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LEGEND

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Green = Collaboration

Yellow = Others work, but involved in process.

Strikethrough = No real influence

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1.

Today

2018

1.1. Where are we now?

1.1.1. What is a city?

A city is usually defined as an inhabited place of greater size, population or importance than a town or a village. This quantitative definition, as much as it might be appropriate for a dictionary, unfortunately, misses the most important aspects of a city and what makes it special as a construct of man.

Throughout history, cities have been the pinnacle of civilizations achievements; they are the culmination of all technological achievements, societal revolutions and cultural distinctions that are characteristic of a society and its people. Like the ancient Greeks built their temples and forums, as well as the Romans that followed suit, so we build skyscrapers, train stations, and highways. These are the landmarks of our age and they directly reflect our contemporary way of life by materializing it into physical artifacts.

But a city is much more than a collection of objects suspended in space, serving a purpose or reminding of times gone by. The core of a city are its people; cities represent diversity, they allow for individuality as well as a collectivity, they amplify every aspect of our life and in this way create a unique environment of unlimited possibilities. They are hubs of innovation, centers of revolutions and places of interaction. Above all, a city is a place, as the writer Richard Sennett put it, where strangers meet; where new ideas are formed in a public space. A common ground open to anyone and everyone. A place directly created by its inhabitants; a physical reflection of society itself.

This ability of cities to not only exist as a reflection of our society but also amplify and affect its future evolution should be enough to recognize their importance as the true core of our civilization, which inevitably brings us to the question;

Population density and Urban sprawl

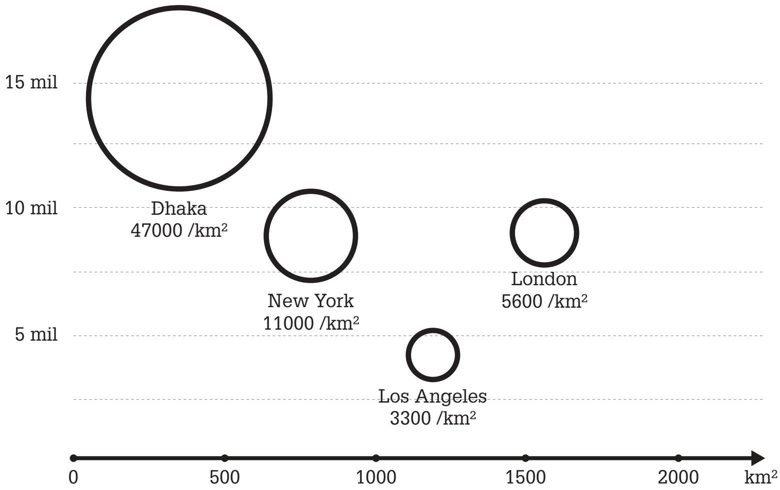
The cities chosen for analysis vary greatly in size as well as their number of inhabitants. Another difference between the results from the division of the city center proper versus the broader metro areas.

Looking at the city center areas the most populous city by far is Dhaka with a total of 14.4 million inhabitants, followed by London and New York with 8.8 million and 8.6 million respectively, while Los Angeles takes the last place with only 4 million inhabitants. The physical boundaries of the aforementioned cities again vary greatly from 306 km^2 for Dhaka, 780 km^2 for New York, 1213 km^2 for Los Angeles and 1578 km^2 for London. The combined result of both factors is the population density per square kilometer; one of the most important indicators describing the urban fabric of a city. Dhaka has by far the highest population density of the analyzed cities with a density of 47.000 inhabitants per square kilometer, making it a truly hyperdense urban environment. The centers of London and New York find themselves in the medium to high-density range, while Los Angeles is last with a measly 3300 inhabitants per square kilometer.

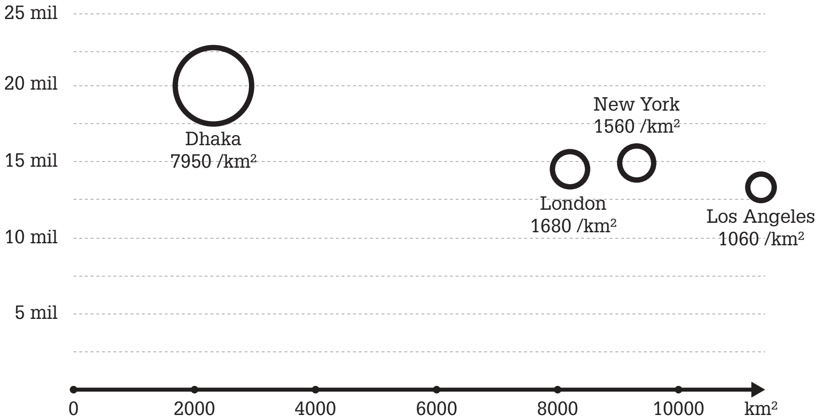
Looking at the broader metro areas the most populous city is again Dhaka with a total of 20 million inhabitants, followed by New York and London with 14.5 million and 14 million respectively, while Los Angeles again takes the last place with 13.3 million inhabitants. Again the physical size of the metro areas varies greatly from 2160 km^2 for Dhaka, 9100 km^2 for New York, 12500 km^2 for Los Angeles and 8300 km^2 for London. Combined, both factors again add up to the population densities of metro areas. Dhaka is again the densest with 7950 pers/km^2, with Los Angeles again being last with only 1060 inhabitants per square kilometer.

The consistent statistics of Los Angeles' low density together with its physical size - it has the largest metro area - strongly point towards an intense urban sprawl. This is also confirmed by the proportion of the metro area compared to the city center; a whopping 1034%.

City area population density



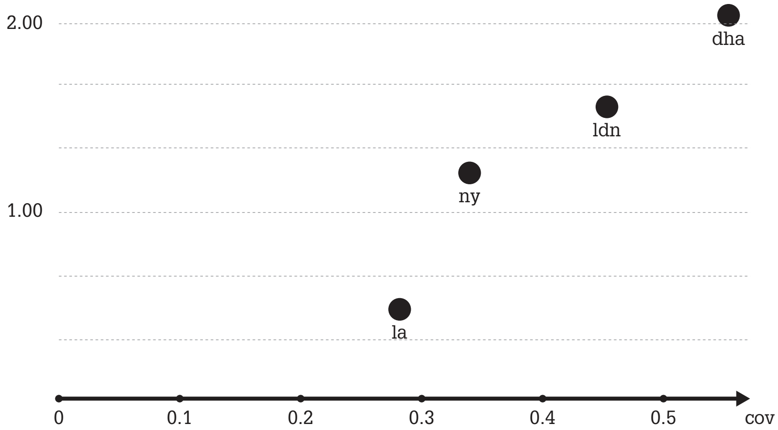
Metro area population density



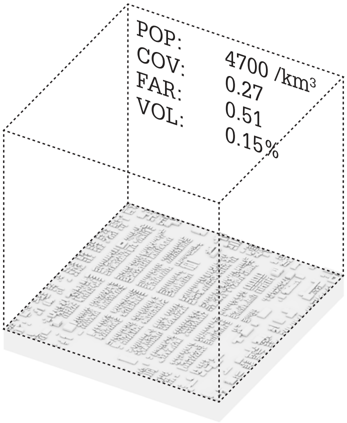
Built density

Analyzing built density has shown to be quite an unenviable task, as there is practically no publicly accessible data regarding average land use of global cities. To tackle this issue and area of one square kilometer of a generally representative part of the city was cut out of each of the four cities and modeled in 3d to act as a base for spatial analysis. These locations included Inglewood in Los Angeles, Westminster in London, Brooklyn in New York and Central Dhaka.

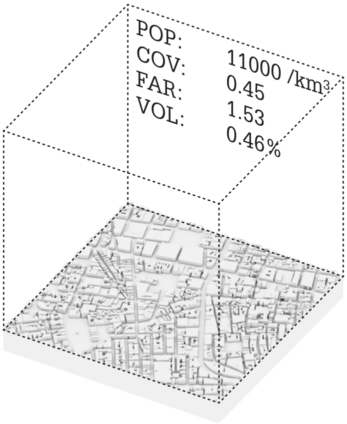
The results of the analysis showed a linear increase between coverage and floor area ratio, showing that Los Angeles is by far the least dense city out of the four, pointing towards considerable urban sprawl. Another important takeaway was the total built volume; something we would use for later comparison of contemporary cities to our project. Again, Los Angeles was last on the scale with a 0.15% of built volume per km3, translating to 1.500.000 cubic meters of built area. Lastly, we calculated the amount of built area per person according to the population density in that area. In this case, London seems to be most wasteful, but this could also be misinterpreted, due to Westminster being part of inner city London - an area with many commercial buildings and fewer dwellings.



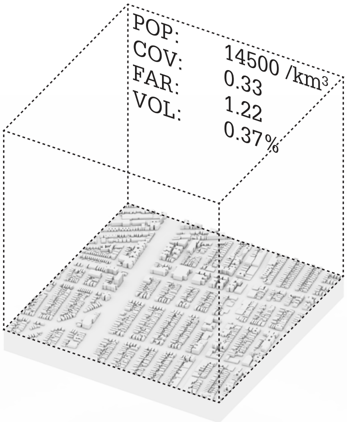
Built density analysis per km³



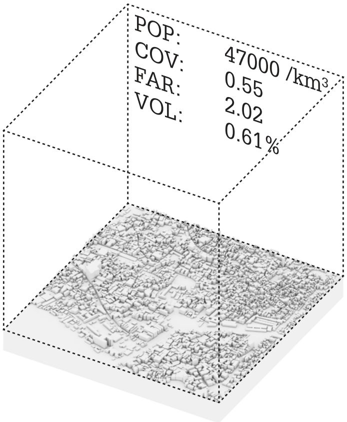
Los Angeles - Inglewood



London - Westmister



New York - Brooklyn



Dhaka - Central

Built area per person
(area in m² per person)

1.1.4. Los Angeles; the Symbol of Sprawl

All of the analysis performed pointed towards a single “winner” - a city of extremely low population, as well as built densities, with a small center and an enormous supporting metro area around it. A city of extreme distances, long commutes and excessive use of the car as the predominant means of transport with no regard for public transport. Los Angeles; the international symbol of sprawl.

This sprawling nature of Los Angeles is not a new phenomenon; it is deeply ingrained into the cities’ DNA and has steadily increased its influence as the city grew throughout history finally resulting today in the concrete carpet spreading as far as the eye can see. The influences contributing to its emergence have been many, but most important among them being strip development, the shopping mall and the private car as the symbol of freedom and of societal standing. The resulting cocktail is a city spilled over an enormous distance with an intricate web of roads and highways acting as always overburdened arteries trying to keep it all alive and running, usually to limited success.

Although the earliest uses of the term “urban sprawl” appear to be describing London in the 1950s, the actual physical phenomenon is a quintessentially American invention. On a cultural level, it symbolises a society of free individualism and limitless wealth, while spatially assuming an unlimited supply of land and resources. These seemingly idealistic aspirations and intentions manifest as a somewhat different, even disappointing, physical reality. To live in sprawl means driving to work, driving to dinner, driving to meet with friends and driving to the supermarket. Most of the time the “driving” is even not actual driving but actually waiting in a traffic jam, wasting time, polluting the environment and, in most cases, being extremely frustrated.

Convenience aside, sprawl also causes exorbitant land use and the destruction of natural landscapes. It is the spatial reflection of our mindset towards space and the environment, an emblem of our carelessness and towards the world, we live in.

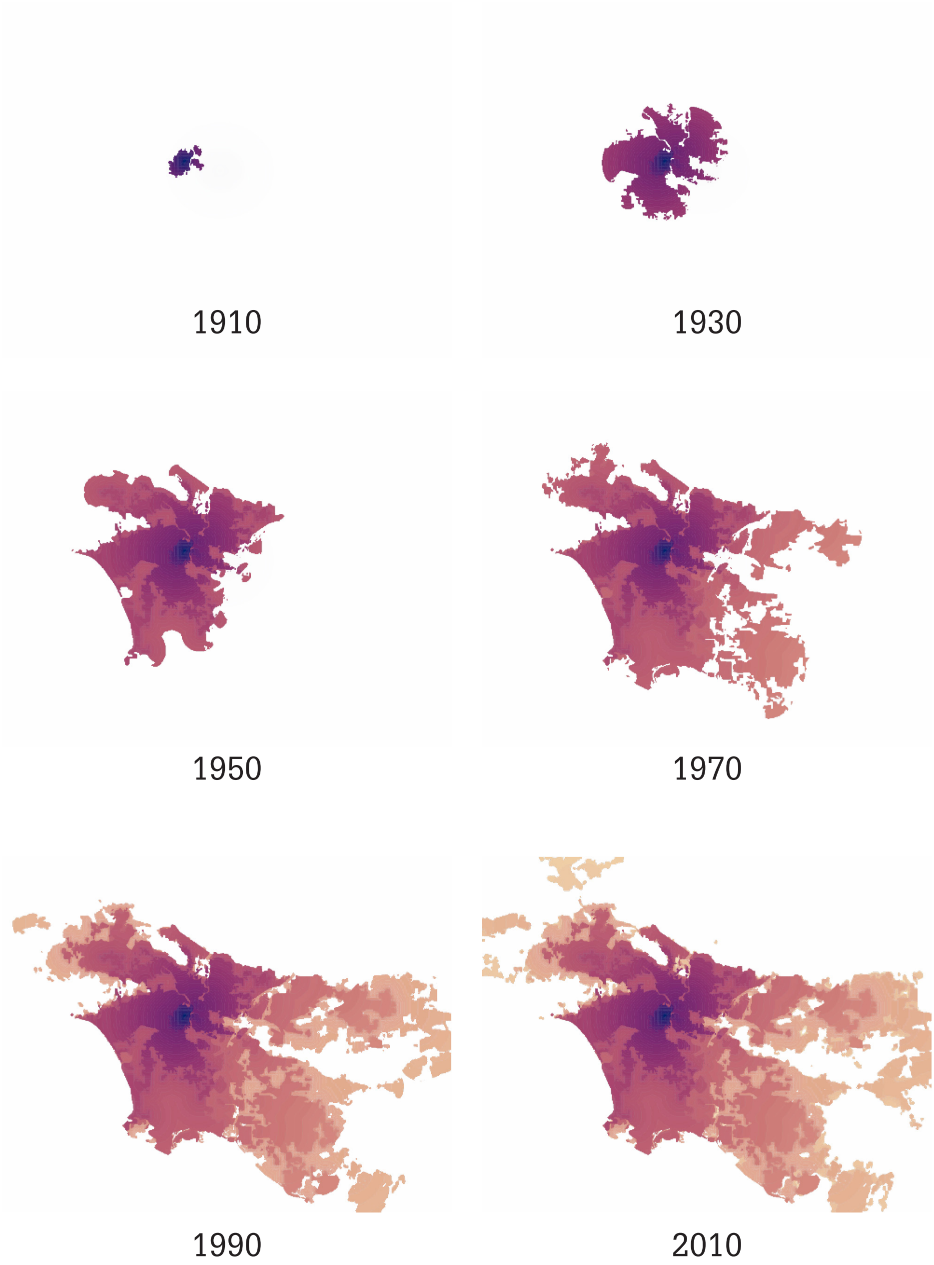
Urban sprawl in Los Angeles

What is today the megacity of Los Angeles was once only a tiny pueblo counting no more than 650 residents. The year was 1821 and the city just fell under Mexican rule as New Spain achieved its independence from the Spanish Empire.

Throughout the next decades, this small settlement that would one day form the Downtown area of Los Angeles slowly grew in size and population. It was not until the turn of the 20th century that the surrounding areas were starting to be settled in small population pockets described by Aldous Huxley as "nineteen suburbs in search of a metropolis" that would eventually expand, merge and sprawl out in the process of creating the megacity that is the contemporary Los Angeles.

The cities' growth started rapidly accelerating around World War I, following which it steadily densified until World War II and then finally burst out as a full grown sprawling metropolis from 1970 onwards. In recent history, the spread has considerably slowed and the city is expanding at a much lower speed. Nevertheless, the urban population remains on the rise, requiring careful management and planning on an urban scale. Recently the authorities are focusing much effort into densification of the city within existing limits, which is a sensible strategy, albeit its success is limited, due to the incredible strain put on the infrastructure supporting this urban machine.

Los Angeles urban area growth



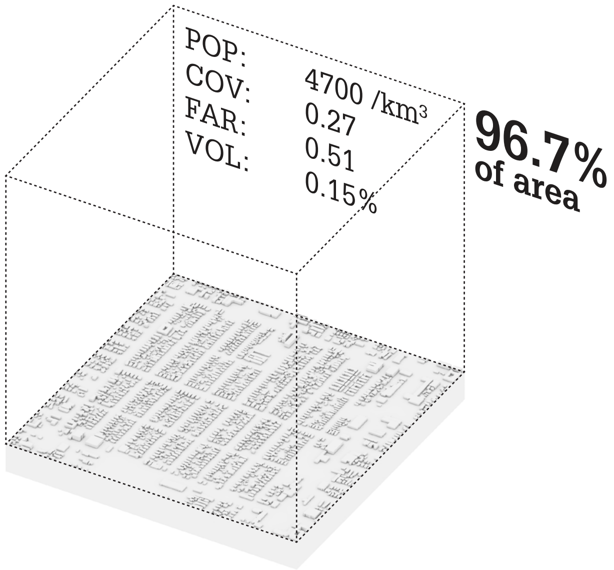
Built density in Los Angeles

The built densities of contemporary cities are hard to evaluate as in the majority of cases there is no comprehensive data describing a specific cities' urban morphology and its parameters. Los Angeles is no exception; excluding the standard values of population densities per square kilometer which are measured on a regular basis in every city in the world, we found no additional data on the density of built tissue in L.A.

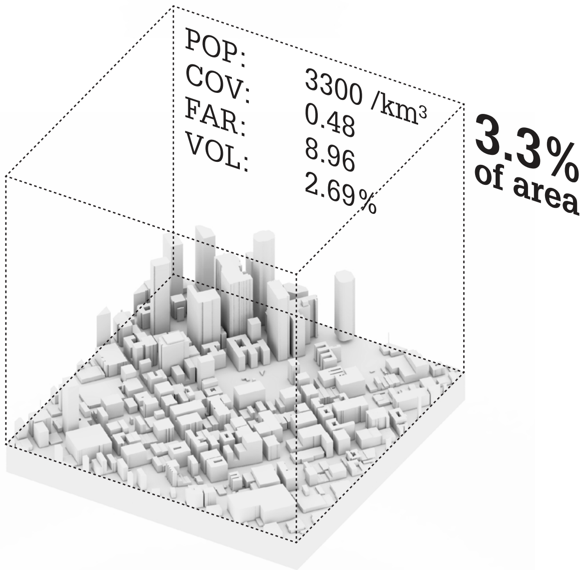
In order to work around this problem the urban area of the Los Angeles inner city was split into two distinct types: firstly a low-density morphology describing the condition of urban sprawl and secondly a high-density area found in the city center and consisting predominantly of skyscrapers. In the second step, a specific part of Los Angeles was chosen as a representational cut-out of 1 km^2 for each of the two morphologies; a section of the Inglewood neighborhood was chosen as a representative of low density and the central Financial district as representative of high density.

Both representative sections were modeled in three dimensions based on building height data and subsequently used for data extraction about built density. The differences in both areas were drastic; all of the spatial parameters, from coverage (COV) to floor area ratio (FAR) and subsequent volume indicated significant differences in spatial density. The central Financial district exhibited extremely high built densities, but unfortunately only covers approximately a mere 40 square kilometers; a measly 3.3% of the entire city area. All of the remaining space is covered by a sprawl morphology which, as shown in the earlier chapter, is of extremely low built density which leads to an unstoppable urban sprawl and all its accompanying problems.

Built density analysis per km^3



Los Angeles - Inglewood



Los Angeles - Financial district

4.

Where do they live?

4.1. Introduction

4.1.1. Towards a Sky City

To project where architecture is going to be in the future, its history needs to be understood. Therefore, we will shortly reflect on the last hundred years, to see which global effects have had a major influence on the topic of architecture and urbanism.
We will start at the second industrial revolution, also known as the technological revolution, which started around the final 3rd of the 19th century and ended in the beginning of the first world war, in 1914. This period which has been characterized by a rapid industrialization, has brought forth innovations in manufacturing, such as the establishment of a machine tool industry, the development of methods for manufacturing interchangeable parts, the invention of an inexpensive industrial process for the mass production of steel. Advancements in manufacturing and production technology enabled the widespread adoption of preexisting technological systems such as the telegraph, railroad networks and generic gas, water and sewage systems. Two other notable technological innovations of the period were the electrification of factories and the introduction of the production line. (Wikipedia, 2019)
Modernist architecture emerged at the end of the 19th from revolutions in technology, engineering, new building materials and the desire to reinvent society and the build environment. With the newly gained possibilities the use of cast iron, plate glass and reinforced steel structures could become stronger, lighter and taller. After the second world war, le Corbusier got commissioned his first work in ten years in 1947. He called it the ‘Unité d’Habitation’ and was built in Marseille. Following his design principles, he lifted the building of the ground and organized 337 duplex apartment units, or as he called them ‘Machines for living’.
Another pioneer in modern architecture was Ludwig Mies van der Rohe, his architecture strove toward: ‘minimal framework of structural order balanced against the implied freedom of unobstructed free-flowing open space. One of his iconic buildings, is the Seagram building in

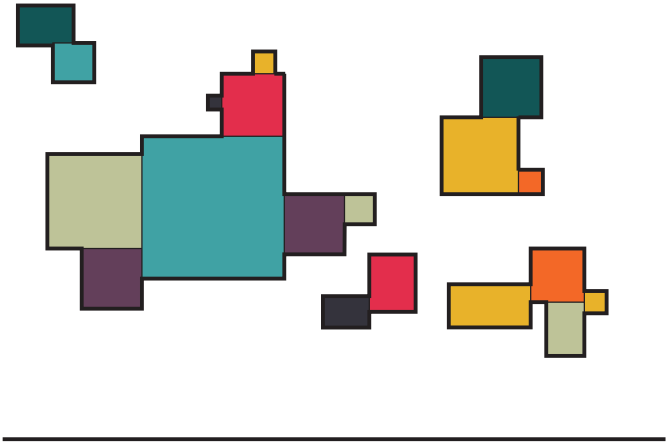
Chicago built in 1958, the same year that Oscar Niemeyer finished the president's residence in Brasília. Contrary to these modernists, Mies worked mainly with steel and glass, his 'less is more' approach gives the work a generic feeling. But inspecting the building from a closer angle reveals that 'God is in the details'.

Kenzo Tange was invited to what would become the last CIAM meeting, here he exposed the work of his students to the biggest gathering of modernist of the time. His presentation, focused on the tower-shaped city and the build 'Sky House', it would become the first display of the Metabolist Movement. The key concept of this movement was the fusion of architectural megastructures with those of organic biological growth. The Nakagin Capsule tower was erected in 1972 and completed in 30 days. Prefabricated in a factory, the 140 high tech capsules where plugged into two cores and where designed in such a way that they were interchangeable. Sadly, the capsules never went into mass production.

As of the beginning of the 21st century the need for a greener approach to how we deal with the built environment and the planet has started shifting the way we built. Today, we are using technological solutions to become more sustainable and these can fall into two categories either they are: High Tech or they are Low Tech systems. Two trends that are worth mentioning are that architecture is truly becoming a 'machine for living', the emphasis being that, nowadays almost everything can be computed, made virtual or automated. The other trend being a new approach to how we work with materials, the most innovative of these being the concept of circularity. Where materials never would go to waste, a good example of this second trend is the Wikkelhouse. Which is being fabricated in a factory in Amsterdam, in simplistic terms, the architecture consists of modules which are being wrapped in cardboard. The modules can be organised in different programs.

Reflecting on these historic effects, a framework in which key moments are highlighted to indicate that certain trends will likely continue in the future. For example, rapid industrialization is a key factor for the architecture movement to survive, the lack of this caused the Nakagin Tower capsules to become irreplaceable. Interchangeable parts were first introduced on products in the technological revolution, however they haven't yet been introduced in the field of architecture on a mass scale. The Wikkelhouse is a new sustainable approach which is intending to launch a new type of generic module that can be mass produced and consists of interchangeable parts. Two, very important elements of Modernism are the so-called machines for living, and the desire for unobstructed free-flowing open space. Are increasingly being used in architecture and we expect this trend to continue into the future. The last two take-aways from the research is the increase in prefabrication and the advancements in circular design.

Today



Sky City

4.2. Environment

4.2.1. Sprawl and Density in the Sky City

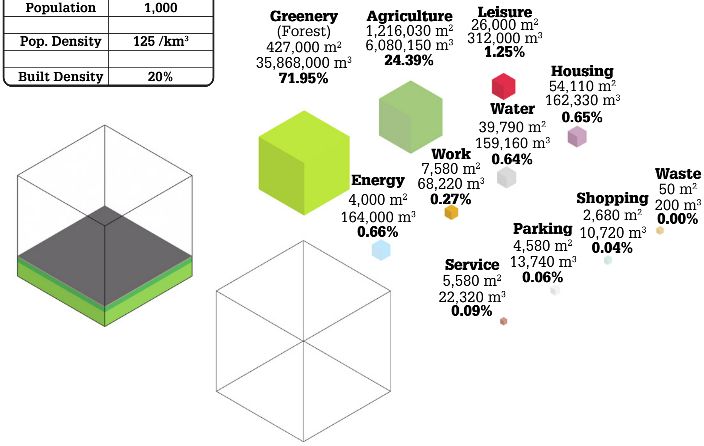
By gravitating off Earth's surface, we release ourselves from the burden which is gravity. Although vital for the functioning of our planet, on the human scale it limits us to horizontal movement. In the Sky City we have been liberated and our now able to live and construct in the sky. Which raises a few questions like, can we enforce densities that would lead to a more productive city? Or can we an increase in density lead to much more pragmatic variety? And will this increase generate more synergy, social encounters? These changes in urbanity can surely lead to more possibilities for architecture?

As learned from the previous research, Los Angeles high density suburbs compensate for the comparatively low density of the cities urban score and it's inability to produce a mass transit system has given the city of one of the worst congestions. Also because of the automobile the city has integrated into a series of satellite cities to form the Greater Los Angeles.

For the design of Sky City, a cube has been used to scope the work and make it comparable. The cube has been set to 500 x 500 x 500 m or 0.125km^3. The starting point for the density study is the data which was used for the KM3 research and is based on Dutch cities but will be considered as generic for this research.

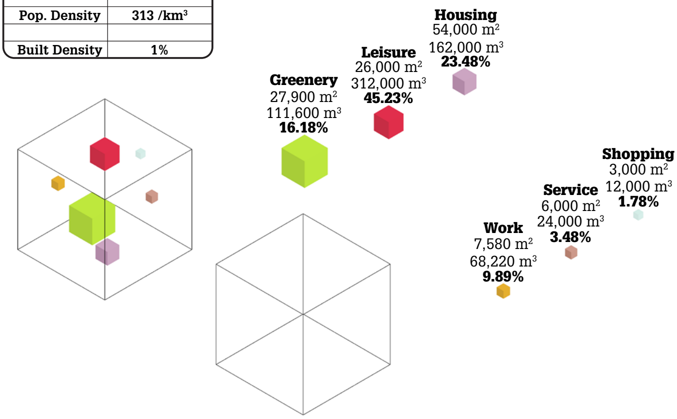
The data which considers the third dimensionality of space has been simplified to avoid over-complexity, but informs us about quantities that build up a generic city. For the Sky City we have taken this data and modified it according to the expected necessities of an elevated city.

Summary	Units
Cube	0.125 km^3
Population	1,000
Pop. Density	125 /km^3
Built Density	20%



KM3 density on the ground.

Summary	Units
Cube	0.125 km^3
Population	1,000
Pop. Density	313 /km^3
Built Density	1%



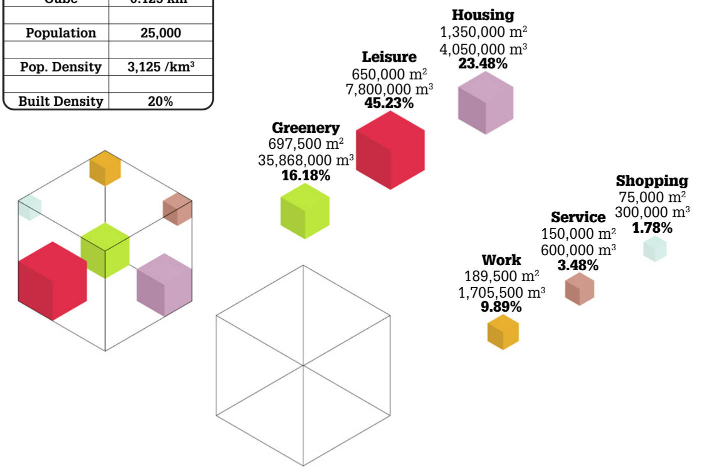
Sky City with a population of 1,000 citizens and a built density of 1%.

To understand how the Sky City would work in terms of density and population, calculations have been made that quantify the amount of space needed per capita. By using this a starting point the mass and size of the city can be visualized and better understood. Therefore we have modified the initial data to project what the Sky City would need in terms of build mass. This elimination process however has been done through thoughtful discussion and research that focus on trends and tendencies that we expect to see in the future.

We eliminated the volumes for Agriculture, as we expect that once we have taken off we could still access Los Angeles agricultural land for luxurious commodities like organic grown food, and assuming that we will also have laboratories and other artificial environments to produce food like cultured meats. Because of the expected emergence of a yet to be determined energy source, power plants and the need for an energy grid will become redundant. Water management will become integrated into individual systems which will provide for the self sufficient units. The expected developments in autonomous vehicles should be enough to relinquish the notion of parking. And lastly, as we are moving towards a circular economy we wont have waste.

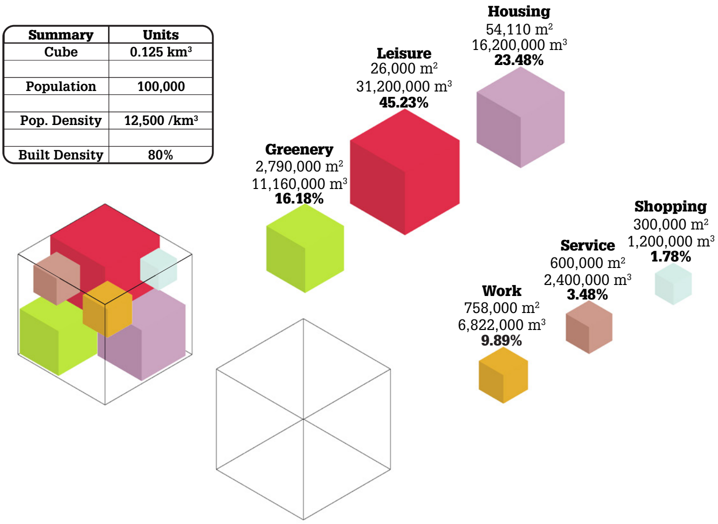
The Sky City gives us the possibility to build more efficient cities. Not having to rely on large industries such as agriculture or energy. The tendency to use built as dense as possible has been considered, but raises fundamental questions in terms of the necessity to live so close to each other. Especially when in the case of Los Angeles, there is an abundance of space. As we have seen in the research before, Los Angeles when compared to other cities has a disproportionate amount of space and relatively low density. Therefore we opted toward a more decentralized approach whereby the Sky City takes the same approach that is already present. Emphasizing the wishes of the current citizens which is a low density, relatively large amount of solar radiation and green space.

Summary	Units
Cube	0.125 km^3
Population	25,000
Pop. Density	3,125 $/km^3$
Built Density	20%



Sky City with a built density of 20% and population of 25,000.

Summary	Units
Cube	0.125 km^3
Population	100,000
Pop. Density	12,500 $/km^3$
Built Density	80%

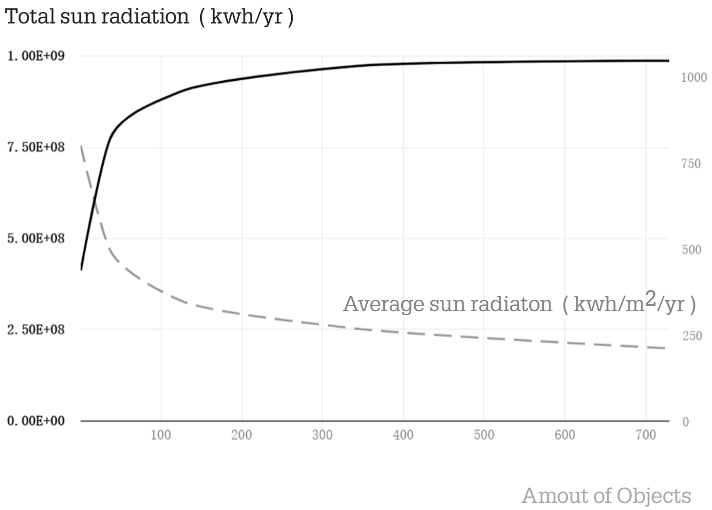


Sky City with a built density of 80% and a population of 100,000.

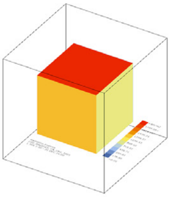
4.2.3. Sun Radiation

This experiment shows how the sun radiation performs in a 3D world. The following 5 cases are all in the same volume (20% built density) and placed in the 500x500x500 m cube. With the increasing of subdivision, the total sun radiation in the system will increase radically first and becomes steady. But the average sun radiation on each surface will decrease as what shows in the following graph.

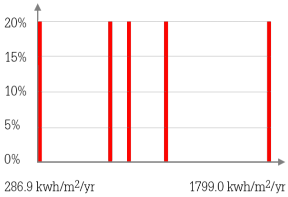
Also, the ratio of objects which get the lower sun radiation will increase since more and more objects will be trapped in the center when we are keeping increase subdivision

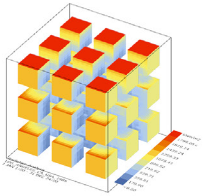


Total/average sun radiation changes with the increasing of city cube subdivision

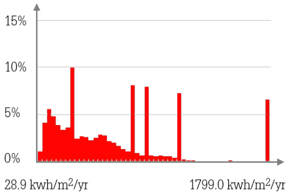


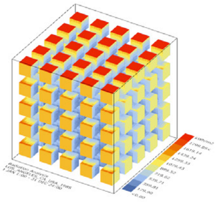
Built density: 20%
Amount of objects: 1
Dimension of each object: 292 m
Total sun radiation: 4.1e+8 kwh/yr
Average sun radiaton: 805 kwh/m^2/yr
Value distribution:



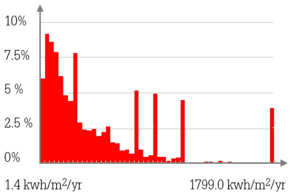


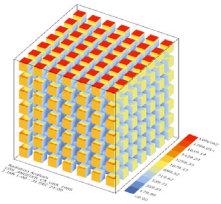
Built density: 20%
Amount of objects: 27
Dimension of each object: 98 m
Total sun radiation: 7.7e+8 kwh/yr
Average sun radiaton: 501 kwh/m^2/yr
Value distribution:



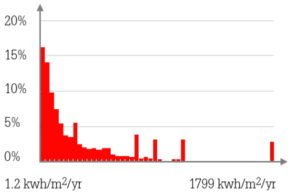


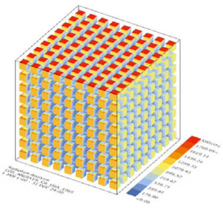
Built density: 20%
Amount of objects: 125
Dimension of each object: 59 m
Total sun radiation: 9.0e+8 kwh/yr
Average sun radiaton: 352 kwh/m^2/yr
Value distribution:



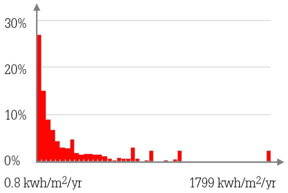


Built density: 20%
Amount of objects: 343
Dimension of each object: 42 m
Total sun radiation: 9.7e+8 kwh/yr
Average sun radiaton: 271 kwh/m^2/yr
Value distribution:





Built density: 20%
Amount of objects: 729
Dimension of each object: 32 m
Total sun radiation: 9.9e+8 kwh/yr
Average sun radiaton: 214 kwh/m^2/yr
Value distribution:



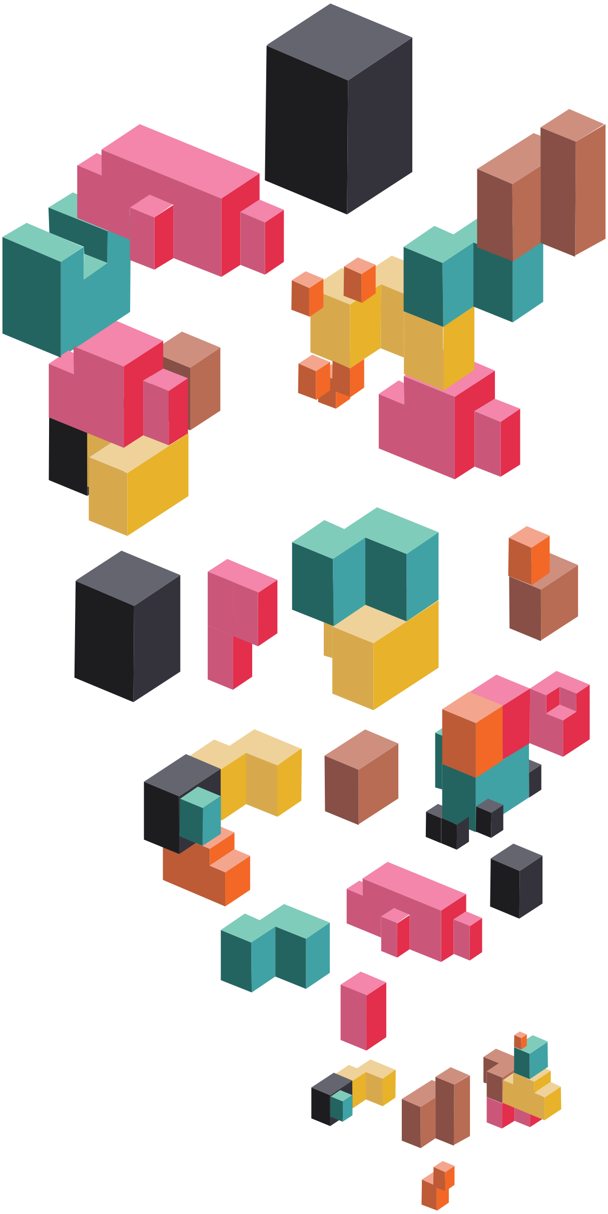
The image shows the sun radiation performance in 5 cases which are all in the same volume (20% built density). Right graph shows the percentage of surfaces get different value of sun radiation in each case.

4.3. Sky Architecture

4.3.1. Sky Architecture Intro

Architecture and urbanism dramatically changed in the 1960's after the first Computer-aided design system went mainstream. Although this would not be possible without the mathematician Euclid of Alexandria. Who, in 350 B.C., wrote his treatise on mathematics "The Elements" expounded many of the postulates and axioms that are the foundation of Euclidean Geometry which is the basis for todays CAD software. In the 1960's Citroen's de Casteljau made fundamental strides in computing complex 3D curve geometry, this work continues to be one of the foundations of 3D CAD software. However it would take until 1987 for a 3D CAD software to become common practice. When Parametric Technology Corp. Launched their first UNIX workstation, the Pro/Engineer, which heralded greater use of future-based modeling methods and parametric linking of the parameter features. Fast forward to today, CAD software has integrated so much so that it is even possible to use your phone to project augmented or virtual objects. Architectural students are required to make 2D drawings and 3D models and most recently are encouraged to partake in scripting and additive manufacturing.

For the design of the Sky City we used a generative design which is an iterative process that involves CAD software to generate a certain amount of outputs that meet a certain constraints. More specifically we used the Wasp plugin, which is a set of Grasshopper components, developed in Python.

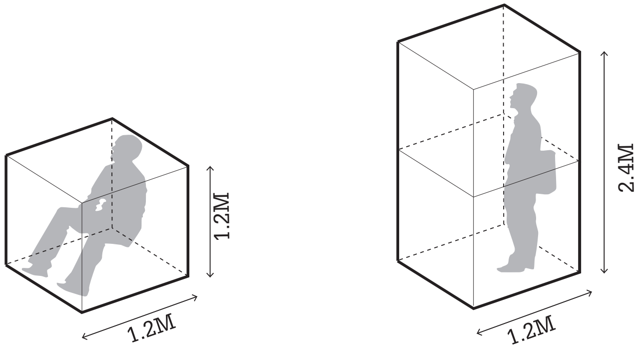


4.3.2. The Voxelised Grid: Why voxels?

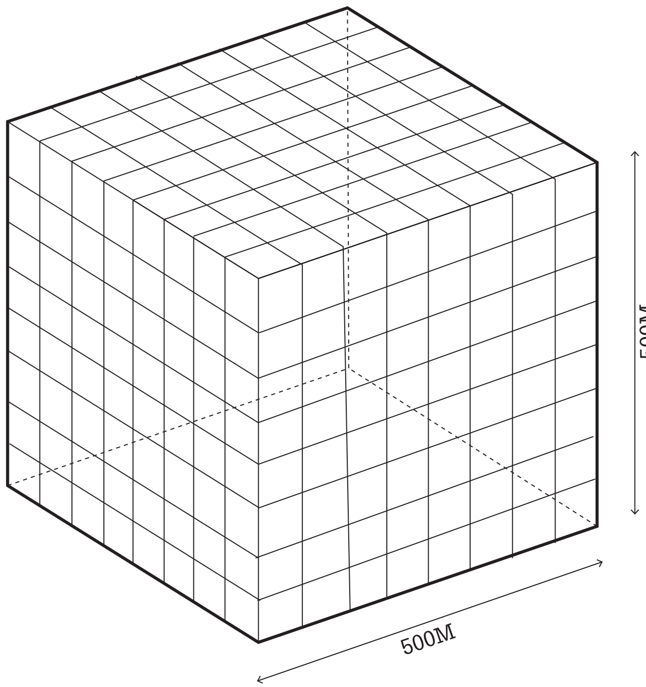
A voxel is a unit of measurement which comprise three dimensional objects. (Collins Dictionary, 2019).

Voxelisation is the conversion of continuous geometry into smaller three-dimensional pixels (voxels). (Cohen, Kaufman and Yagel, 1993).

In Sky City, a voxelised grid is used to create three dimensional pods and objects. Voxels of 1.2m x 1.2m are used: the dimensions of a cube surrounding a seated human. Multiples of this size allow pods of human dimensions to be designed within within the 500m x 500m grid.



Voxels: in a pod, sitting human dimensions are multiplied to create comfortable spaces



500m x 500m Sky City voxelised grid

4.3.3. Elements, Pods, Objects, Hybrids

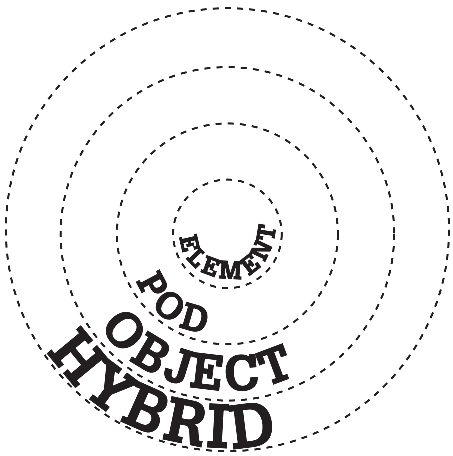
The architecture of Sky City is composed of pods: the smallest building units. Pods are created using elements, which are furniture units including their circlulation space. These units are functional spaces for the Sky Citizens which cater to the basic activities of the citizens. Pods aggregate with and detach from one another according to a set of rules (see 4.5), which allows them to form aggregations of pods known as objects. Groups of objects are known as hybrids.

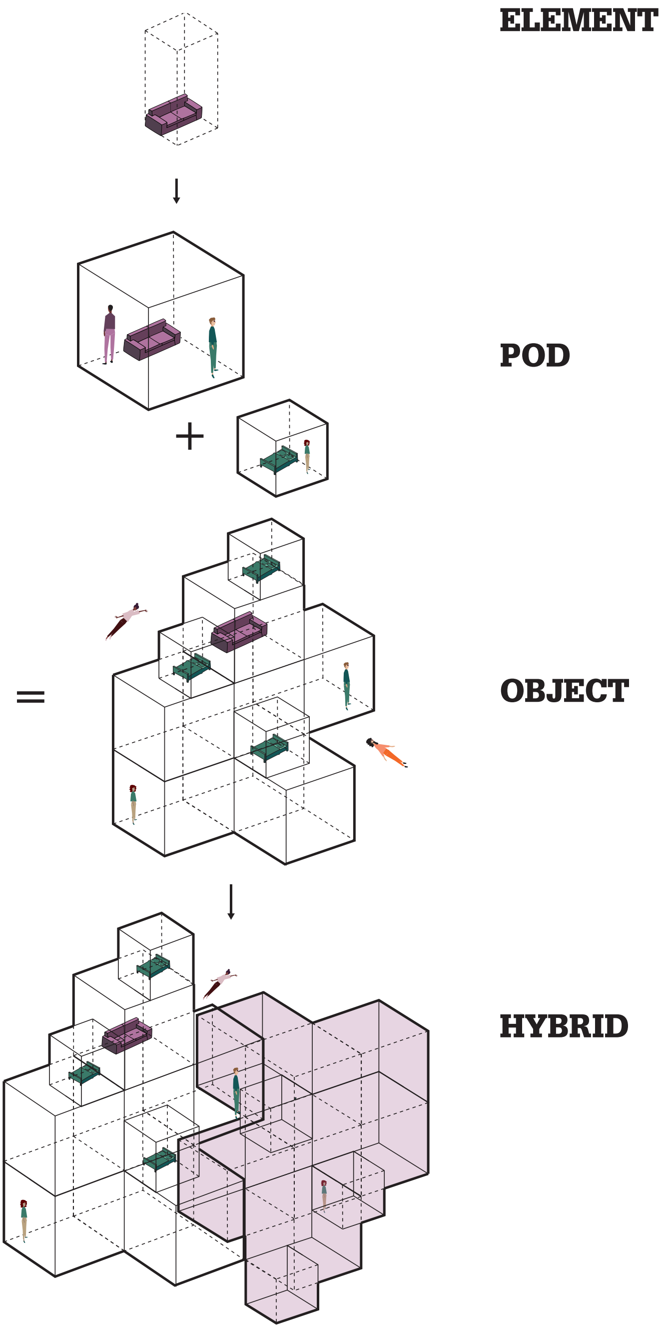
Element:
Single furniture unit and its corresponding circulation space.

Pod:
The smallest building unit in Sky City: a space created using elements. These spaces are stationary and moving in Sky City.

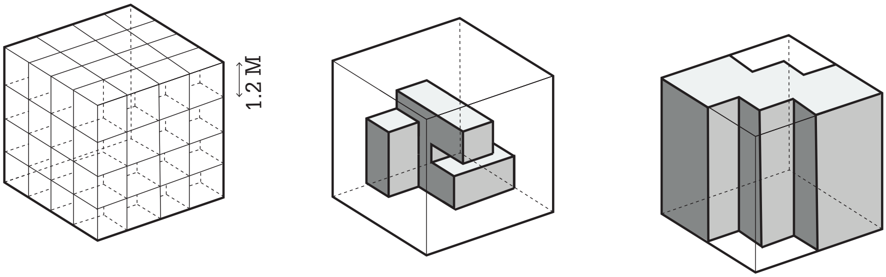
Object:
A group of pods aggregated together, creating a series of attached functional spaces.

Hybrid:
A series of objects grouped together, forming a neighbourhood.





Pods aggregating to form objects within Sky City.

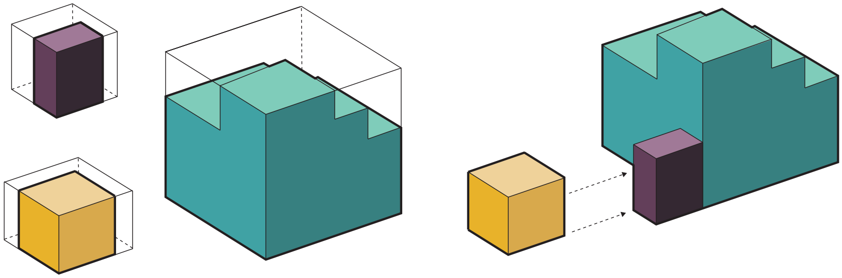


Pods within bounding boxes

4.3.4. Bounding Boxes

When building pods, a maximum bounding box was first created using dimensions obtained from Neufert standards according to the needs of users in each pod.

The pods were then created within these bounding boxes using voxel dimensions of 1.2m x 1.2m..



Specific pods attaching to generic pods

4.3.5. Generic Pods and Specific Pods

A generic pod serves as a simple space for commonplace activities. These pods attach to specific pods: unusual pods which serve specific purposes.

An example of a generic pod includes a bathroom pod, many of which may attach to a specific pod, such as an exhibition pod. The number of generic pods attaching to a specific pods depends on the occupancy of the object.

4.3.6. Parameters

Parameters are used in pods as well as in objects to determine preferences of influences that affect a certain pod or object. Based on these preferences the location, design and aggregation of pods and objects is controlled. The different parameters that will be used in this book are:

Activity
The activity describes what a pod or object is (most) used for. Pods and objects are chosen by and for Sky Citizens based on the activity they need or want to perform at a certain time.

Sunlight
The sunlight parameter describes the amount of daylight the people inside a pod or object usually prefers to receive to the people in other pods and objects.

Privacy
The privacy parameter describes the amount of privacy that people inside of the pod or object usually would want to have relative to the people in other pods and objects.

Noise
The noise parameter describes the amount of noise that people inside of the pod usually want to experience relative to the people in other pods and objects.

Activity

Sunlight

Privacy

Noise

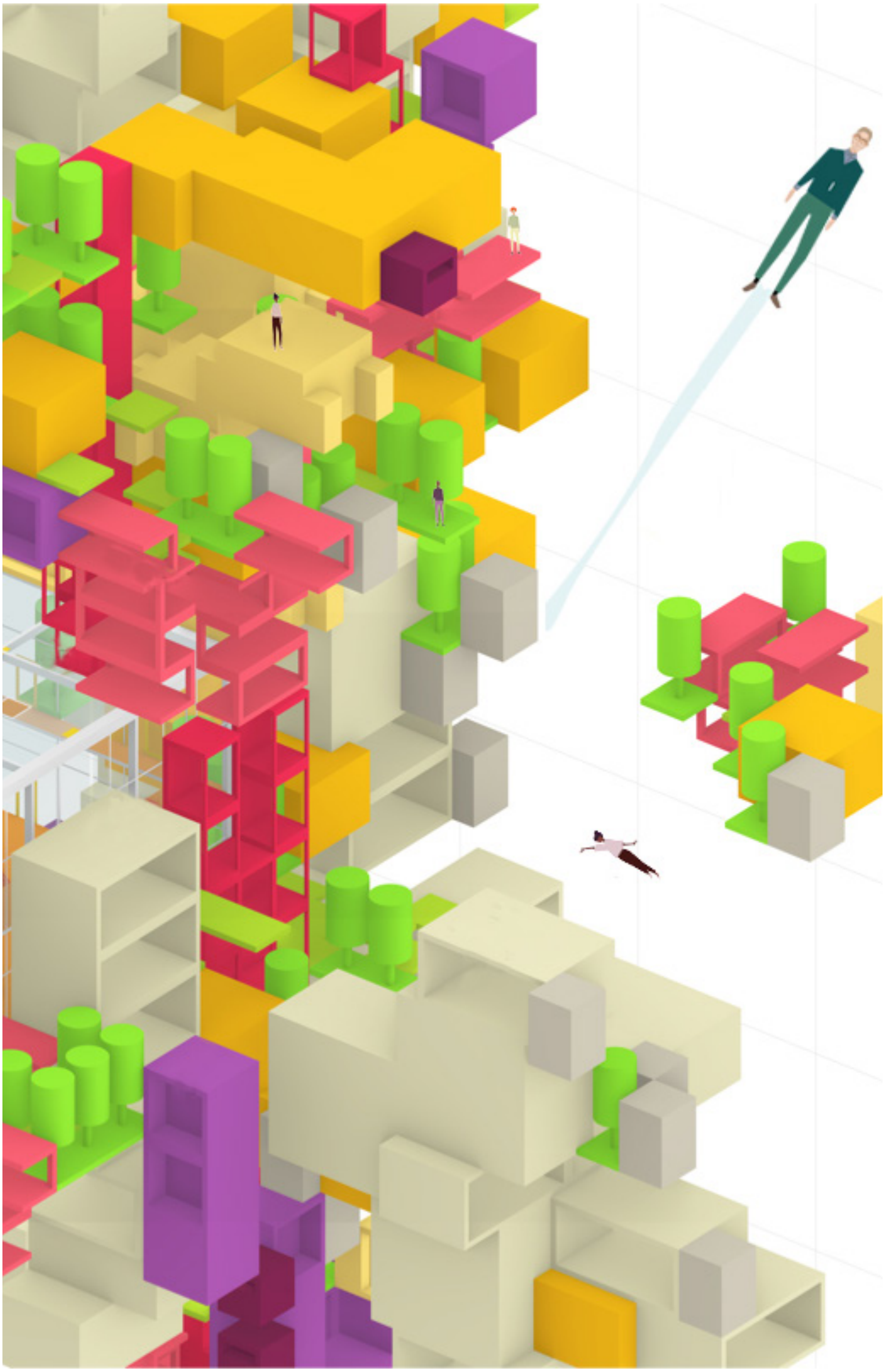
4.3.9. Aggregation

The understanding of the Discrete Mathematics led to the creation of the aggregation algorithm, which relies on certain constraints to produce certain outputs. The outputs being pods or objects, the constraints can be divided into rules and parameters. The rules provide a programmatic constraint that influences the pod and object composition. While the parameters also have influence on the composition, their role enforces certain qualities to be integrated in the final output. Furthermore a quick reminder towards some key terminology, it is vital to understand that for the creation of generic pods, elements are required as the input for the Pod Maker. And that for the creation of objects, generic pods are required as input for the Object Maker. Hybrids will be discussed further on as they are created by the same Object Maker script.

The Sky City pods and objects are based on the activities that take place inside the space, these have been defined by the American Time Survey, which produces the Sky City Schedule. But both pods and objects are not limited by these categories as they can be generic or hybrids. Generic pods can connect within a hierarchical set of rules, at a moments notice to accommodate the users wishes to transition into another activity.

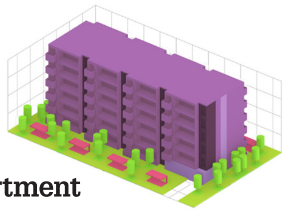
The plugin which is directed at representing and designing with discrete elements. The description of each individual element or generic pod includes parameters for the aggregation process (geometry, connections location and orientation). The set of connections define the topological graph of the element or generic pod, which is then used to define the possibilities of aggregation with other parts to form generic pods or objects.

The core of the framework relies on a set of aggregation iterations, allow the generation of specific structures from the combination of different elements of generic pods. Each of these iterations is composed of strategies for the selection of aggregation rules. Which can be described as an instruction to orient one element or generic pod over a selected connection of another element or generic pod.

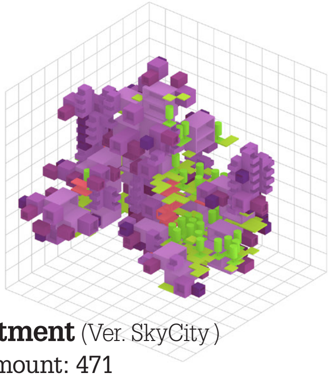


4.5.6. Reflections

To measure the advantages of the Sky City. We have developed a tool which can quantify and compare multiple parameters, such as space efficiency, porosity, terraces and sun radiation. We have chosen to compare an apartment and have therefore deconstructed a contemporary building and computed a sky city object. In the following comparison we can see how the Sky City object outperforms the apartment building in the chosen framework.



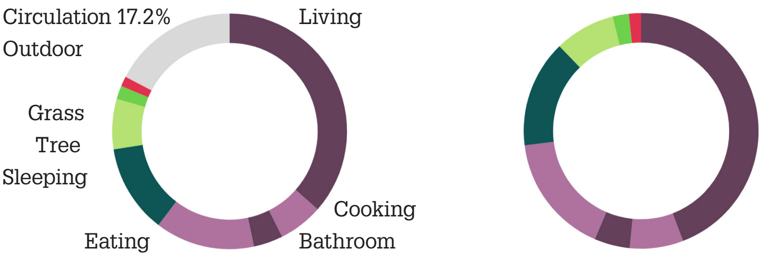
Apartment
Floors: 6
Unit: 47
Area: 4350 m²
Volume: 16008 m³
Capacity: 141



Apartment (Ver. SkyCity)
Pod amount: 471
Volume: 13233 m³
Capacity: 141

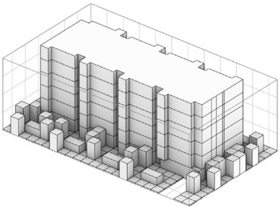
To compare Sky City Objects with buildings nowadays, an apartment building is chosen as an example to analyze. This apartment is taken apart according to different pods and aggregate again with the same capacity but in a Sky City way. In the following comparation, we can see how the porosity, terraces surface and sun radiation performance of an Object are improved in Sky City.

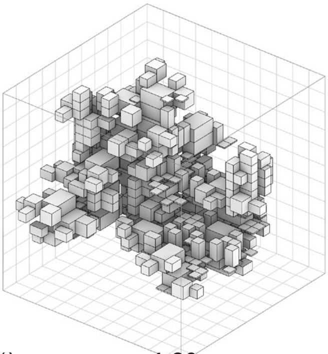
1. Space efficiency (Functional volume/total volume)



83.8% (Increase 19.3%) 100%

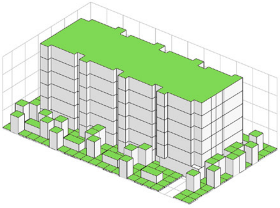
2. Porosity (surface/volume)

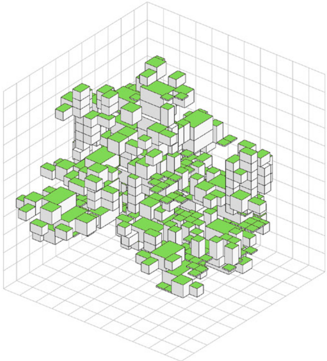




	0.49	(Increase 165%)	1.30
Bounding box:	41804 m^3	(Increase 294%)	164540 m^3

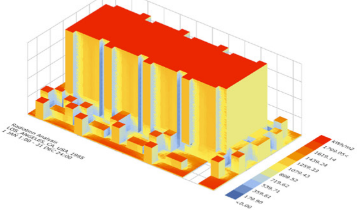
3. Terraces

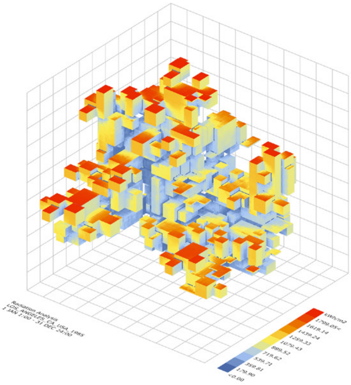




1889 m^2 (Increase 121%) 4178 m^2

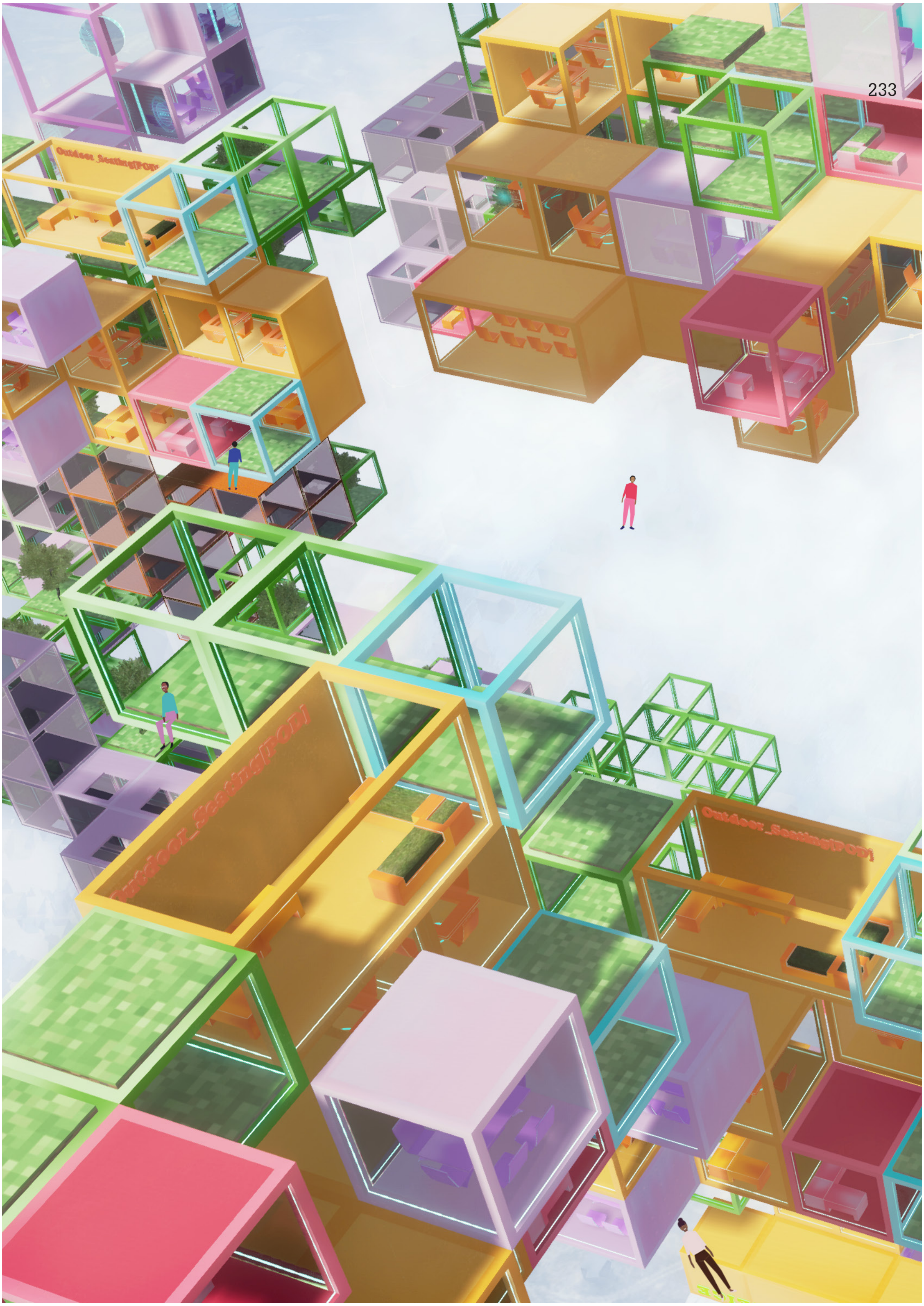
4. Sun radiation





4.8e+6 kwh/yr (Increase 39.6%) 6.7e+6 kwh/yr


OFFICE
OFFICE


Outdoor_Seating[POD]