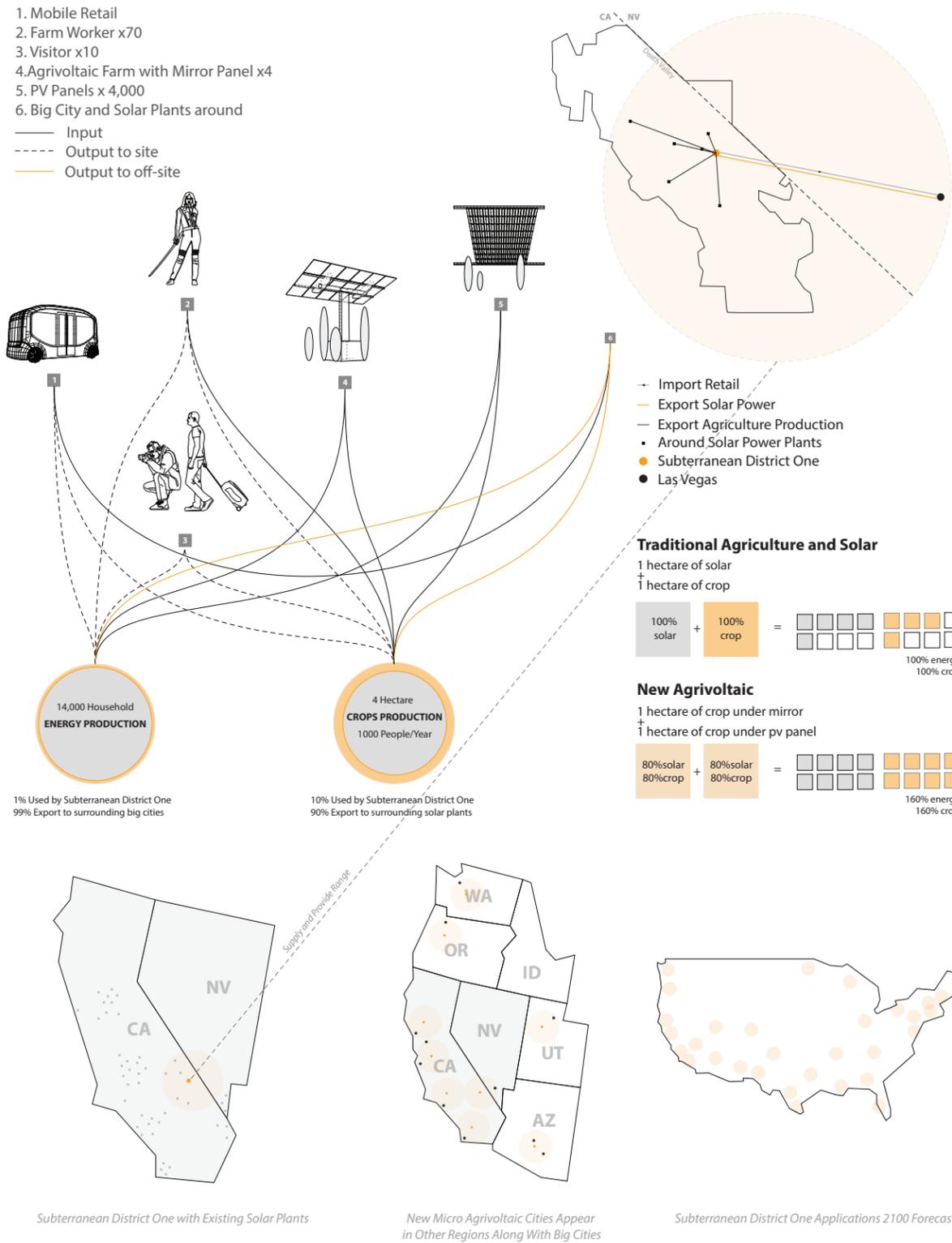Perspective Rendering - Mobile Retail Center

System Diagram - Agri-voltaic Fram

ENERGY FOOD WATER

The agri-voltaic farm combines agriculture and solar energy harvesting in a mutually beneficial way. Co-located agriculture and solar infrastructure maximizes crop yields, minimize water use, and produce resilient, renewable energy.

The reduction in direct sunlight exposure beneath the solar panels leads to cooler air temperatures during the day and warmer temperatures at night, which allow the crops under the solar arrays to retain more moisture, increasing crop yields and reducing water loss.

1 Improves Renewable Energy Production
Traditional ground-mounted PV panels get substantially warmer during the day due to the heat island effect. This is particularly problematic due to PV panels sensitivities to temperature increases. Swapping gravel for vegetation counters this heat feedback loop.

The PV panels and Mirrors proved to be cooler during daytime hours compared to the traditional panel array by approximately 9°C and produced 10% more electricity.

2 Increases Food Production and Efficiency
Consistant and greater moisture in the soil and air creates an ideal environment for greater crop yields.

Pepper production was three times greater. Water-use efficiency for the jalapeño was 157% greater. Cherry Tomato total fruit production doubled and the water-use efficiency was 65% greater compared to traditions farming.

3 Substantial Water Savings
Pants have a limit to how much sun they can actually use. It's called the light saturation point. Once reached, any light beyond that point does not increase photosynthesis or help the plant grow, it only increases the plant's water demand. It simply makes the plant sweat, which in turn makes it more thirsty.

When irrigating every two days, soil moisture remained approximately 15% greater and 5% greater when irrigating daily.

System Diagram - Import and Export

ENERGY PRODUCTION | 14,000 Household
1% Used by Subterranean District One
99% Exported to surrounding big cities

Boiler Tower
Concentrated sunlight strikes boiler's pipes, it heats water inside to more than 1,000 degrees, creating steam. Steam is piped to a turbine to generate electricity.

Satellite Solar Plants
Subterranean District One is helping nearby Solar Plants transition from single focused production to a more sustainable multidimensional production approach.

4,000 Photovoltaic Panels
Create a shaded canopy above crop beds and an open market.

10,800 Heliostate Mirrors
Computer driven mirrors track the sun and reflect light to a boiler on top of a tower. Each Heliostate mirror is 7.2 feet wide by 10.5 feet high and is tilted upright.

Import City Services
Healthcare, Dental, Retail and Specialty Food services arrive once a week to Subterranean District One. Creating a true city-like community

Shade Crops
Crops that require defused sunlight are harvested under translucent PV panels, such as tomatoes and cucumbers.

Sun Crops
Crops that require direct sunlight are harvested under the heliostate mirrors, such as peppers and melons.

Export Crops
Excess crops are exported to nearby solar plants that have not yet adapted to agri-volteic methods

FOOD PRODUCTION | 1,000 Humans per year in 4 Hectors
10% Used by Subterranean District One
90% Exported to surrounding Solar Plants

System Diagram

1. Mobile Retail
2. Farm Worker x70
3. Visitor x10
4. Agrivoltaic Farm with Mirror Panel x4
5. PV Panels x 4,000
6. Big City and Solar Plants around

—— Input
- - - Output to site
—— Output to off-site

CA NV

→ Import Retail
—— Export Solar Power
—— Export Agriculture Production
· Around Solar Power Plants
● Subterranean District One
● Las Vegas

14,000 Household
ENERGY PRODUCTION

4 Hectare
CROPS PRODUCTION
1000 People/Year

1% Used by Subterranean District One
99% Export to surrounding big cities

10% Used by Subterranean District One
90% Export to surrounding solar plants

Traditional Agriculture and Solar
1 hectare of solar
+
1 hectare of crop

100% solar	+	100% crop	=

100% energy
100% crop

New Agrivoltaic
1 hectare of crop under mirror
+
1 hectare of crop under pv panel

80%solar 80%crop	+	80%solar 80%crop	=

160% energy
160% crop

Sierra Nevada

Supply and Provide Range

NV
CA

WA
OR
ID
NV
UT
CA
AZ

Subterranean District One with Existing Solar Plants

New Micro Agrivoltaic Cities Appear in Other Regions Along With Big Cities

Subterranean District One Applications 2100 Forecast

1/16 Physical Model

Persoective Rendering - Solar Farm in 9 am

02

Weaving Bridges
Cross Bronx Expressway Mobility Infrastructure

Advanced Design Studio
Columbia University
Instructor: Michael Bell
Site: Cross Bronx Expressway, NY

The Weaving Bridges is designed as a light-conscious construction of future mobility above cross bronx expressway, with a syntax of cable-stayed bridge systems. The main design purpose of this project is to intervene in the expressway to prevent pollution and provide transportation and potential educational benefits for those communities around who cannot afford a vehicle for transportation but suffer from the noise and air pollution. The main program elements include educational events, study area, and gallery. For raising health awareness and prevent emission from cross bronx expressway, a series of light-weight PVC-PES filter devices are embedded in-between the cable stayed framework.

In this collaborative studio course, I work with the students from Mailman School of Public Health in Columbia University, imaging a new way of collaborating and expanding what we see as the intermarriage of social policy and design intended to re-envision infrastructure that has harmed the well-being of those who are of color or socio-economically disadvantaged.
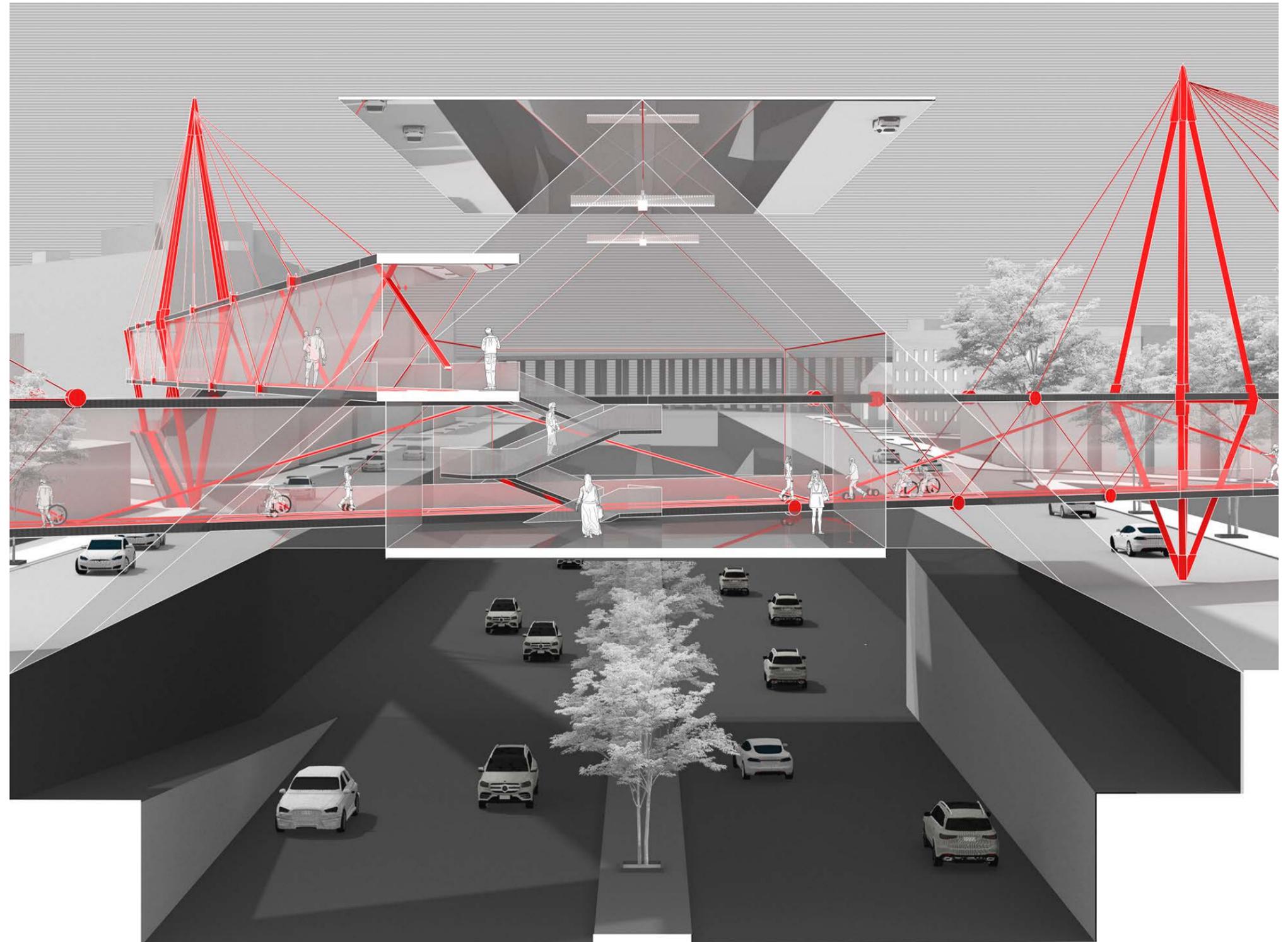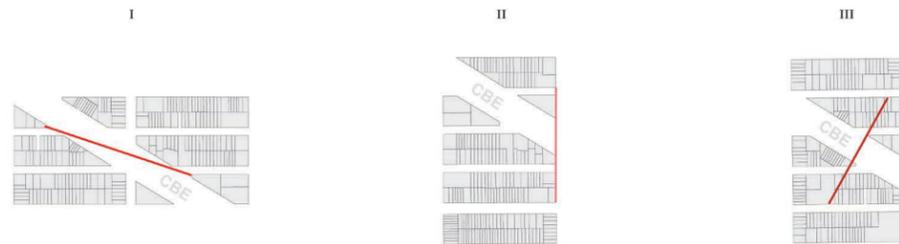
Sectional Diagram of Prototye

Prototype Strategy
These weaving bridges are repetitive and can be classified by three types which are designed with "woolly urban paths" to minimize the detour of passengers. The first one is diagonally connecting the ends of two pathways. The second is vertically parallel to a pair of pathways from north to south. And the third is connecting the opposite ends of two pathways that are parallel and would never join together. Therefore, these three types of bridges can be applied and arrayed along the expressway in repetitions.

Mobility Strategy
The electron wireless electric vehicle charging rail functions through a system of copper coils embedded in the decking. The energy from these coils are transferred wirelessly to the vehicle batteries through magnetic induction as the vehicle travels along the pathways. This very idea of wireless charging has be applied in Scotland, Sweden and Italy.
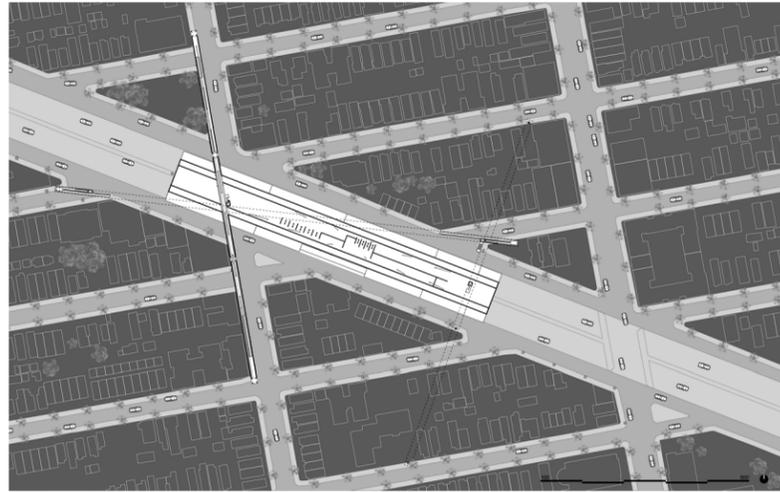

Expressway Site Analysis Map_ Zero Vehicle Households Distribution
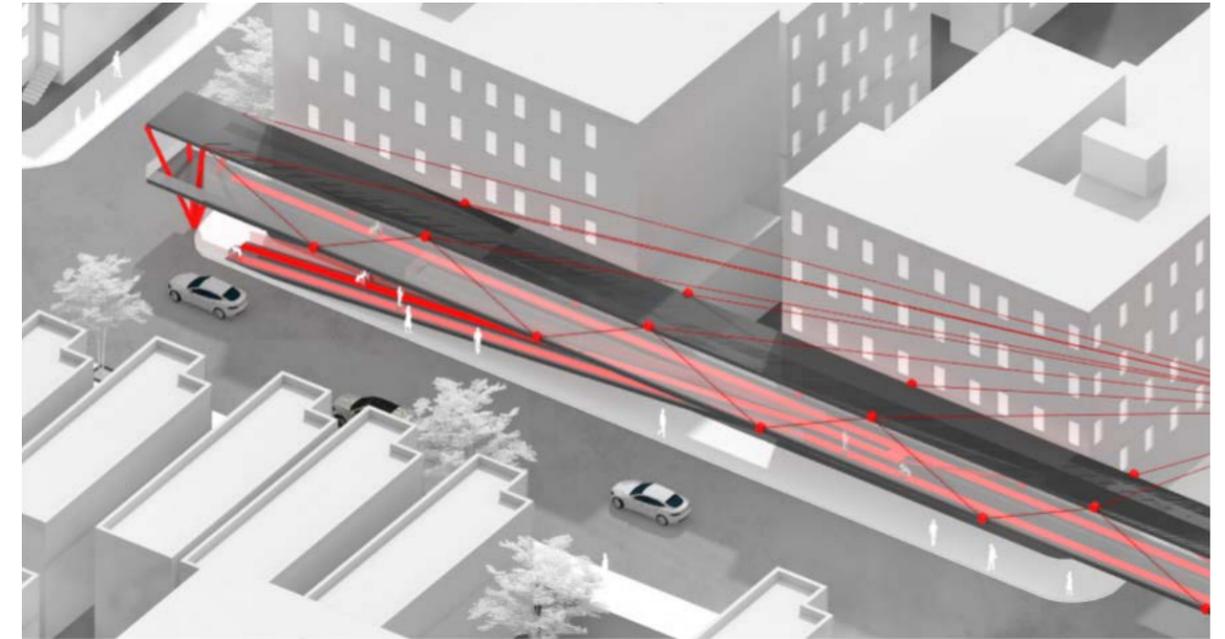
Perspective Render_Charging Rail

Prototype Diagram_ Three Rrepresentative Ways of Bridging
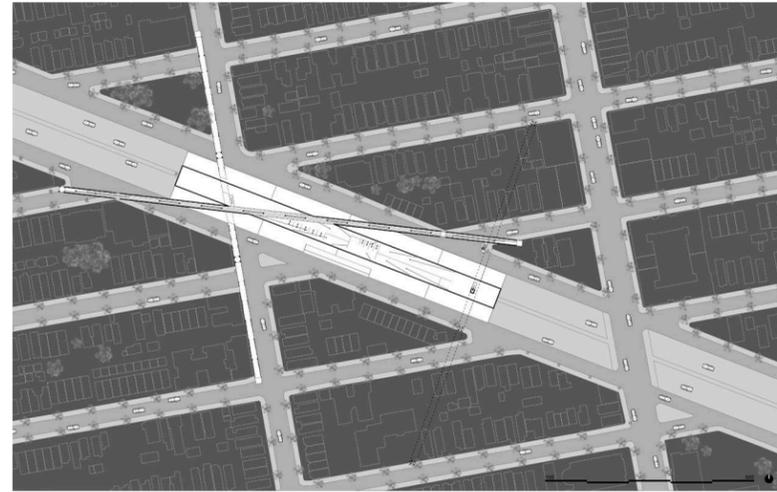
I   II   III
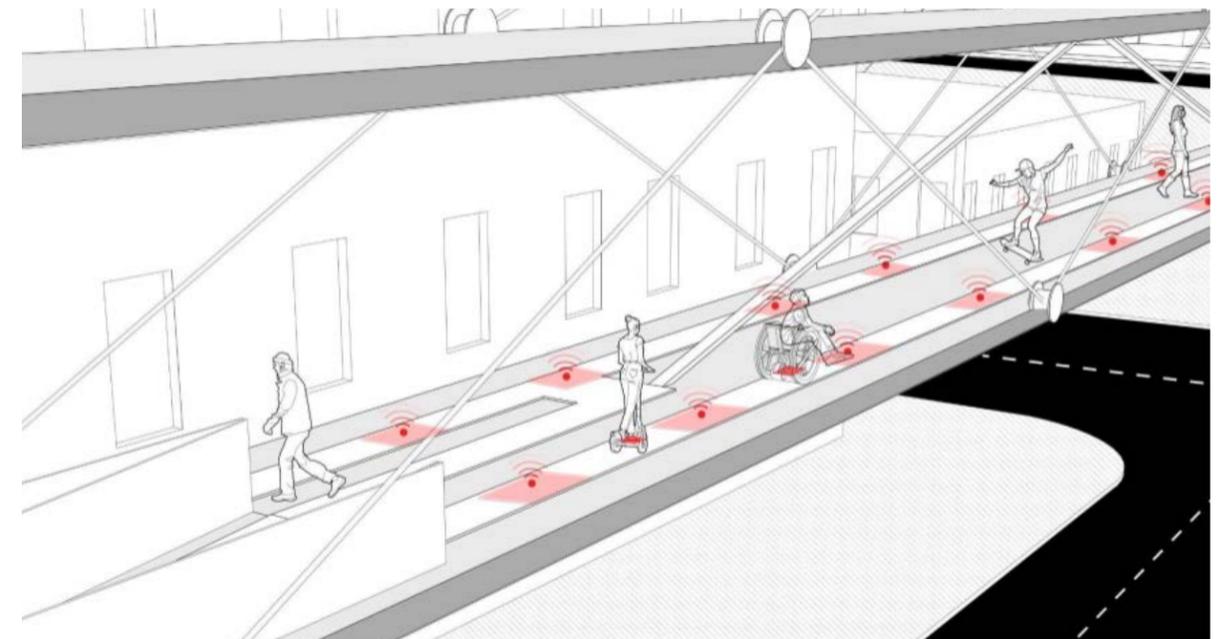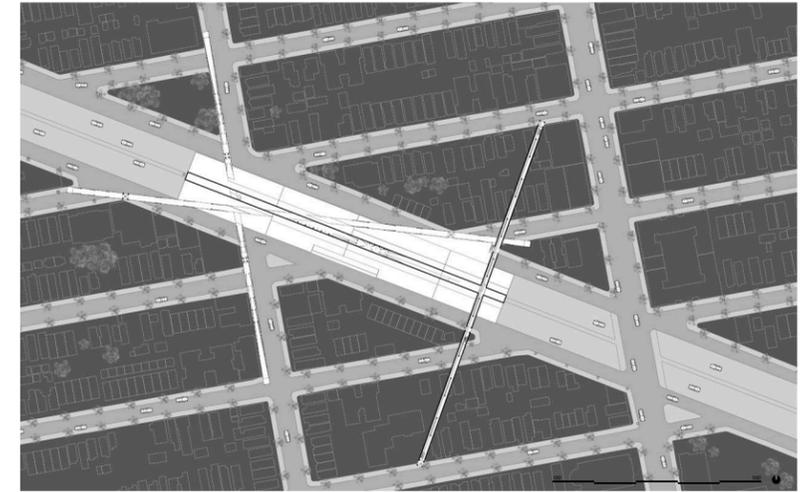

Charging Rail Analysis Diagram

First Floor Plan

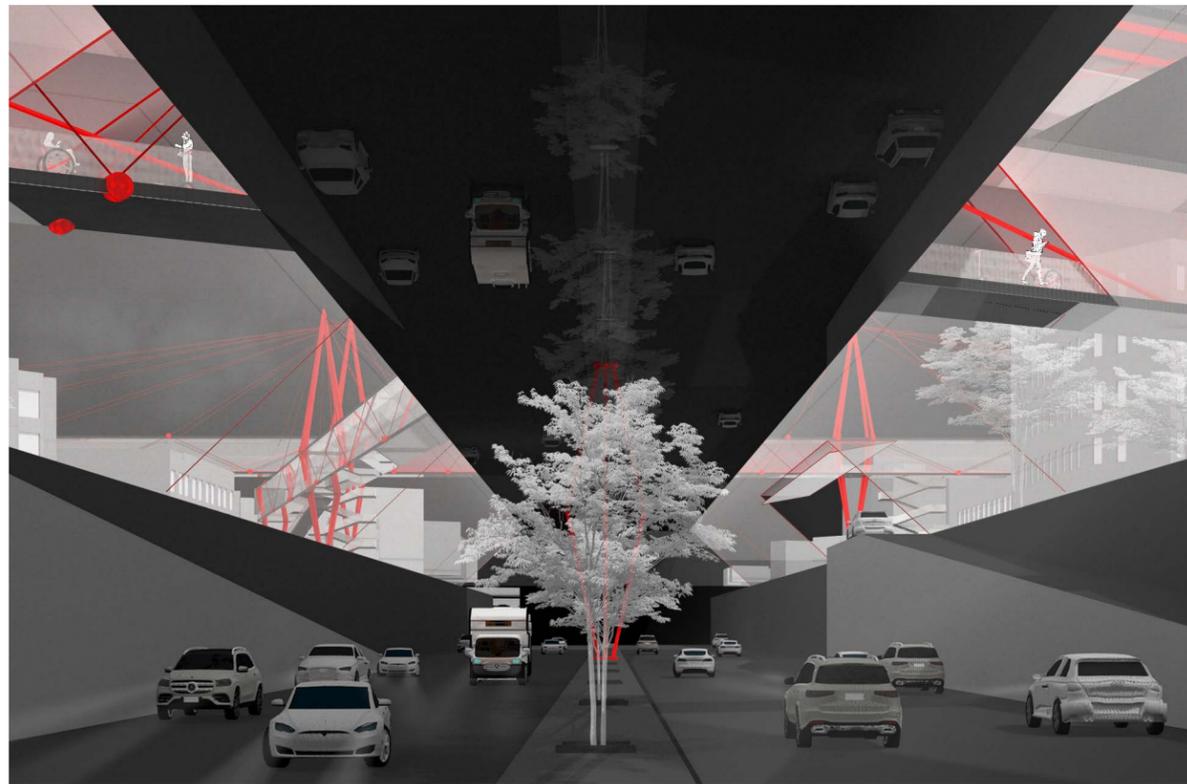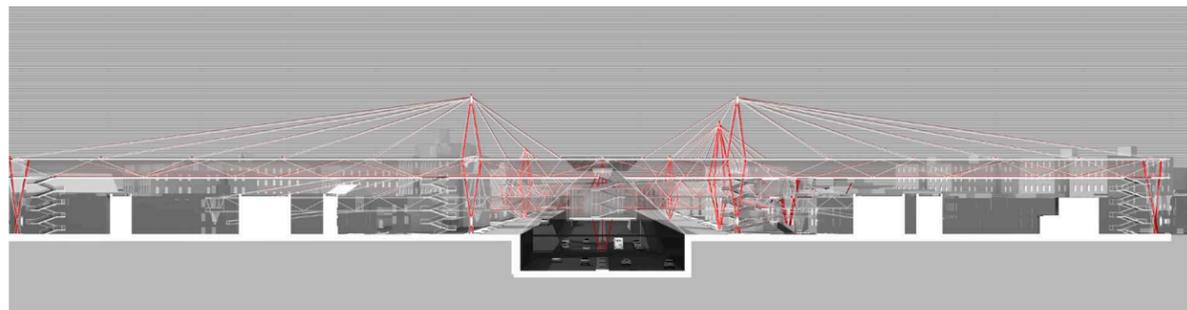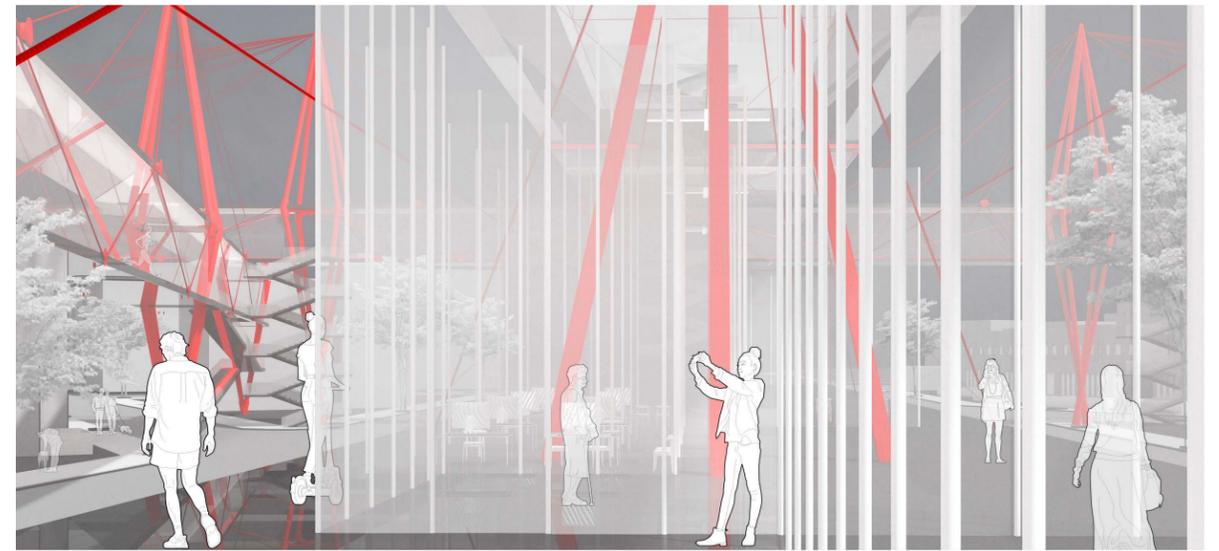Second Floor Plan

Third Floor Plan
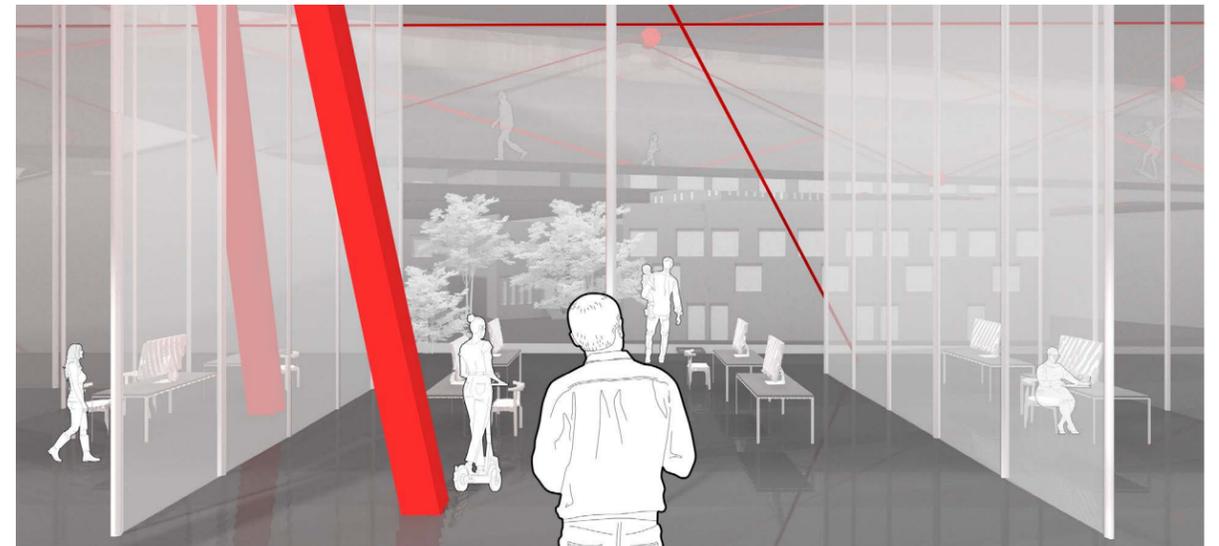

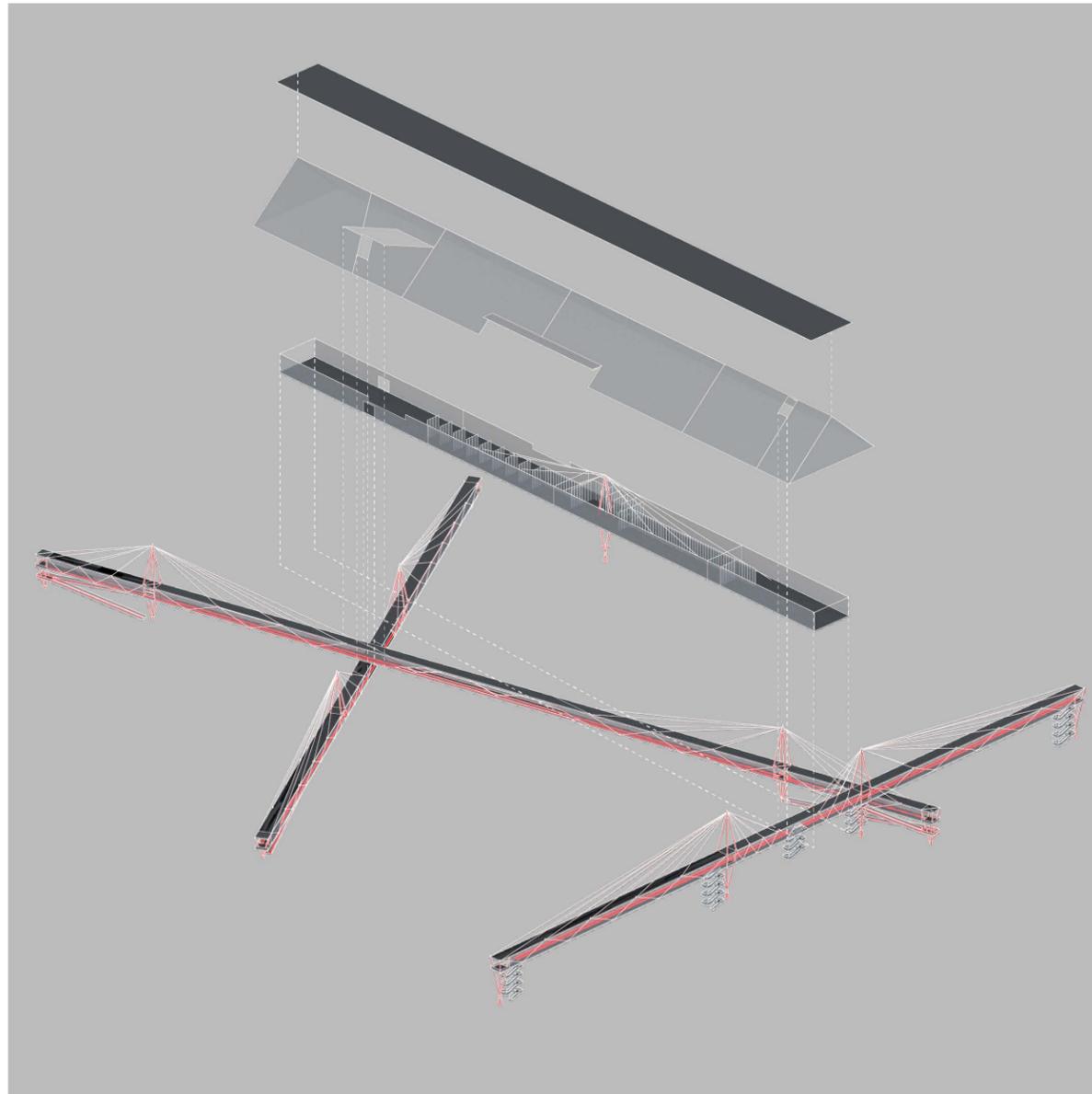Perspective Rendering_ Inside Cross Bronx Expressway

Sectional Diagram

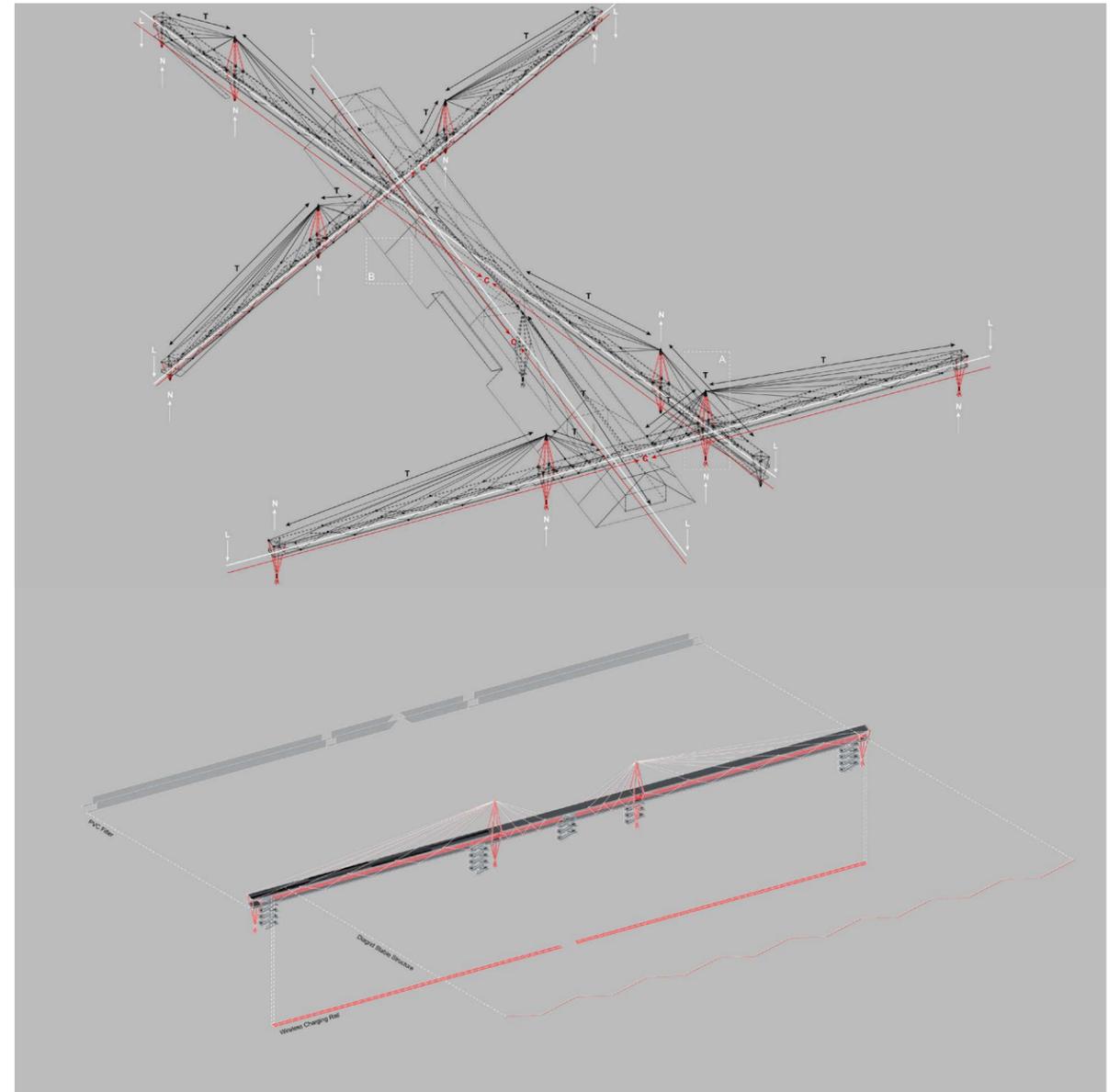Interior Rendering_Gallery

Interior Rendering_Study Room

Exploded Diagram

Force Analysis Diagram

03

Water After Oil
Water Cycle Infrastructure
### Posted by GSAPP official website

Advanced Architecture Design Studio
Columbia University
Instructor: Jorge Ambrosi, Gabriela Etchegaray
Site: Big City, TX
Team: Gejin Zhu, Risa Mimura

The purpose of this research is to explore the intricate water cycle behind the crude oil extraction taskscape, one of the most dominating extraction industries in the world. Before oil extraction, a process called hydraulic fracturing that requires enormous amount of water to extend the lifespan and flow rate of oil wells takes place for each well. After the process, the majority of fracking water remains underground and becomes an invisible contamination source that infiltrates the ecosystem and our daily life. By analyzing existing data and focusing on the water cycle impacts caused by the hydraulic fracturing process at multiple scales, our approach generates an inflatable device that intervenes this issue in a subtle way that will be embedded in the existing taskscape and evoke awareness of this water crisis.

The fields of floating balloon devices transform this invisible relationship of water after oil into visible forms by flipping the underground taskscape to above-ground. The device interacts with different states of water cycle and becomes an active agent that performs and operates in relation to water. The main concept of this project is to convert the water crisis into an opportunity of architectural performance design that transcends the terrestrial limitations.

Perspective Rendering - Instrumental Device

Water Cycle Sectional Diagram
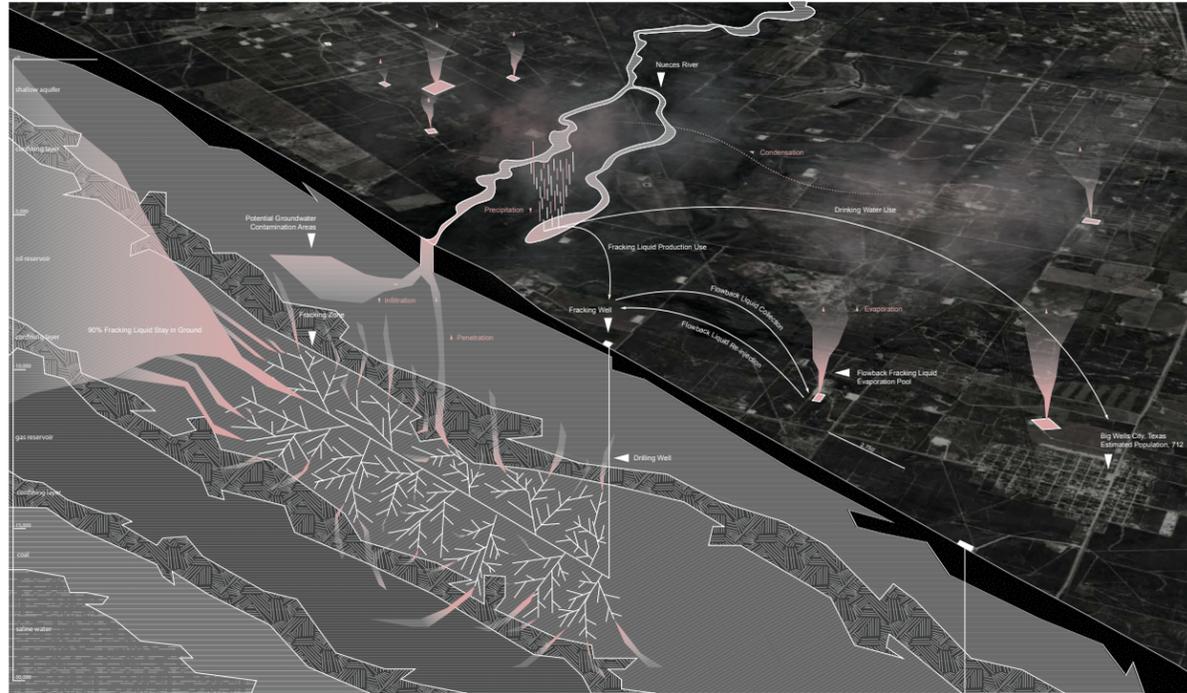
Potential Underground Contamination Map
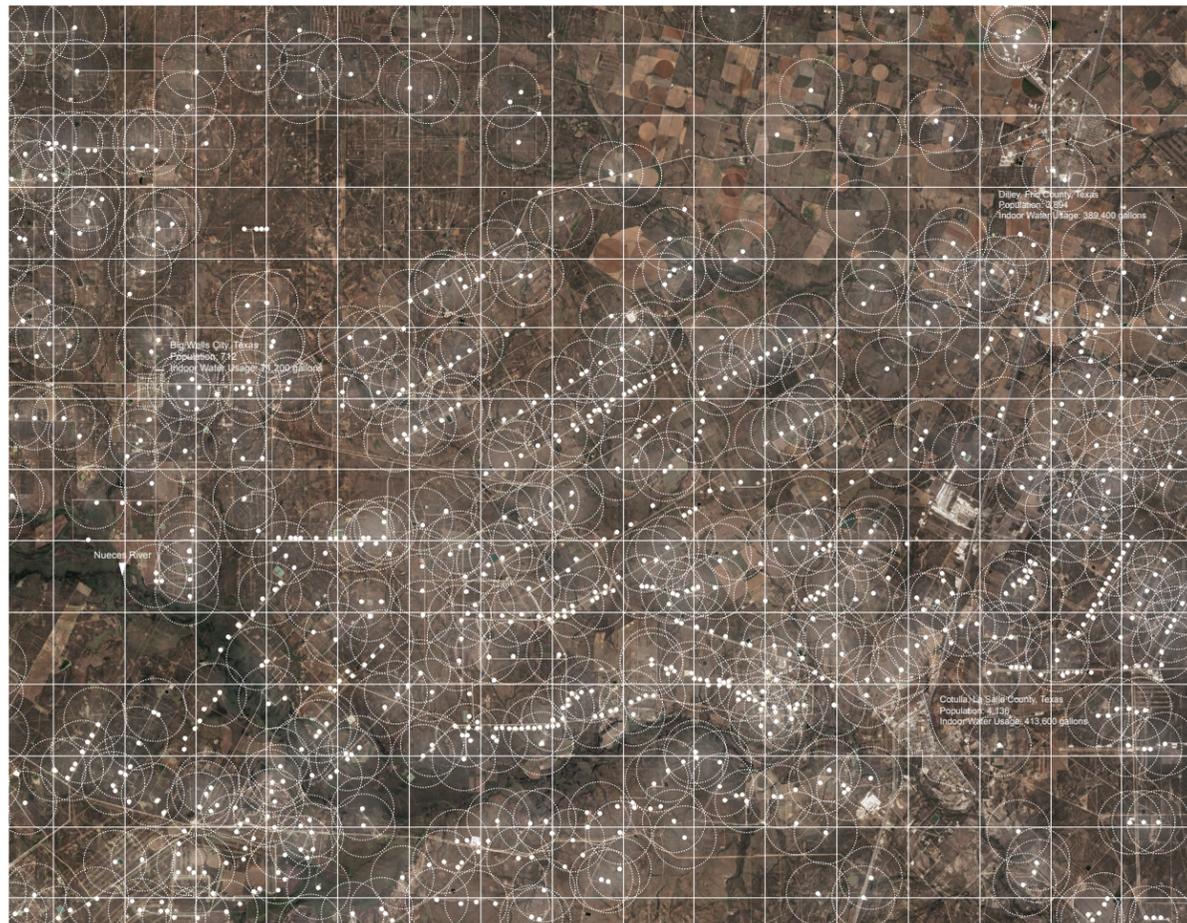
Fracking Use VS Water Use Map
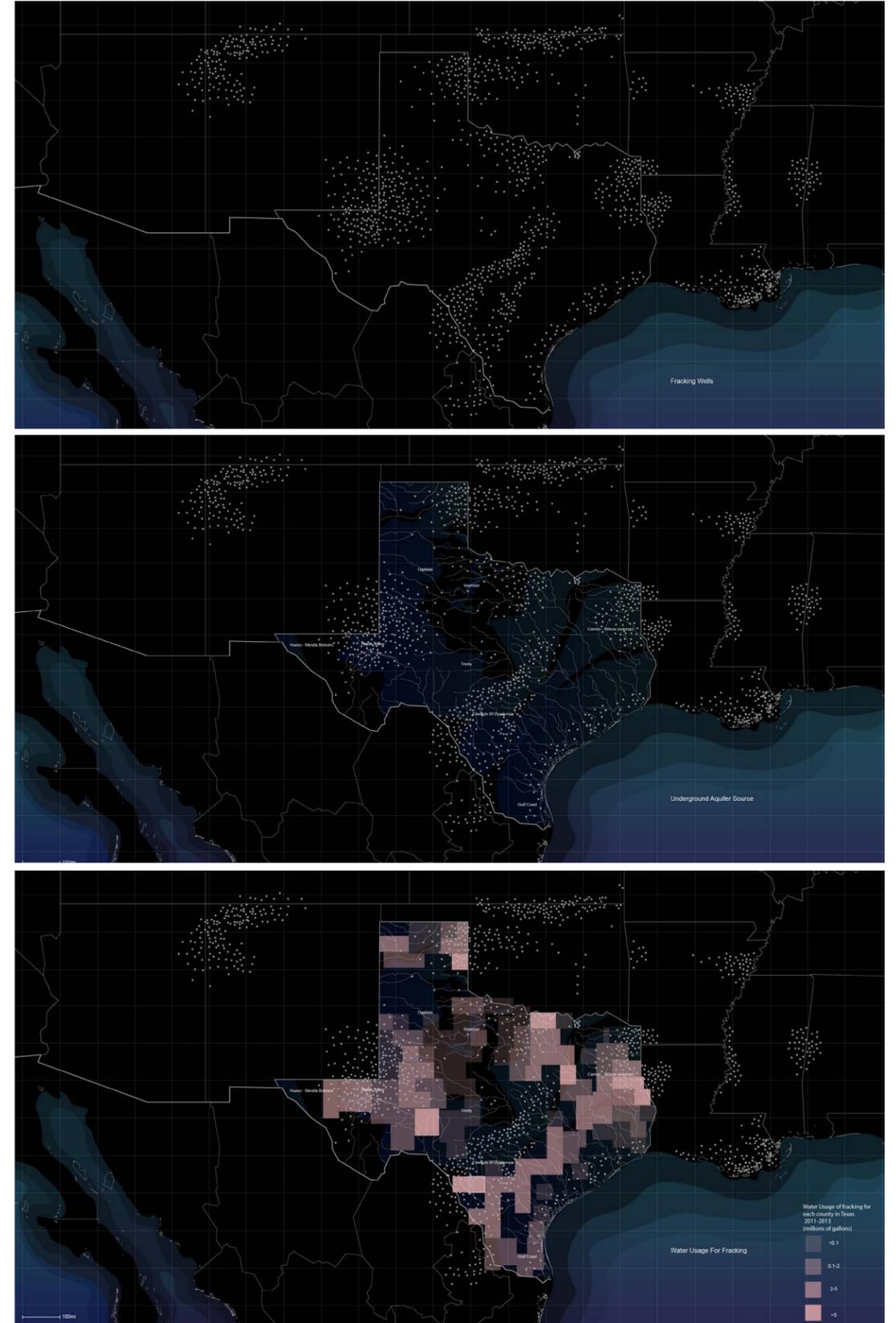
Oil and Natrual Gas Industry in US
Income Distribution

Positions	Sub-sector Description	Labor Income / $ millions
320,100	Support Activities for oil and gas oprations	28,506
80,400	Drilling oil and gas wells	8,458
142,900	Oil and gas pipeline and related structures construction	13,364
832,300	Oil and gas extraction	107,353
49,300	Pipeline Transportation	33,520
71,200	Petroleum Refineries	21,860
80,100	Fuel dealers	4,985
102,900	Petroleum and petroleum products merchant whole-salers	9,485
953,100	Gasoline Stations	35,591
11,600	Petroleum lubricating oil and grease manufacturing	2,490
14,400	Asphalt paving mixture and block manufacturing	2,966
10,800	Asphalt shingle and coating materials manurfacturing	2,268

Legend:
- Hydraulic Fracturing Water Process
- Crude Oil Processing
- Hydraulic Fracturing Hazardous Process
- Contamination caused by water usage

Crude Oil Extraction
General Process

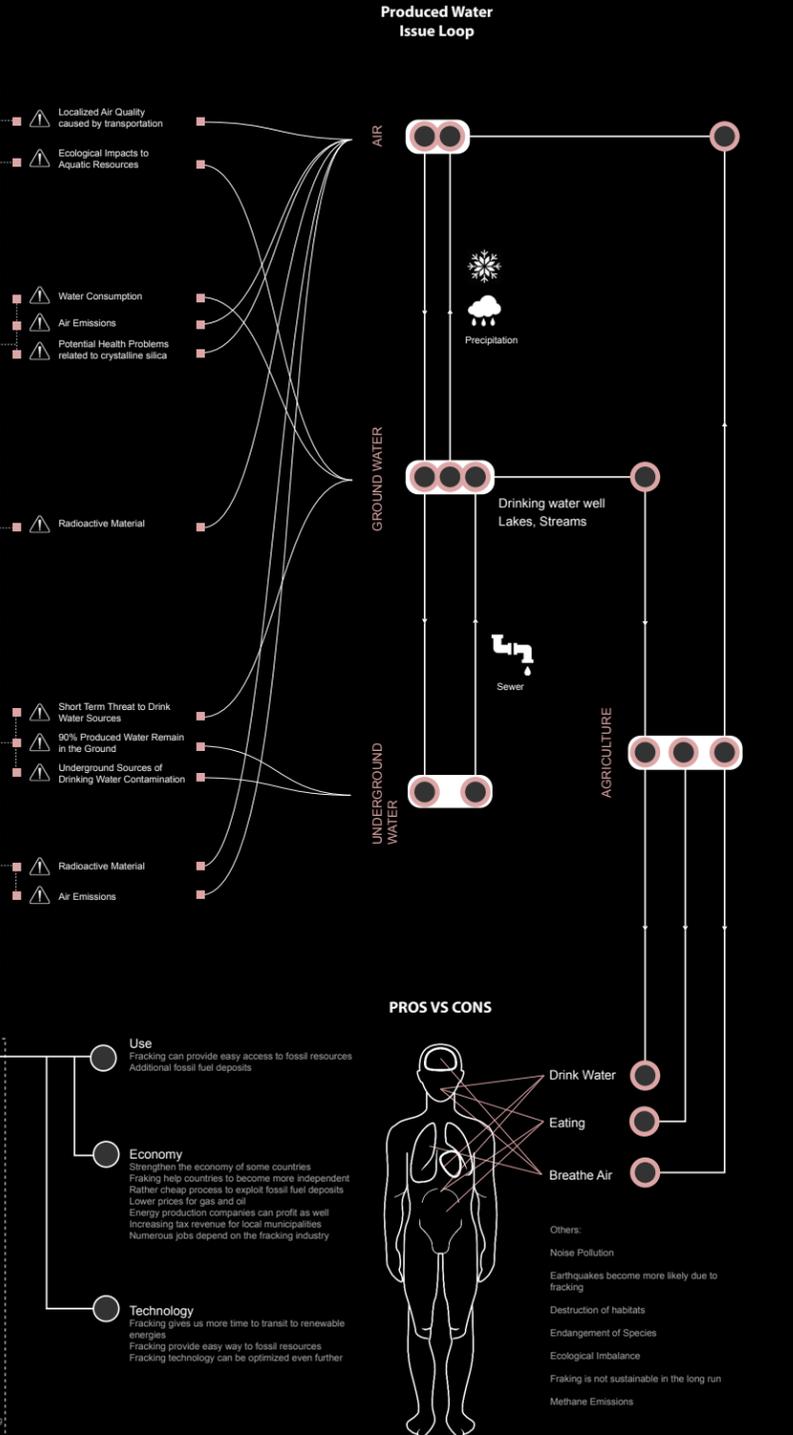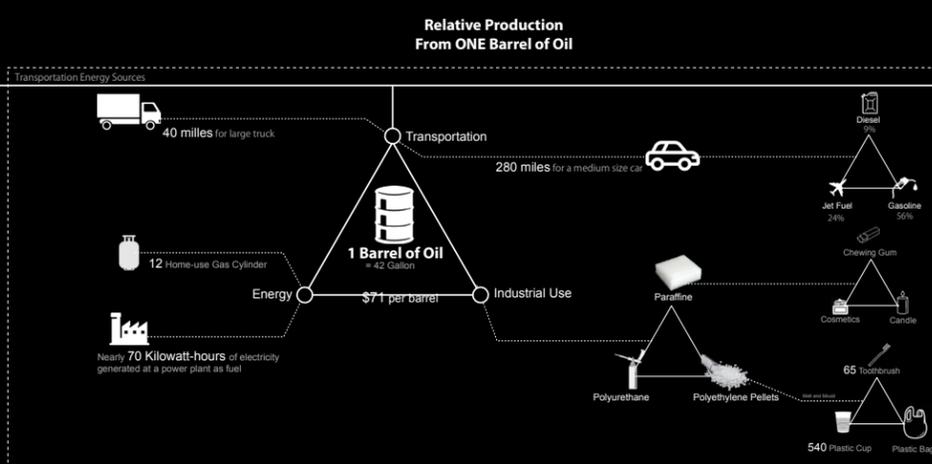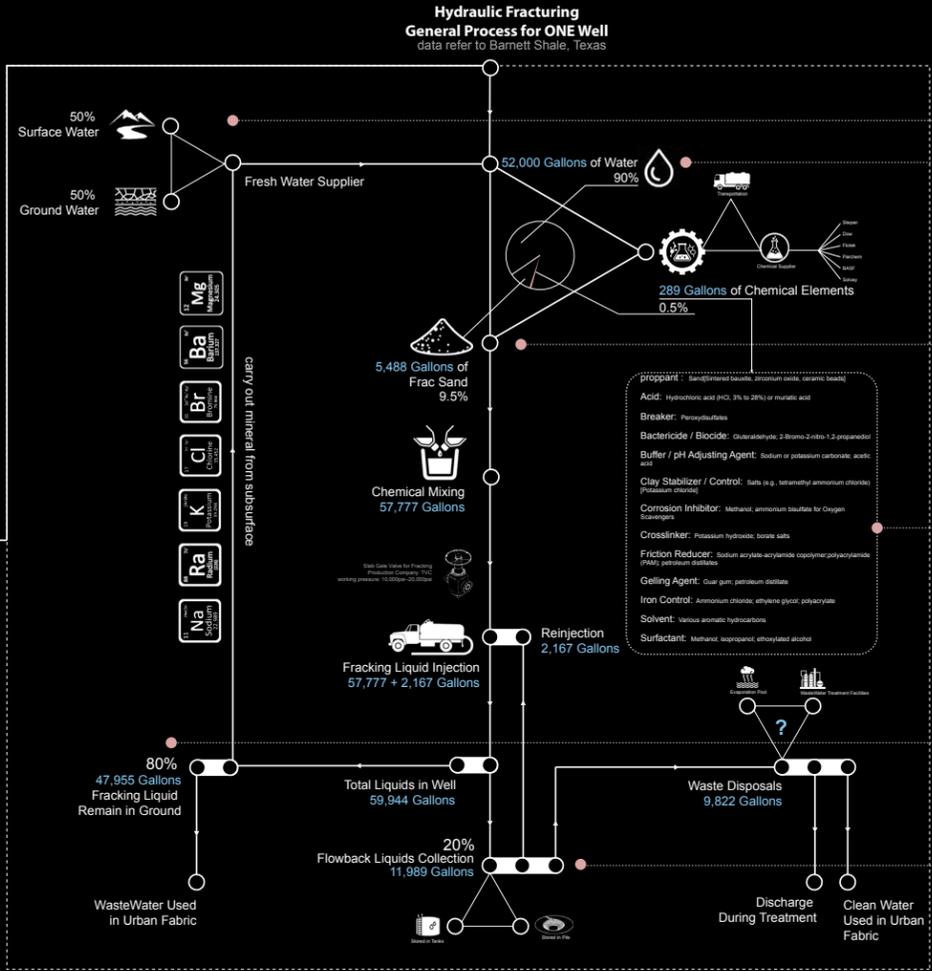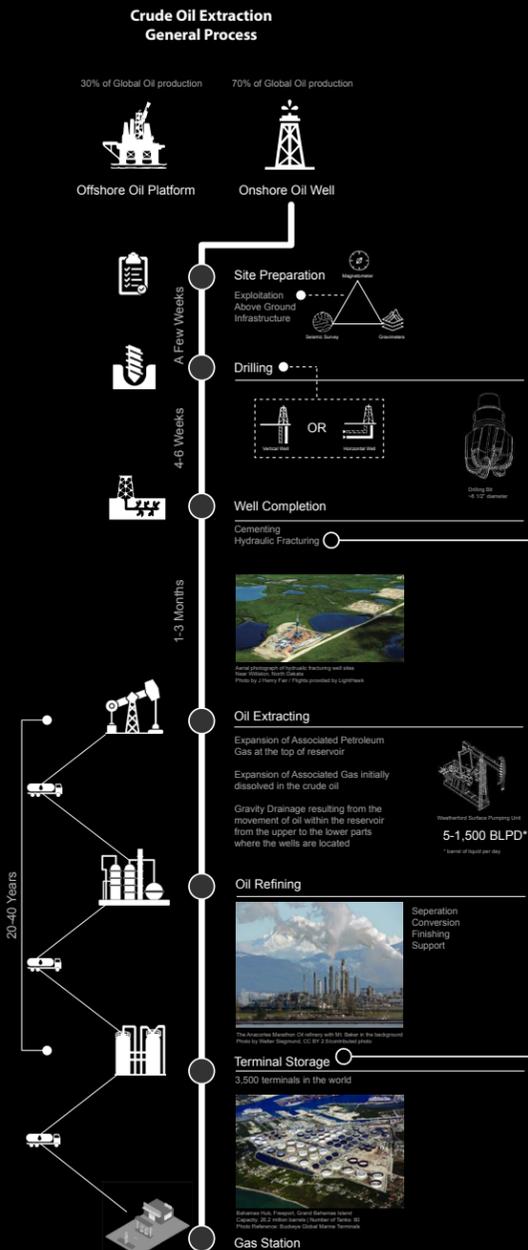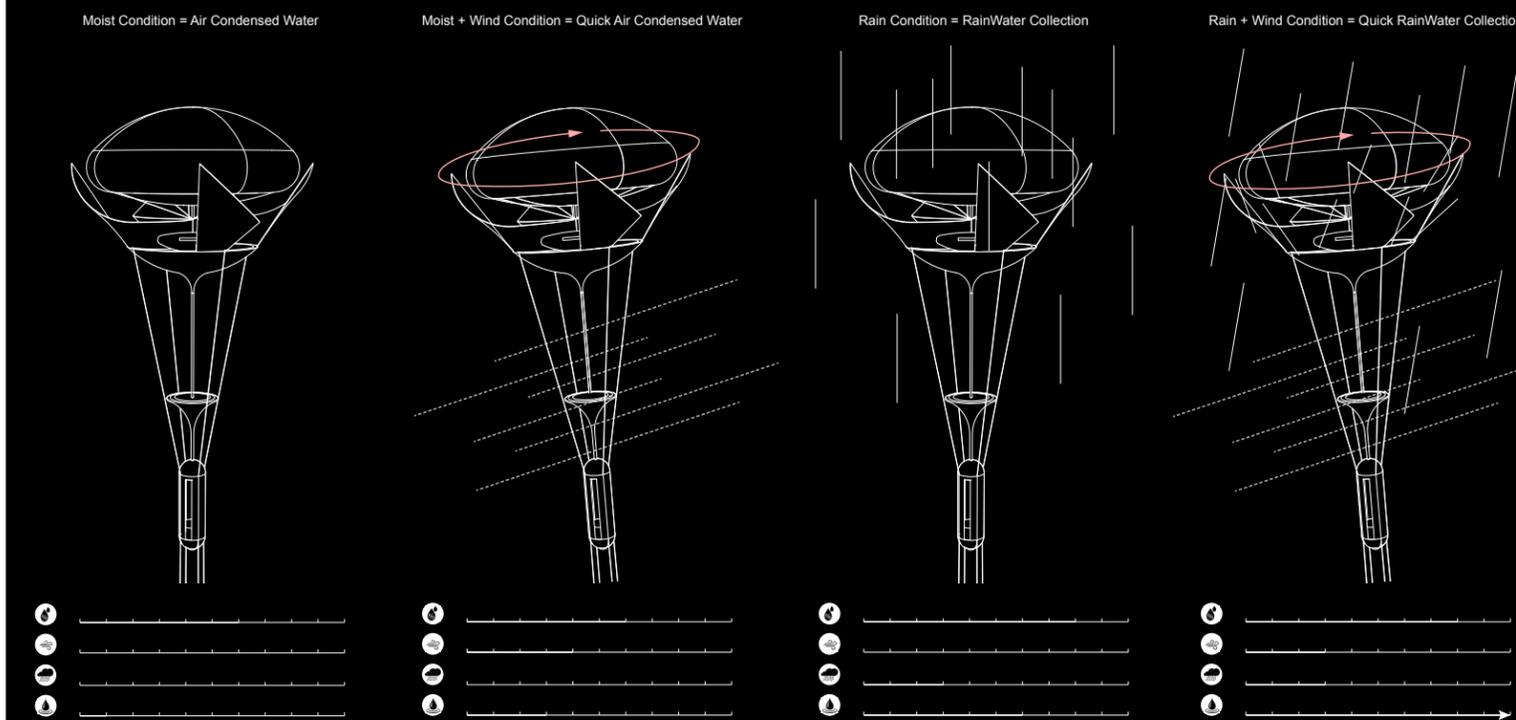30% of Global Oil production
70% of Global Oil production

Offshore Oil Platform
Onshore Oil Well

A Few Weeks

Site Preparation
Exploitation
Above Ground
Infrastructure

4-6 Weeks

Drilling

carry out mineral from subsurface

Well Completion
Cementing
Hydraulic Fracturing

1-3 Months

Aerial photograph of hydraulic fracturing well sites
Near Williston, North Dakota
Photo by J Henry Fair / Flights provided by LightHawk

Drilling Bit
~8 1/2" diameter

Oil Extracting
Expansion of Associated Petroleum Gas at the top of reservoir
Expansion of Associated Gas initially dissolved in the crude oil
Gravity Drainage resulting from the movement of oil within the reservoir from the upper to the lower parts where the wells are located

Weatherford Surface Pumping Unit
5-1,500 BLPD*
* barrel of liquid per day

20-40 Years

Oil Refining
Seperation
Conversion
Finishing
Support

The Anacortes Marathon Oil refinery with Mt. Baker in the background
Photo by Walter Siegmund / CC BY 2.5/contributor photo

Terminal Storage
3,500 terminals in the world

Bahamas Hub, Freeport, Grand Bahama Island
Capacity: 26.2 million barrels / Number of Tanks: 80
Photo Reference: Buckeye Global Marine Terminals

Gas Station

Hydraulic Fracturing
General Process for ONE Well
data refer to Barnett Shale, Texas

50% Surface Water
50% Ground Water

Fresh Water Supplier

52,000 Gallons of Water
90%

289 Gallons of Chemical Elements
0.5%

5,488 Gallons of Frac Sand
9.5%

Chemical Mixing
57,777 Gallons

proppant : Sand(sintered bauxite, zirconium oxide, ceramic beads)
Acid : Hydrochloric acid (HCl, 3% to 28%) or muriatic acid
Breaker : Peroxydisulfate
Bactericide / Biocide : Glutaraldehyde, 2-Bromo-2-nitro-1,2-propanediol
Buffer / pH Adjusting Agent : Sodium or potassium carbonate, acetic acid
Clay Stabilizer / Control : Salts (e.g., tetramethyl ammonium chloride)
Corrosion Inhibitor : Methanol, ammonium bisulfite for Oxygen Scavengers
Crosslinker : Potassium hydroxide, borate salts
Friction Reducer : Sodium acrylate-acrylamide copolymer,polyacrylamide (PAM), petroleum distillates
Gelling Agent : Guar gum, petroleum distillate
Iron Control : Ammonium chloride, ethylene glycol, polyacrylate
Solvent : various aromatic hydrocarbons
Surfactant : Methanol, isopropanol, ethoxylated alcohol

Slab Gate Valve for Fracking
Production Company: TVC
working pressure: 10,000psi~20,000psi

Fracking Liquid Injection
57,777 + 2,167 Gallons

Reinjection
2,167 Gallons

Mg Magnesium
Ba Barium
Br Bromine
Cl Chlorine
K Potassium
Ra Radium
Na Sodium

80%
47,955 Gallons
Fracking Liquid
Remain in Ground

WasteWater Used in Urban Fabric

Total Liquids in Well
59,944 Gallons

20%
Flowback Liquids Collection
11,989 Gallons

Stored in Tanks
Stored in Pits

Waste Disposals
9,822 Gallons

Discharge During Treatment

Clean Water Used in Urban Fabric

Produced Water
Issue Loop

Localized Air Quality caused by transportation
Ecological Impacts to Aquatic Resources
Water Consumption
Air Emissions
Potential Health Problems related to crystalline silica
Radioactive Material
Short Term Threat to Drink Water Sources
90% Produced Water Remain in the Ground
Underground Sources of Drinking Water Contamination
Radioactive Material
Air Emissions

AIR
Precipitation
GROUND WATER
Drinking water well
Lakes, Streams
Sewer
UNDERGROUND WATER
AGRICULTURE

Relative Production
From ONE Barrel of Oil

Transportation Energy Sources

40 miles for large truck
Transportation
280 miles for a medium size car

12 Home-use Gas Cylinder
1 Barrel of Oil
= 42 Gallon
Energy
$71 per barrel
Industrial Use

Nearly **70 Kilowatt-hours** of electricity generated at a power plant as fuel

Diesel 9%
Jet Fuel 24%
Gasoline 56%
Chewing Gum
Paraffine
Cosmetics
Candle
Polyurethane
Polyethylene Pellets
65 Toothbrush
540 Plastic Cup
Plastic Bag

Use
Fracking can provide easy access to fossil resources
Additional fossil fuel deposits

Economy
Strengthen the economy of some countries
Fraking help countries to become more independent
Rather cheap process to exploit fossil fuel deposits
Lower prices for gas and oil
Energy production companies can profit as well
Increasing tax revenue for local municipalities
Numerous jobs depend on the fracking industry

Technology
Fracking gives us more time to transit to renewable energies
Fracking provide easy way to fossil resources
Fracking technology can be optimized even further

PROS VS CONS

Drink Water
Eating
Breathe Air

Others:
Noise Pollution
Earthquakes become more likely due to fracking
Destruction of habitats
Endangerment of Species
Ecological Imbalance
Fraking is not sustainable in the long run
Methane Emissions

Crude Oil Extraction Process Diagram

Technical Analysis Diagram

+6,600'
Stratocumulus Cloud

+6,500'
Average Depth of Oil Well
in Dimmit County

+4,200'
Waterfowl

+2,722'
Burj Khalifa

+2,500'
Songbird

+1,250'
Empire State

+0'

-1000'
Aquifer

Side Elevation
1. Inflatable Ballon
2. Wind Turbine
3. Informative Sensor
4. Water Tank
5. Suspended Cable
6. Oil Well

Wind Turbine

Lighting Fixture
indicate water quality

Suspension Wire

Suspension Column

A. Lighting Fixture Under Ballon

Elastic Water Pipe
transport rainwater from ballon

Suspension Wire

Water Tank
collect purified water

Elastic Water Pipe
transport rainwater to ground

B. Two Sided Water Tank

Suspension Wire

Water Tank Supportor

Suspension Wire
post restraint plate

Elastic Water Pipe
transport purified water to underground

C. Wire Winder System

Confining Layer

Water Pipe

Shallow Aquifer

Oil Well

Confining Layer

D. Underground Aquifer Access

Weather Condition Analysis Diagram

Moist Condition = Air Condensed Water

Moist + Wind Condition = Quick Air Condensed Water

Rain Condition = RainWater Collection

Rain + Wind Condition = Quick RainWater Collection

Water Cycle Intervention Process Diagram

50% Surface Water

50% Ground Water

Fresh Water Supplier

52,000 Gallons of Water 90%

289 Gallons of Chemical Elements 0.5%

5,488 Gallons of Frac Sand 9.5%

Chemical Mixing 57,777 Gallons

Mg Magnesium

Ba Barium

Br Bromine

Cl Chlorine

K Potassium

Ra Radium

Na Sodium

carry out mineral from subsurface

Slab Gate Valve for Fracking
Production Company TVC
working pressure: 10,000psi~20,000psi

Reinjection 2,167 Gallons

Fracking Liquid Injection 57,777 + 2,167 Gallons

80% 47,955 Gallons Fracking Liquid Remain in Ground

Total Liquids in Well 59,944 Gallons

Waste Disposals 9,822 Gallons

20% Flowback Liquids Collection 11,989 Gallons

Discharge During Treatment

Clean Water Used in Urban Fabric

Ground injection

Filtering

Penetration

Rain Water Collection

Precipitation

Condensation

Evaporation

28

29

04

Ford Fooundation Building
Renovation with Communal Space

Rethinkinig BIM
Columbia University
Instructor: Joseph Brennan
Site: 320E 43rd St, New York, NY
Team: Gejin Zhu, Bingyu Xia

The main design concept of this project is to maximize circulation and communal space and minimize the loose of daylighting for Ford Foundation Building on 43rd Street in midtown of Manhattan. Almost half of the space inside the building is the atrium and garden, however the interior curtain walls separated the atrium space with the working area. What's more, the exterior playground is lifted up to the streets, and its disconnected with the indoor landscape by a layer of curtain wall system. Therefore, both the public and the office workers in ford foundation do not interact with the interior landscape a lot.

By proposing a series of ramps that bridge between floors and designing communal spaces in-between garden and atrium, our team are trying to improve the interior circulation and space use without sacrificing daylight. Through using grasshopper to analysis the efficiency of circulation and daylighting, we optimize the best solution for ford foundation with the inspiration from existing public-owned-private spaces in the city of New York.

Perspective Rendering
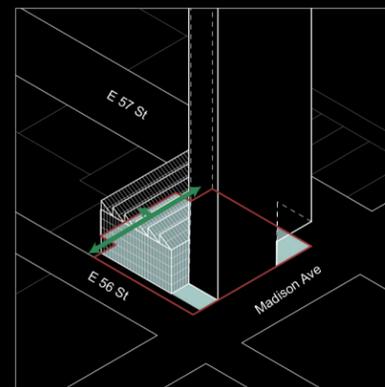
590 Madison Ave
Lever House
Paley Park
MMC Plaza
FordFoundation
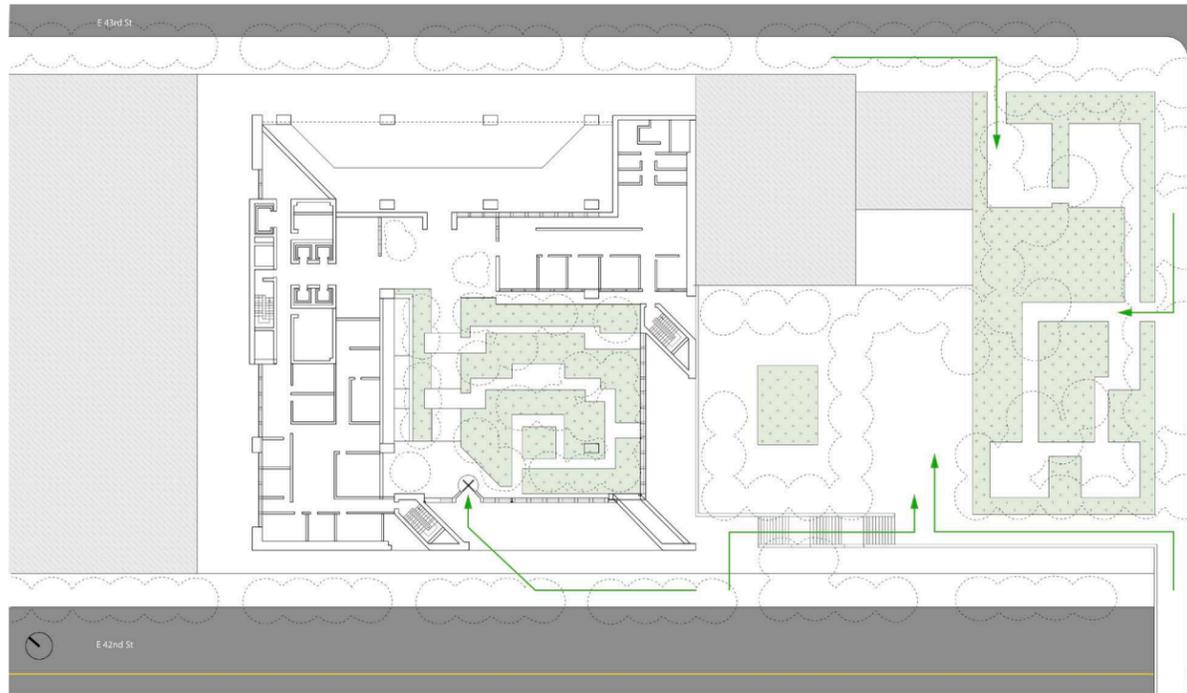Mary O'Connor Playground
Three Bryant Park
100 William St
180 Maiden Lane
55 Water St - Elevated Acre
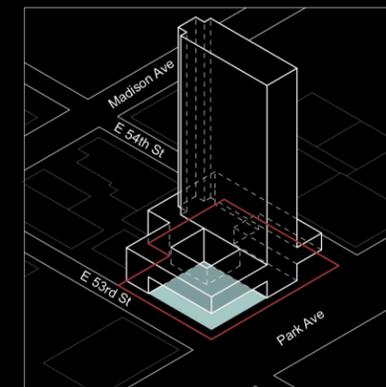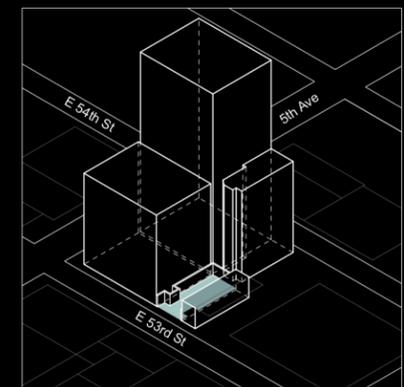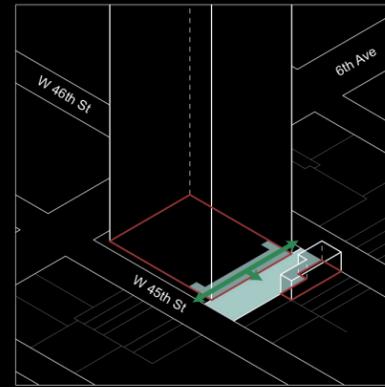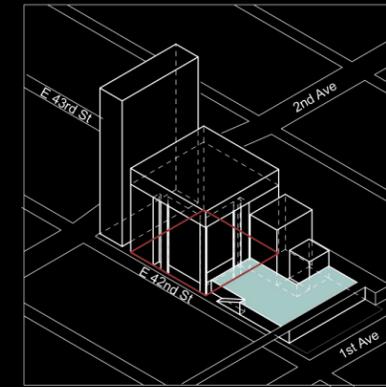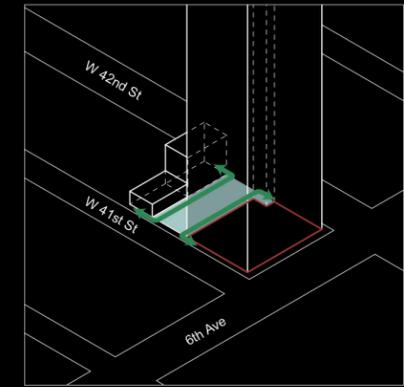
590 Madison Ave

Lever House

Paley Park

MMC Plaza

FordFoundation - Mary O'Connor Playground

Three Bryant Park

100 William St

180 Maiden Lane

55 Water St - Elevated Acre

Public-Owned-Private Spaces Analysis of Manhattan
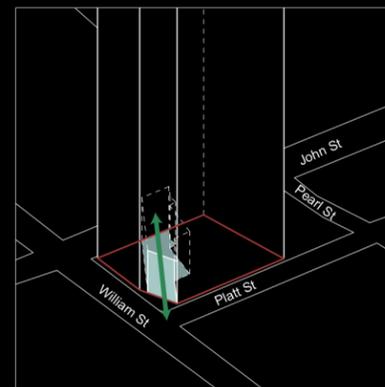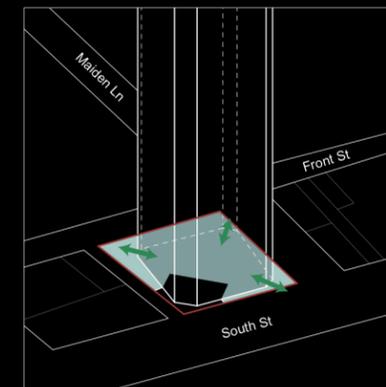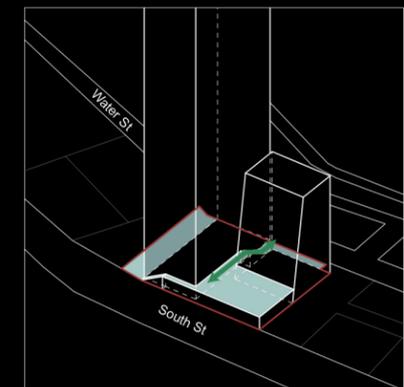
Existing Site Plan - Not Very Accessible Garden

Sectional Diagram - Rams and Communal Spaces in Atrium

Exploded Isometric Diagram - Analysis of Circulation and Daylighting
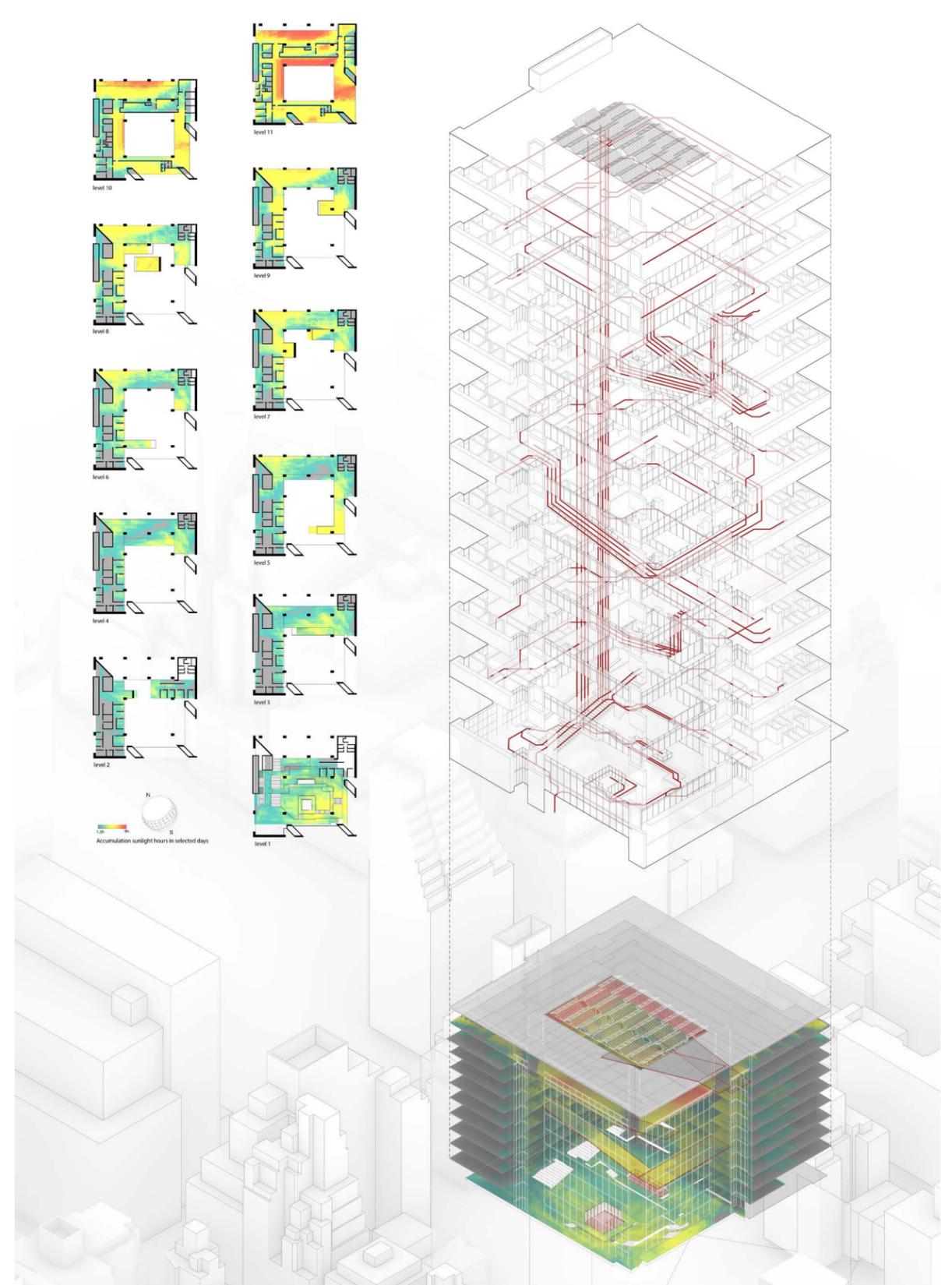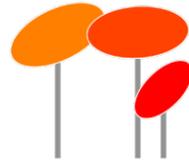
05

Central Park Solar Folies
Optimization for Great Hill Central Park

Generative Design
Columbia University
Instructor: Danil Nagy
Site: Great Hill
Team: Gejin Zhu, Bingyu Xia,
Yining Lai, Zihan Sun, Risa Mimura

"Solar Mushroom Folie" is a design proposal to suggest a possibility to make better use of the abundant sunlight that shines on Central Park. More specifically, we are introducing a multi-layer system of single column supported solar panels in the meadows located in Central Park. Great Hill, one of the highest points located at the northwest corner of the park, is selected as the site for this study. The goal for this project is not only to increase the solar energy production and reduce greenhouse gas emission in New York City, but also to raise awareness of the scarcity of sunlight in the city of New York. Renewable energy is becoming a central topic for energy production during the era of climate change. It is crucial for people to understand the production of solar energy in relation to the power usage of the entire city.

The objective for our project is to maximize solar energy production through solar panels with a series of solar angles without disrupting the existing space use and circulation. Great Hill is closed during winter season but is a very active area of Central Park during the other seasons, the solar panel installation would not be disturbing the original purposes of the meadow.

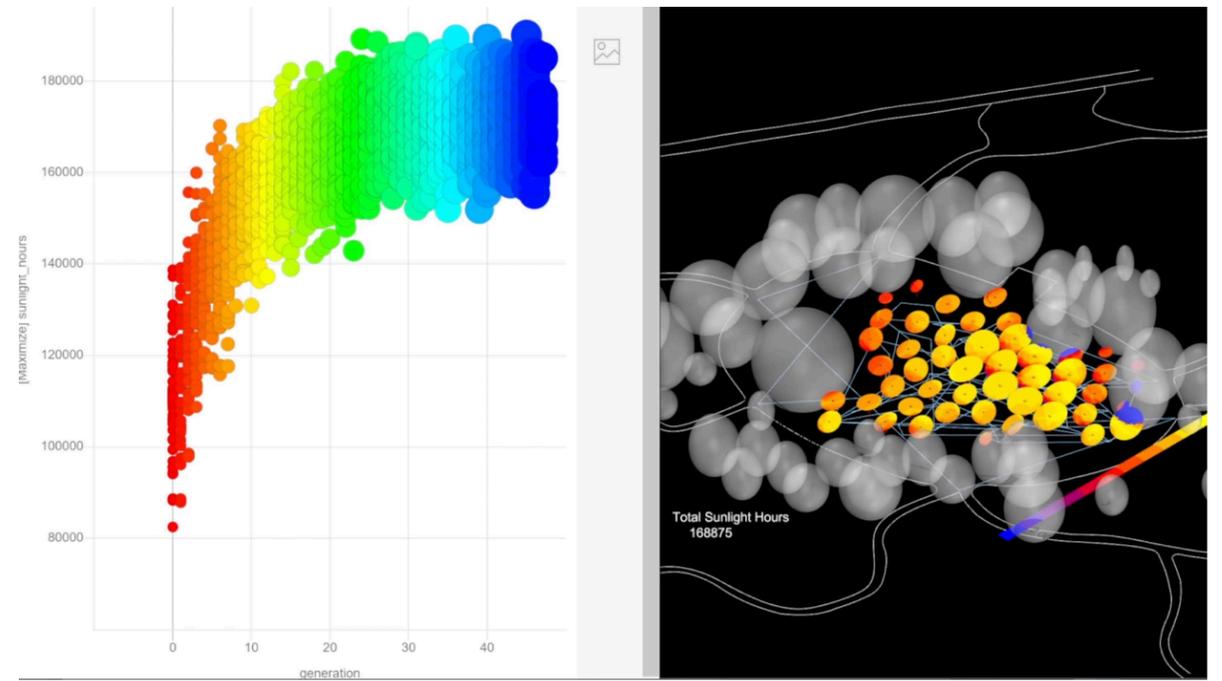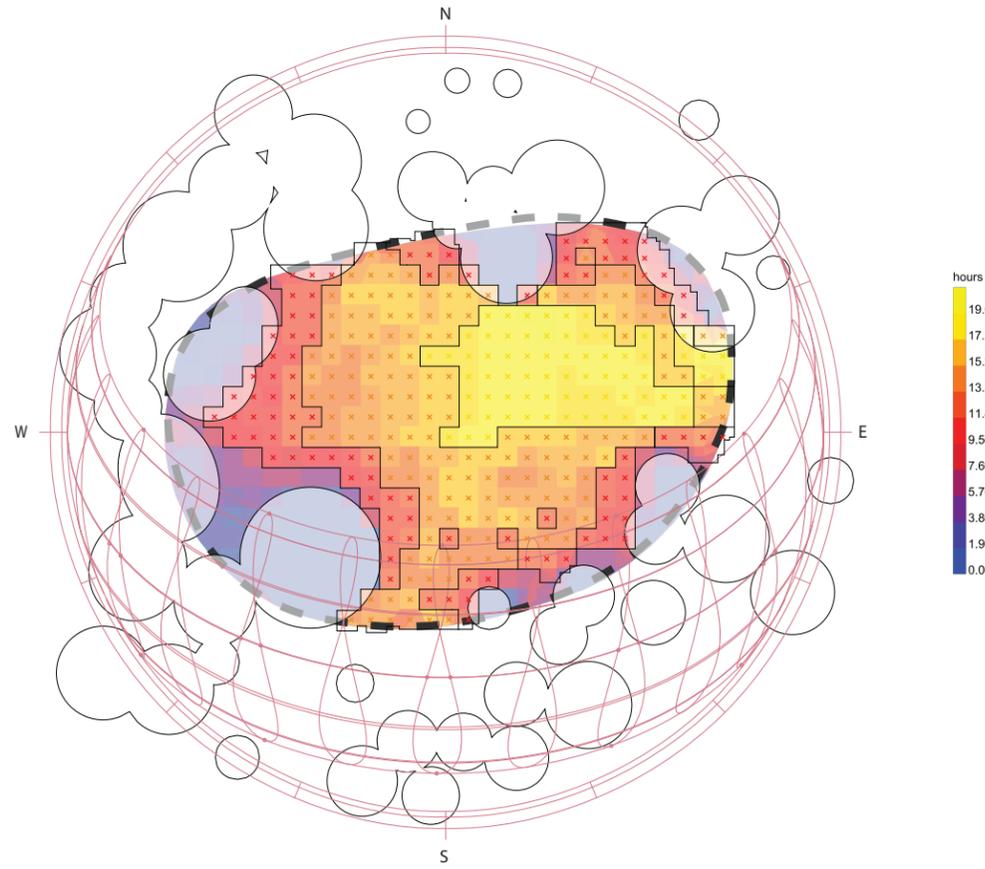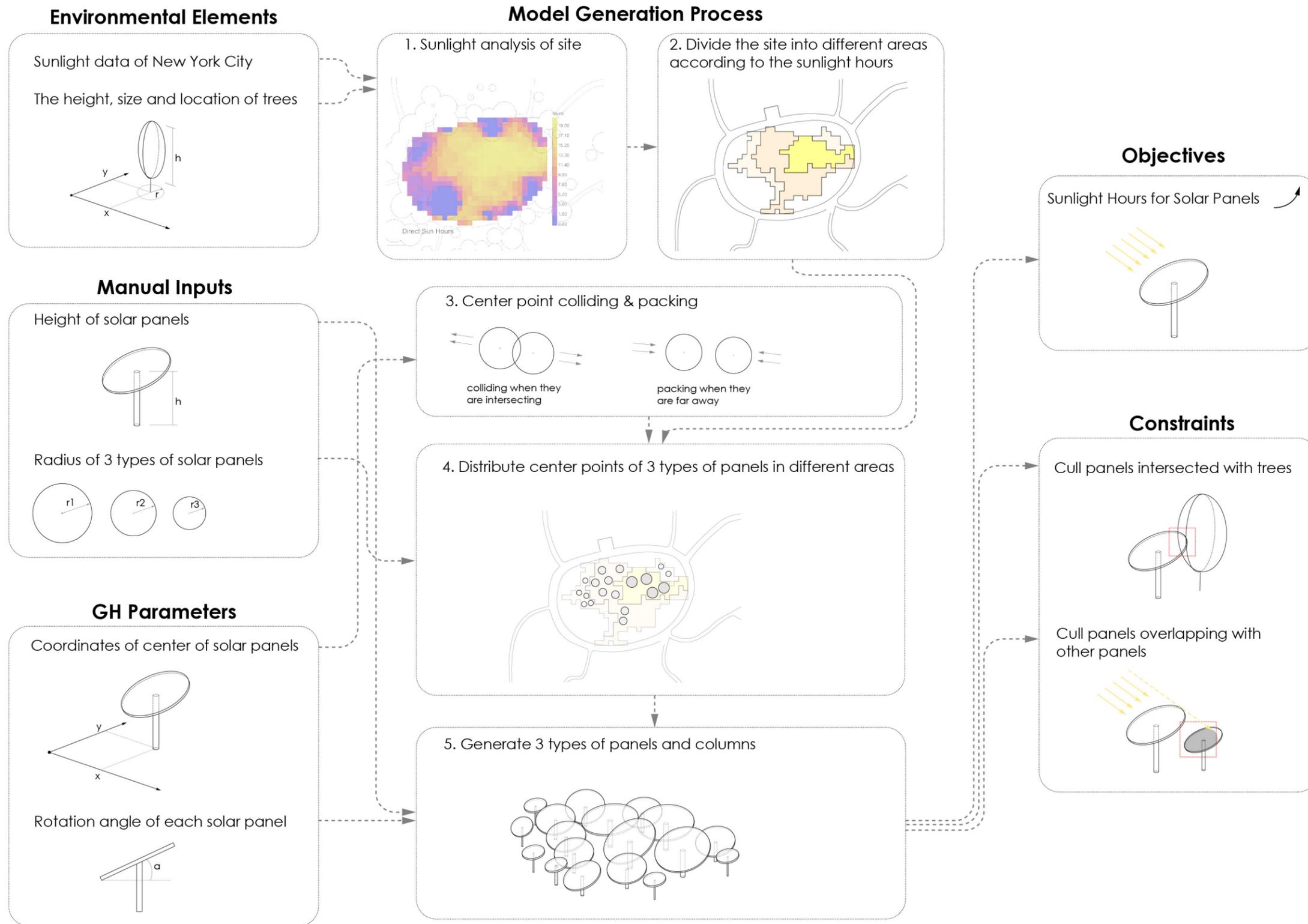Perspective Collage - Folies in Great Hill of Central Park

Perspective Rendering of Best Solution
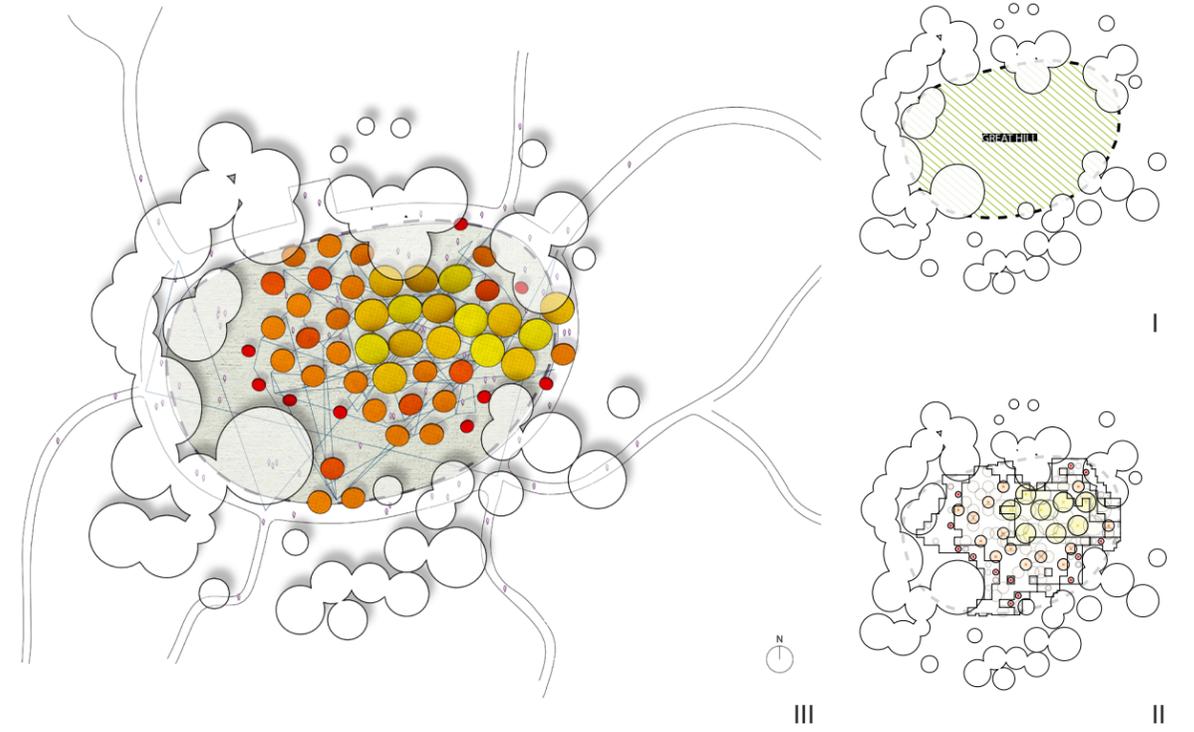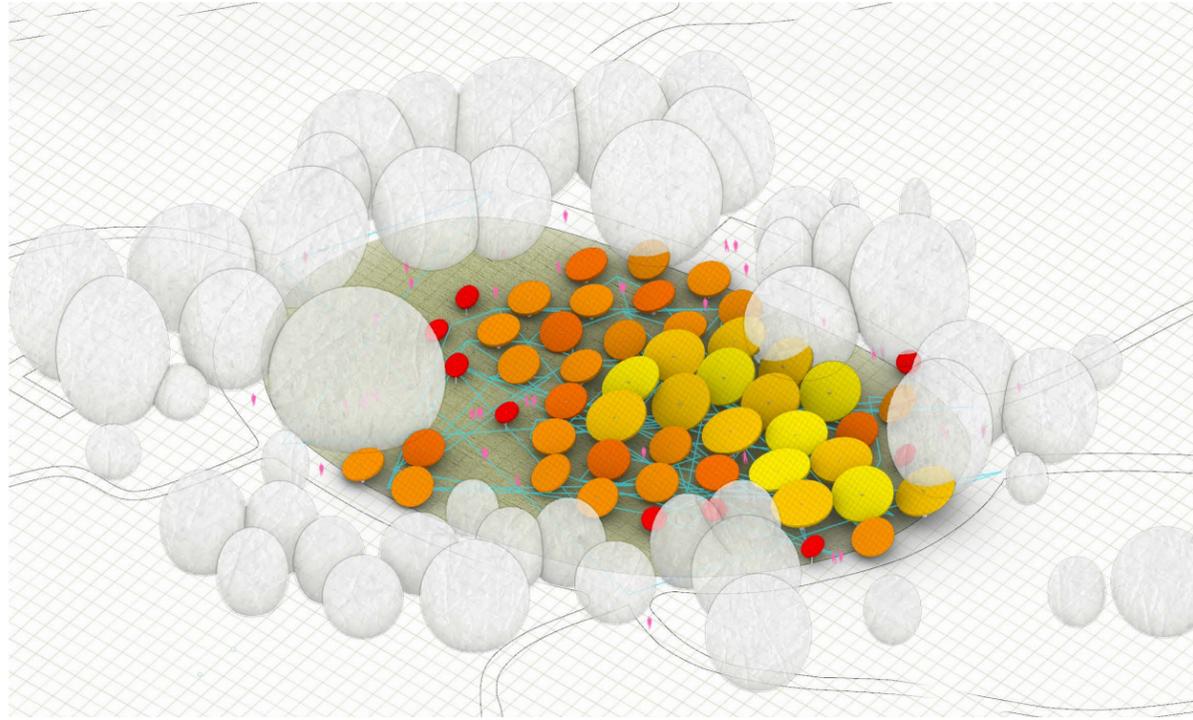
Site Plan - I Existing Plan - II Optimization Plan - III Best Solution Plan

I

II

III

Daylighting Analysis with Ladybug

hours

19.00
17.10
15.20
13.30
11.40
9.50
7.60
5.70
3.80
1.90
0.00

Optimization Progress in Discover with Rhino

Total Sunlight Hours
168875

Environmental Elements

Sunlight data of New York City

The height, size and location of trees

Model Generation Process

1. Sunlight analysis of site

Direct Sun Hours

2. Divide the site into different areas according to the sunlight hours

Objectives

Sunlight Hours for Solar Panels

Manual Inputs

Height of solar panels

Radius of 3 types of solar panels

r1   r2   r3

3. Center point colliding & packing

colliding when they are intersecting

packing when they are far away

4. Distribute center points of 3 types of panels in different areas

Constraints

Cull panels intersected with trees

Cull panels overlapping with other panels

GH Parameters

Coordinates of center of solar panels

Rotation angle of each solar panel

5. Generate 3 types of panels and columns

Work Flow Diagram

40

41

06

Axiety Age
Video Game Deisgn

Virtual Architecture
Columbia University
Instructor: Nitzan Bartov
Platform: Unreal Engine 5
Team: Gejin Zhu, Bingyu Xia, Yining Lai

This project is an installment of architecture, acoustic and visual art, that conjures the bombardment of emotion, secrecy, and information. It aims at arousing public emotional resonance of negative feelings, like anxiety, fear and pressure. To illuminate human's anxiety that arises from conflicted desires, the character is trapped in an infinite corridor with a series of scenes when being in highly approach motivated states.

Anxiety Age is imaged with a physical maze of corridors that fully immerse viewers. By organizing random sequences and infinite scenes, this project provide distinct experiences to individuals with broached themes of isolation, disassociation, transmission, interconnectedness, etc.
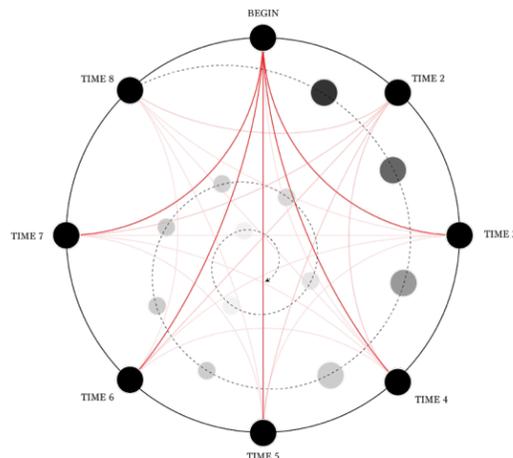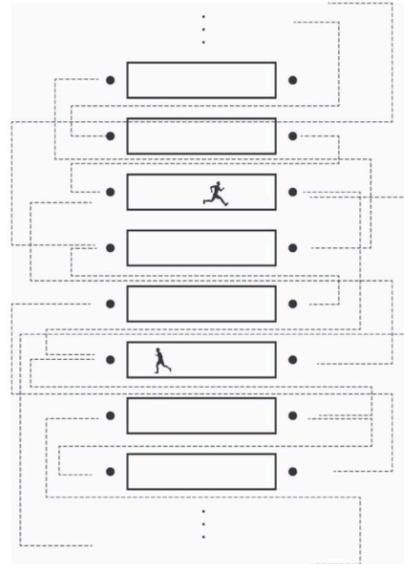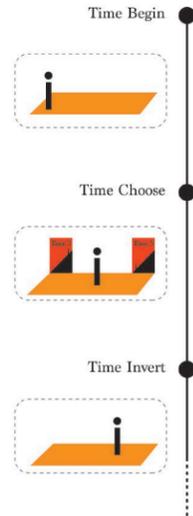
Inspiration Diagram - Teleportation

Inspiration Diagram - Random Circulation between Corridor Maze

Inspiration Diagram - Teleportation Between Maze

Prototype Corridors of Four Scenes