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Architecture of Video Games: Potential Reference

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ARCHITECTURE OF VIDEO GAMES : POTENTIAL REFERENCE

BY

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To my parents:

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What a journey this was.

Abstract

The Architecture perspective/scale in video games has evolved throughout time to the extent that it is no longer a mere spatial visualization to host the game. Still, it has become an interaction medium between the player and the game. Architecture in recent video games played a fundamental role in bridging the gap between the real and the digital world. The analogy between these two is increasingly established through the representational immersion and the player's participation in a highly realistic environment transforming the gaming experience into an entertaining and educational journey.

The aim of this thesis is not only to explore insights into the depth of video games referencing through an urban and sustainable way but also to investigate the potential application of video games' architectural environment in real-life settings as guidelines to promote sustainability in both Architecture and Urbanism.

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Introduction

Video games and Architecture are two specific things. On the one hand, Video games are about immersion in a virtual space, like what Janet Murray, a professor in the School of Literature, Media, and Communication at Georgia Institute of Technology, attributed the experience of video games in her book: *The Future of Narrative in Cyberspace* as follows:

> *"The experience of being transported to an elaborately simulated place is pleasurable, regardless of the fantasy content. Immersion is a metaphorical term derived from the physical experience of submerging in water. We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming pool: the sensation of being surrounded by a completely other reality, as different as water is from the air that takes over all our attention, our whole perceptual apparatus*." (Murray 1997)

This statement was a clear announcement of the degree of authenticity, believability, and realistic immersion provided in the digital world of video games, which have come from an unexpected evolution throughout the past 30 years. These ever-growing worlds are all about the fluidity of the image inside an actual free of constraints of physics and logic. Yet, they are becoming more and more intertwined with the real world.

On the other hand, Architecture is the art of building. Strictly rooted in the real world of physics, norms, and logic, these entities house functions indispensable for the human species' daily life from the dawn of time.

They are derived from different circumstances and constraints which define the typology/morphology of the building entity as a single unit and also as a component of a whole. They are built to host their dwellers' multiple needs and are expected to respond to very well-defined building, environmental, and zoning codes.

> *"Architecture is really about well-being. I think that people want to feel good in a space . . . On the one hand, it's about shelter, but it's also about pleasure . . . it's about people enjoying that space. That makes life that much better. If you think about housing, education, whether schools and hospitals, these are all very interesting projects because of the way you interpret this special experience*." Zaha Hadid (Kate 2011)

> *"As an architect, you design for the present, with an awareness of the past, for a future which is essentially unknown." — Norman Foster* (Arenas 2014)

From Zaha Hadid's citation, the fact that architecture is represented as a pleasurable shelter, a unique experience proves that thinking architecture is not only about 4-corner edifices, but it is about the induced lifeful immersion in the space. As for the second one, Norman Foster ends his quote by saying that architects design for an unknown future. This claim is an announcement of the uncertainty of the upcoming challenges and constraints for architecture in the future.

Each building design is a statement of articulation of different forms considering several requirements. The space provided by the building creates an experience based on the response of the design part of the architect.

The fact to be drawn from these two statements is that even though the architecture is a well-defined science of art legislated by several aspects, it is still wrapping potential perspectives yet to be seen or discovered.

Problem statement

In the actual time, video games heavily rely on delivering the best architectural space content to its users as it enhances their immersive experience of the game, and this has set up a whole different approach to what the digital space represents in terms of playability but also its intertwined relationship with the actual space. Recent incidents like the Notre Dame church in Paris and Ubisoft's rebuilding support (Ubisoft 2019) prove an unforeseen future that could be nothing like one has ever imagined. It is undeniable that the progression and evolution of the digital world happen much faster than the actual one, and this rhythm is so different that it is highly predictable that referencing digital architecture is a near future to take place

How will video games influence future architecture, and how long will the world witness its first digital reference?

What are the means and methods to introduce sustainable architecture through video game references?

Literature Review

In recent years, the relation between Architecture and video games grew stronger as recent games became more graphically rich and implemented many spatial details in their contents. In early videogames, the role of architecture was less significant compared to the digital characters of the plot. The role architecture played was merely that of providing the user/player with a sense of space without any significant approach to the architecture itself specifically or the environment in general. Due to the low resolution and limited graphics and looking back at video games of the early 80s through 90s, it is quite distinctive how consistent but yet not really established the role architecture was playing, the user attention was mainly focused on the plot of the game/characters and events.

This role started taking more emphasis and importance in contemporary 3d video games, which deliver a digital transmission of a whole universe through architecture to its new audiences with realistic graphics and textures.

To provide instances of the evolution of architecture in video games and highlight one of the most driving factors of contemporary video games, which not only imitates the actual architecture but started establishing its owner style/profile.

The area of interest of this research is focused on how architecture can be used to teach/establish sustainable principles in terms of architectural and urban design. The history that traced this evolution is very crucial to review and how architecture/architects of nowadays could be influenced by the emergence of architecture, free of constraints and norms.

In the Article of Ewan Wilson, 'The impossible architecture of video games' (Wilson 2019), the author highlights the free of nature/physical constraints of architectural buildings/structures/monuments using findings and works from the past to support its theory. The

author investigates this phenomenon through the use of a stage of a map in the games of Dark Souls and Bloodborne, in which both environments bear the concept of abstract forms folding forms in darker shaded spaces. The author traces back these orientations of concepts to the early forms of impossible architecture through the likes of paintings of Varro called 'Tomb of Porsena.' It is not about daring architecture; it is about thinking about architecture in a non-rational unbuilt form, at least for the actual time. The article further stresses its theory by investigating other forms through the work of French architect Etienne Louis Boullee who worked during the revolutionary period. His concept was straightforward, a mere representation of geometry at an unimaginable scale.

The article does make a significant contribution through the analogy of these abstract forms of art done by painters from the early 1700-1800 to video games of recent times. Half-Life 2, a game that heavily emphasizes the concept of a great science-fiction environment, presents some of these artistic architectural impossibilities. City 17, a central citadel, is immensely tall to a point it disappears into, as described in-game, the heavens. This building erects from the ashes of a chaotic city to invigorate the players leaning on the dystopian quality of this concept. The combination of this game's distorted architecture is a statement of radical evolution.

Evaluating this article, the author was quite subjective in their approach by providing materials of his findings and certain comments on each of them. It is also quite interesting that the author did provide a detailed analysis of the game only possible by someone who has already experienced these games. Therefore, his approach to analyzing this topic was quite convincing and concise. The conclusion drawn by the author does an emphasis the future possibility of the influence of these impossible built forms not only on the 'big-budget games, which usually play it safe when it comes to designing environments but also to the actual architecture.

Another area of interest in my research is the role of architecture in video games. It no longer stands by as an envelope but more like a factor engine that runs and influences the whole sequence of events in a video game.

In the Article of Luke Pearson, 'Worlds that are given, How architecture speaks through videogame (Pearson, Worlds that are given, How architecture speaks through videogames 2018), the author mentions recent video games (Skylines, Block'Hood)and video games engines (Unity and Unreal Engine) to provide a concrete instance to the development of the world of architecture inside videogames. According to the article, the scale of the explorable world that used to be in the games of the 80s and 90s is nowhere near as astronomical as nowadays games, which offer more than one instance. It offers the main map, different sub-mini-maps (once the player enters a specific location: House, shop, dungeon.), and so on that the sense of space getting shrunk depending on the instance renders these virtual geometries more realistic than ever before.

In order to convince the reader and renders its theory more credible, the author cites the famous sayings of well-known architects:

Dishonored's Dunwall, or 'architecture is defined by the actions it witnesses as much as by the enclosure of its walls' 3 - Bernard Tschumi

Constant handshakes: 'the door handle is the handshake of the building' 5 - Juhani Plasma

Katamari urbanism, or rather 'there are 360 degrees, so why stick to one? '10 - Zaha Hadid

The Last of Us, where 'even a brick wants to be something' 12 - Louis Kahn

After each of these citations, the article prolongs in discussing its analogies to the world of digital architecture through exclusive games representing the concept/theory mentioned in the citations. For those who have previously experienced some of the games the author mentioned (Last of Us was a genuine multiple award-winning masterpieces) the link between the games and citations is

strongly visible, which further enhances the theory of the author and provides it with a solid foundation.

The author's contribution to the theory discussed is quite invisible for someone who has not experienced these games; it might not be easy to recognize. Or maybe was it a prior condition to be a previous player of these games to actually grasp the fundamental approach of Pearson?

The spatial perspective of real and digital is astonishingly different, despite the potential similarities between them. Recent video games replicate the actual environment in a jaw-dropping way. Not only that, but there could also be other additions to it that make us, the players, wonder the reason why they are still absent from the actual one.

'Architectures of deviation: exploring the spatial protocols of contemporary videogames by Luke Pearson (Pearson, Architectures of deviation 2015)

This article's objective is to shed light on the perceived space in video games and compares it to the real one. Also, it highlights different games' spatial protocols and how players are part of these interactive environments; it gives a perspective of the means used to offer an understanding for architects about the bridging between the computational and the representational in architectural design.

To achieve that, the author uses iconic video games with outstanding and unique maps, multimillion record-breaking franchises like Grand Theft Auto (GTA V in this article specifically), and Minecraft. The use of these games as case studies to implement his arguments starts with a well-established solid ground.

Was the author's objective? Not really, and in my opinion, should not be. The storytelling of these games' experience of space is quite similar to one's adventure or childhood memories. Objectivity is not really considered throughout these sequences.

The articles investigate mainly four important chapters/concepts; scalable symbolism, the 'Ludodromic' space and ubiquity, the new gemology, and the long-zoom landscapes.

These four chapters are investigated thoroughly in the aforementioned games, specifically in GTA V. Each of these spaces gives a new perspective to the notion of space and its use or implementation depending on the course of events.

The player interaction and personal decision do also affect its surroundings and end up simulating a different ending with different spatial circumstances.

This article did contribute to the understanding of the theory proposed. Out of the three articles I mentioned in this literature review m I find this one quite informative and convincing by a small margin.

Theory and Methods

The approach to analyzing the spectrum of the project's success is based on the referencing of in-game cities established in an extremely hostile environment. Through a constraints and opportunities analysis, a baseline tool of comparison will provide a convenient threshold to be considered in proposing an alternative answer in a similar extreme hostile environment.

The research will be based on evaluating, selecting, and comparing the current sustainable design methods and the digital settings and merging them at a certain point in the proposed design location, and verifying their efficiency.

The preferred research methods will be both quantitative and qualitative.

Quantitative: by measuring the level of efficiency in referencing sustainable design concepts in the in-game-based settings.

Qualitative: by measuring the reliability of the threshold and establishing a final validity answer.

Chapter I: Theoretical Approach: Architecture of video games

Figure 1: Assassin's Creed Origins. Source : https://www.wallpaperflare.com/assassin-s-creed-egypt-bayek-assassin-s-creed-origins-architecture-wallpaper-chddg

" A game is an opportunity to focus our energy, with relentless optimism, on something we're good at (or getting better at) and enjoy. In other words, the gameplay is the direct emotional opposite of depression."[1]

Jane McGonial, Reality is broken: Why games make us better and how they can change the world.

[1] ("Video Games Quotes (107 Quotes)" n.d.)

- **History of video games :**

The early traces of video games go back to the year 1958, October 18, when visitors had to wait in line at the Brookhaven National Laboratory to try out William Higinbotham ‘s T42[2]. An undoubtedly a forerunner of the modern video game was a two-dimensional side view of a tennis court on an oscilloscope screen. It was created for an open audience. (Brookhaven National laboratory 2020)

Figure 2: T42 was played by an Oscilloscope. Source : (Museum of electronic games and Art 2020)

In 1962, four years later, the second video game form came out. It was “Spacewar by A.S Douglas, a British professor. It was the first computer-based scale combat type and was regarded as a landmark back in that time. In the same year, Spacewar was also another video game based on

[2] T42: Tennis for Two

computers that were developed by students' programmers and developers at MIT (Massachusetts Institute of Technology) in collaboration with Digital Equipment Corporation (DEC).

Figure 3: Spacewar MIT. Source: (museum 2011)

Ten years after T42 and Spacewar, in 1972, came out the infamous gaming industry revolutionary 'Pong' was created by Bushnell and Ted Dabney. An Atari-based game, the world has now witnessed the birth of a new media, which will be an increasingly sophisticated, immensely popular multi-billion worth industry. (Rachel Kowert 2016).

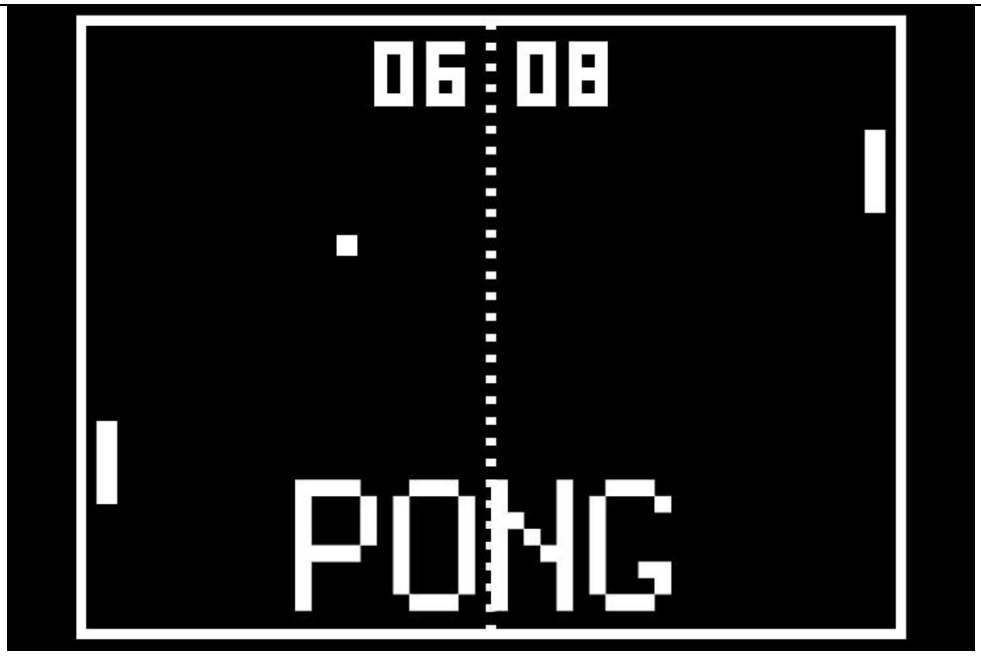


Figure 4 : First video game supported by a computer. Source : (van Roessel 2014)

The world was taken by a new trending form of media, and since 1972, video games have known an unprecedented worldwide level of evolution. The advances in computer technology resulted from the ever-increasing desire to play more advanced videogames pushing it from its initial form of a boxy blocky two-dimensional low graphic version to a photorealistic enhanced 3D rendered interactive environment. (Zach Whalen 2008)

The following section is a video game selection that highlights the most iconic gaming revelations throughout the years. The selection is based on both research and the author's personal experience.

- **Evolution of video games**

Starting from the 70s, the iconic video games of this century, excluding T42 and Pong, were actually building on the original gameplay structure of the two aforementioned.

  - Breakout (1976)

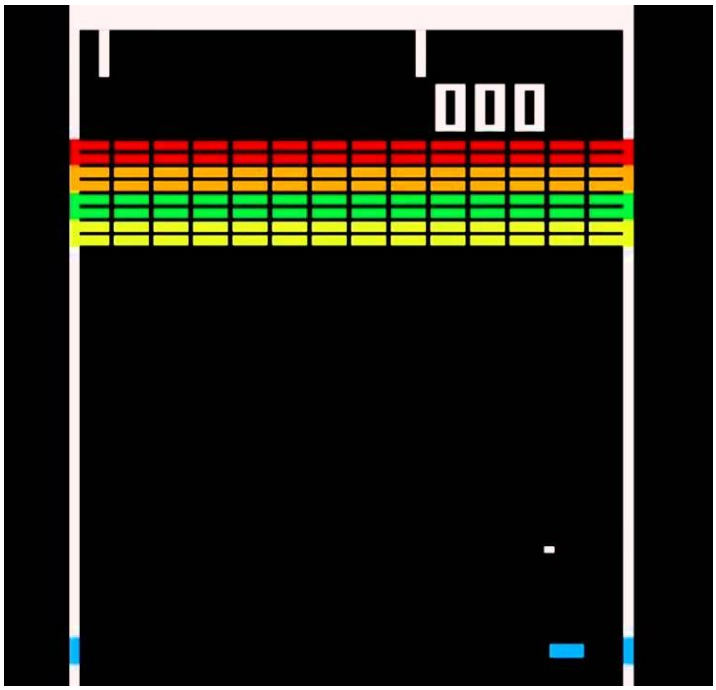


Figure 5: Breakout. Source : (Stulir 2016)

Breakout celebrated its 40th anniversary in 2016, and it was an Atari-based video game released in 1976. The developers initially were eager to make the game different than its predecessors as a statement of moving on from the 'Ball and paddle' game concept. But they still reassigned the game to their 'Grass valley' think-tank. The game was sold from a standard upright or a round cocktail table. Sales were around 11,000 sold cabinets. Several sequels, like Super Breakout, were later released in 1978 and later dates, and these ones featured additional gameplay modes and arcade variations.

- Space Invaders (1978)

Celebrated it was 40th anniversary in 2018, Space invaders was one of the earliest shooting-based games. A lot of controversies surround this game, as it is among the games which have been most copied. But also, some claimed that 'Space invaders' is a copy itself of the legendary 'MIT Spacewar' (1962). This game launched the revolution of the American gaming industry over the Japanese gaming economic mega-growth, and this created a long-lasting rivalry between the two poles. (museum 2011)

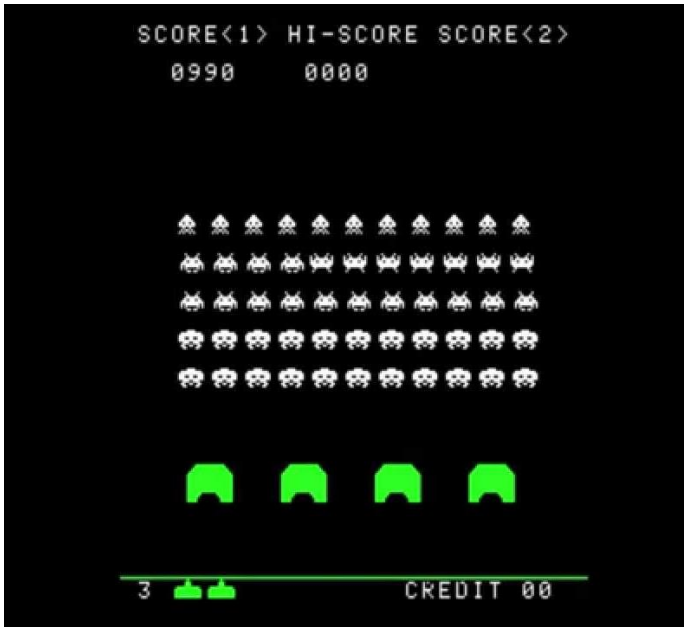


Figure 6: Space invaders. Source: (Stulir 2016)

Other games to mention in the 70s decade were Night Driver (Atari,1976), Tank 8 (Atari /Kee Games,1976), Clowns (Midway,1978), Gee Bee (Namco,1978), Asteroids (Atari,1979), Galaxian (Namco,1979), Lunar lander (Atari,1979), Lunar rescue (Atari,1979), Monaco GP (Sega,1979).

Monaco GP was the only game among the rest of the aforementioned games which didn't share the same 2D dimensional Pitch-Black background screen and injected a fresh, lively color palette instead of the two tones (Black and white) which were previously dominant. It is also important to

note that Night driver (1976) had a false 3D perspective effect despite the limited resources the developers had at that time. (channel 2017)

In 1979, the launch of the infamous multi-billion first third-party game developing company Activision took video games out of the consoles and arcade cabinets. (Editors 2017)

Moving on to the 80s decade of video games, this is where the actual breakthrough in the gaming industry occurred. The following is the list of the most iconic ones with some honorable mentions afterward, as there are just thousands out there to mention them all.

- Pac-man (1980)

One of the most popular games of all time, and when it was first launched, it was regarded as a national fever, especially in the United States. It attracted all ages, but especially teenagers were addicted to the instant satisfaction that comes with every devoured dot. It provides a sense of accomplishment and success. It possessed an unmistakable ambiance of fear, excitement, and fulfillment.(Bowman 1982)

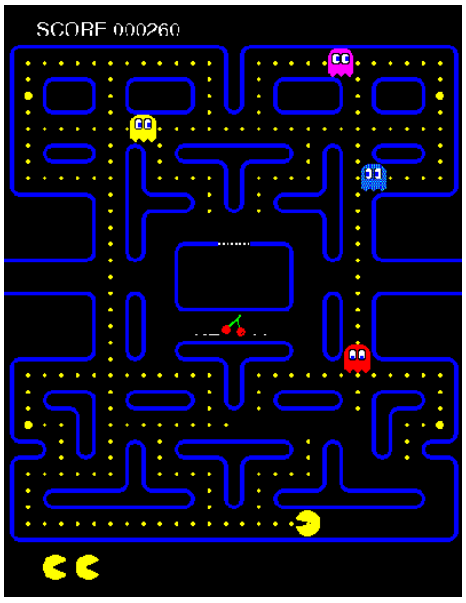


Figure 7: Pac-man. Source: https://www2.cs.duke.edu/courses/summer03/cps006/classwork/objects.html

- Mario Bros (Nintendo, 1983)

Another all-time favorite, Mario bros, hit big, and it went viral worldwide. The Nintendo-based game was not only a revolution in terms of the introduction of an adventure type of gameplay with interactive surroundings through differentiation of levels, heights, gaps, and direction changes, all composing a unique player experience (Pedersen, Togelius and Yannakakis 2009), but also

Figure 8: Mario bros Source: https://www.nintendo.com/games/detail/arcade-archives-mario-bros-switch/

scientific reports affirmed that this specific type of gameplay actually aids in the assessment and development of a child's problem-solving skills abilities. (Gardner 1991)

- Street Fighter (Konami, 1987)

A considerable breakthrough in the gaming industry, Street Fighter (SF) introduced one-on-one battle-type gameplay in enhanced 2D graphics through multiple plans layered one on top of the other. In a contextual reference, SF immerged from the Asian culture and history, specifically the Japanese one. (Ng 2006)

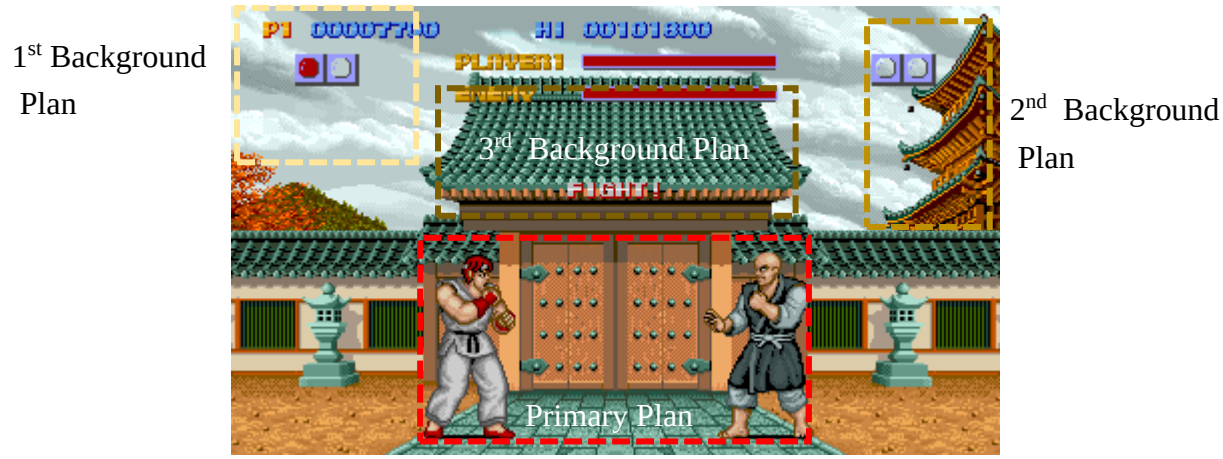


Figure 9: Street Fighter Konami. Source: https://www.fightersgeneration.com/games/sf.html

SF had an undoubtedly revolutionary impact on the arcade scene, especially by paving the way for one of the most recognizable video game franchises to ever be designed. It was a vivid inspiration for many other video game companies to dive into the realm of fighting.

The following are some iconic games that marked this decade and were quite popular. What is more interesting is that each of these videogames initiated a whole series of genres based on its gameplay concept and the player experience: Tank battalion (Namco,1980), Frogger (Konami /Saga,1981), Galaga (Namco, 1981), Pole position (Namco,1982), Pro evolution (Data east, 1983), Tetris (Gameoby,1983), Contra (Konami,1987).

Jumping to the 90s, this was a historical period marked by a number of breakthroughs and innovations in the industry of video games.

- Doom (Nintendo, 1993)

One of the iconic and revolutionary FPS (First-Person-Shooter) gameplay horror games of that decade. It was based on Models to design and animate the characters. The storyline, the sound effects which had metal influences, and the graphics were spot-on in order to create one of the unique player experiences in the modern video game industry. The environment in which the events fold is quite dark-themed and sets the mood for a surviving journey. Materials used are

mostly stone, wood, and concrete. The game showcases the great depth of field and blends well lighting with the space perspective.

Figure 10: Doom Source: https://www.mentalfloss.com/article/62928/14-explosive-facts-about-doom

- SimCity 2000 (Microsoft Windows / PlayStation, 1993)

This is one of the examples of how video games could add a scholarly dimension in addition to the entertainment aspects. SimCity 2000 is a computer-based simulation game, in which players build their own city. The game served as a tool for teaching urban, geographic and environmental

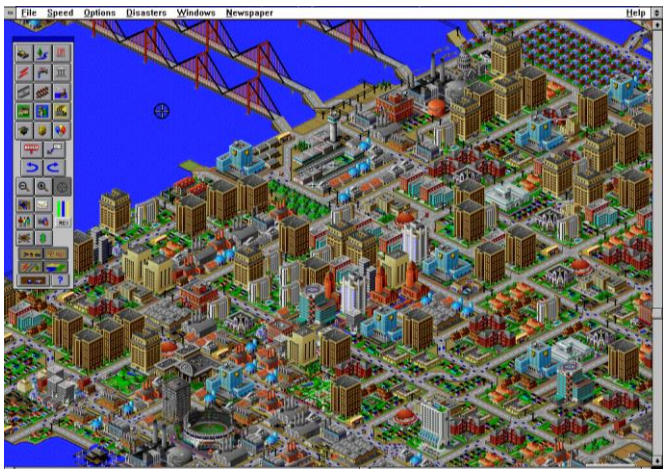


Figure 11: SimCity 2000. Source : https://socket3.wordpress.com/2019/09/26/ebay-purchase-24-maxis-simcity-2000-special-edition/

concepts. It exposes players to the constraints of monitoring the growth/decay of their built city by testing their critical thinking, dynamism, and decision-making abilities. (Adams 2007)

- Metal Gear Solid (PlayStation, 1998)

Figure 12: Metal Gear Solid (1998). Source: https://gizorama.com/2015/computer/pc/metal-gear-solid-ground-zeroes-pc-impressions

Metal Gear Solid (MGS) was a game ahead of its time. It was most famous for its tense stealthy gameplay, cinematic cutscenes, and overall sense of different inspiration either from 80'saction movies or anime in general. The architecture of the game is quite interesting, as it added a touch of materials differentiation, utility, and lighting. This latter is a very important factor in this game, and it does blend well with the stealthy gameplay style. (Allen 2015). In addition to this, MGS was the subject of scientific research on what is likely to possess enough persuasive power through its verbal and textual cues to combine with audio-visual elements and highly specific gameplay strategies. (Dušan Stamenković 2017)

Moving on to the 2000s century, this was a huge leap in the gaming industry, as video games, and mostly its graphics and environment, simply exploded.

- Half-Life 2 (PlayStation,2007)

It presented its environment as a post-soviet eastern European city with a whole new style of landscape, geography, and architecture. It was a subject of scholarly offshoot storyline primarily focusing on the perspective of narratology. The architecture is quite unique as it combines architecture styles dating from pre-World II neoclassicism, post-war classical designs, soviet modernism, and post-soviet contemporary style along with the adaptive architecture of the invasive species. (Half-LifeWiki 2018)

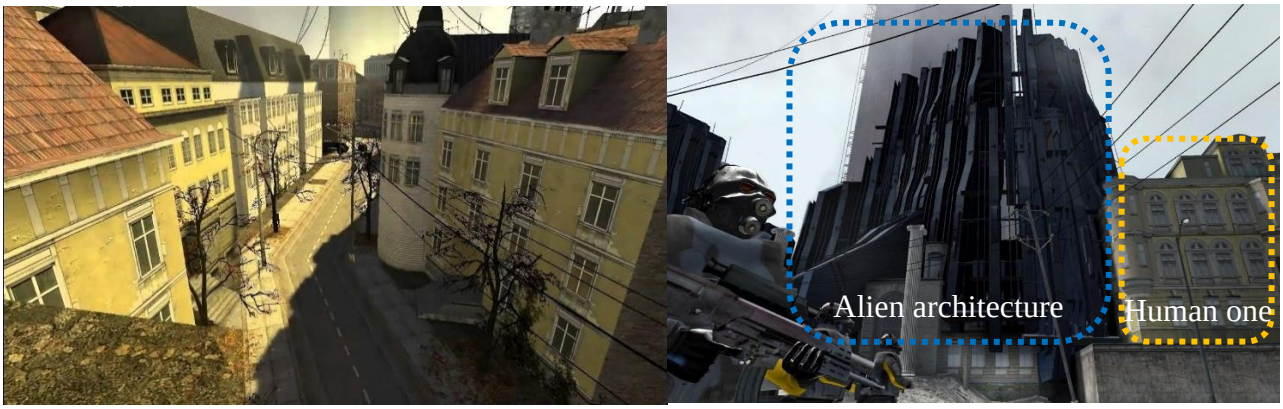


Figure 13: Half-Life 2. Source: https://www.gamesradar.com/half-life-2-review/

In city17, players come across a massive skyscraper, the Citadel, which is tall enough to go through

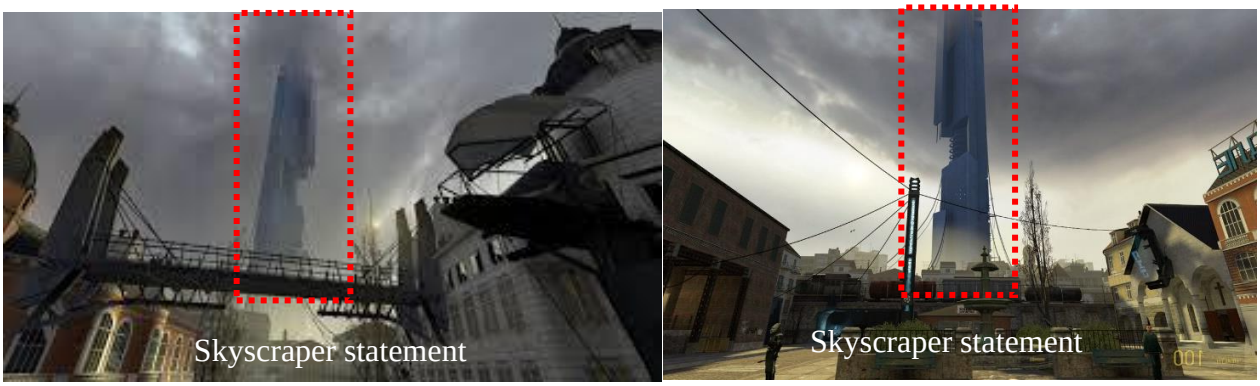


Figure 14: Half-Life tower. Source: https://www.gamespot.com/articles/half-life-2-the-anatomy-of-a-classic-part-one/1100-6419674/

the clouds. This building specifically is a statement of social segregation imposed by the absolute authority through an astronomical rein of economic, social, and political dominance.

The architecture takes a whole new role in addressing the gameplay storyline. This is exactly where videogames and architecture are at their best in harmony, merging into one organism and delivering strong, powerful statements. (Roelf Kromhout 2013)

- Grand Theft Auto (GTA): Vice City (PlayStation,2002)

Figure 15: GTA Vice city (PlayStation / PC, 2002). Source: (GTAwiki 2020)

Figure 16: GTA Vice City (PlayStation / PC, 2002). Source : (GTAwiki 2020)

GTA vice city was a cultural hub filled with nostalgia. It recreated the Miami 80s with an emphasis on visual art, music, fashion, and entertainment. Other than the astoundingly similar geographic and urban layout, density, and architecture as Miami, notably the neon-bathed art deco and

anonymous postmodern high rises, the most interesting theory about Vice city is the American tropical metropolises which are intertwined with certain cultural relics.

Figure 17: GTA vice city. Night under Neon lights. Source : (GTAwiki 2020)

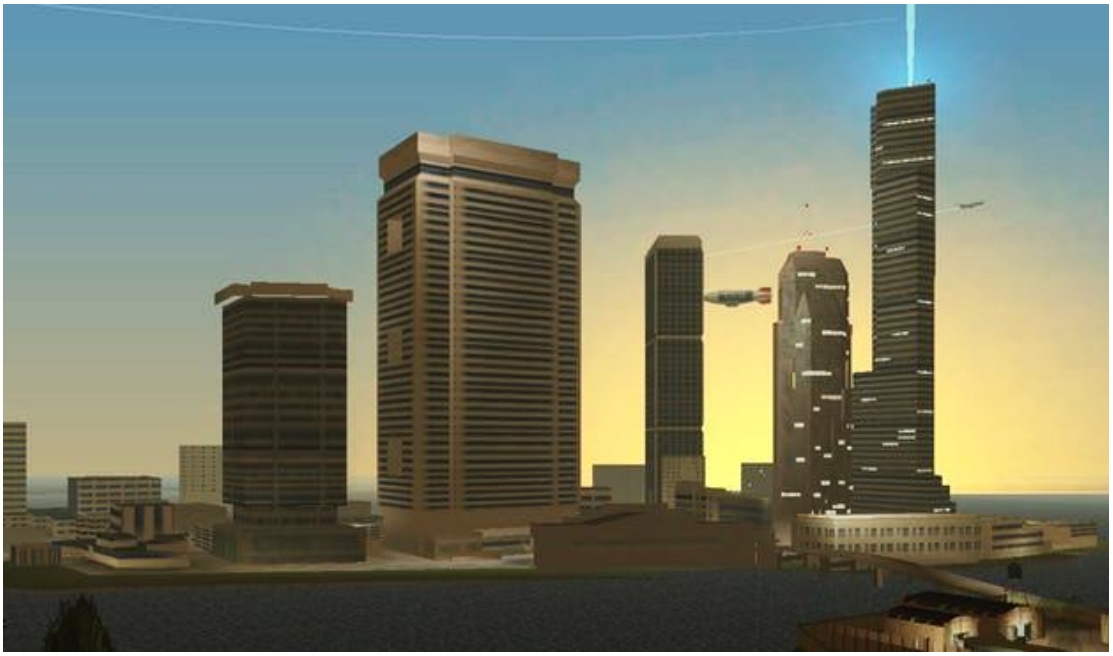


Figure 18: GTA vice city. Anonymous postmodern architecture. Source : (GTAwiki 2020)

- GTA San Andreas (PlayStation2 / Xbox 360, 2004)

Based on the city of San Francisco, the resemblance between the latter and the in-game city ‘San Fierro’ is strikingly notable. San Fierro perfectly represented the iconic qualities of a city known for its countercultural history and architectural/urban heritage through a phenomenal coastal landscape.

Figure 19: GTA San Fierro cultural mishmash. Source : (GTAwiki 2020)

Figure 20: San Fierro coastal landscape. Source : (GTAwiki 2020)

Figure 21: San Fierro's Chinatown. Source: (GTAwiki 2020)

San Fierro goes one step further to embody the post-disaster environment landmarks such as the ostensibly stable Transamerica Pyramid as the city's image of continuous damage following the 1989's Loma Prieta earthquake.

Figure 22: GTA San Fierro Post-earthquake landmarks. Source: (GTAwiki 2020)

Another city that was part of the San Andreas game is Las Venturas, which is a direct reference to the city of Las Vegas. On the one hand, for a city that was cast in the early 90s, it has demonstrated vibes of the Disney-like themed casinos of cities like Las Vegas. This engendered an aspect of virtual escapism, which is basically what most of the iconic buildings within the city showcase to incite diversity, culture, and prosperity.

Figure 23: San Fierro. Las Venturas. Source: (GTAwiki 2020)

Figure 24: The Luxor. Source: https://www.tripsavvy.com/luxor-hotel-casino-4123442

Architecturally, one of the direct references to Las Vegas in the city of Las Venturas is the presence of the Luxor, Caesar's Palace, and Excalibur Casinos.

Figure 25: GTA Excalibur Casinos. Source : (GTAwiki 2020)

Figure 26: Excalibur Casinos. Source: https://www.pinterest.com/pin/331929435014982259/

Figure 27: Caesar Palace reference. Source: https://www.reddit.com/r/PlacesFromGames/comments/egaw1t/gta_san_andreas_caligulas_casino_caesars_palace/

In GTA Liberty City, New York City was the genesis of the map. And Liberty city portrays the latter in its most fashion: through its grime and crime of the 90s, its busy dense street, its nightlife style with the lighting and sound effects, many details inciting the blight and decay of aging brownstones, deteriorating ornamentation.

Figure 28: Liberty City. Source: (GTAwiki 2020)

Figure 29: Portraying NY City through its monuments. Source: (GTAwiki 2020)

- GTA San Andreas Los Santos (PS3/ PS4/PC,2013)

Figure 30: GTA V overview map. Source: https://www.gtaboom.com/gta-v-map-los-angeles/

Figure 31: GTA V Beach view. Source: https://www.gtaboom.com/gta-v-map-los-angeles/

The city of Los Santos, the same city which has previously appeared in San Andreas, is the exact replica of the city of Lon Angeles, California, through numerous identical landmarks and monuments inciting the sense of cartographic realism and authenticity. (Long 2013)

Just like any American city, Los Santos has wide streets, freeways, and many bridges that make mobility through the car the best way of transportation. A tremendous design is focused on in order to make a simulacrum of a city region, giving an authentic style of living. It is well known for being a city model, unlike other archetype games of the past, to be a low-rise city and suburban sprawl.

Figure 32: A city overview from a mansion. Source: (GTAwiki 2020)

Figure 33: MazeBankArena. Source: https://gta.fandom.com/wiki/Los_Santos_(HD_Universe)?file=MazeBankArena-GTAV.jpg

Figure 34: Downtown LosSantos, Vinewood and MorningWood areas. Source: https://gta.fandom.com/wiki/Los_Santos_(HD_Universe)

- **Architecture themes/movements of video games**
    - Prince of Persia (Sands of time): Persian Architecture

Figure 35: Alamut Birdview. Source: https://princeofpersia.fandom.com/wiki/Alamut

Figure 36: Alamut Birdview. source : https://princeofpersia.fandom.com/wiki/Alamut

For a game with innovative gameplay standards, Prince of Persia (PoP) did stand out of its uncommon Persian architecture, unlike the dominant western side. The events unfold in a city called Alamut in which several representations of the Persian architecture through ‘Onion’ shaped domes, pillars, arches, inner courtyards, Moucharabieh (Similar to Bay), Minaret-like towers in

each corner of the castles, oasis, sandy palette of colored materials. (Prince of Persia: Architecture in The Sands of Time 2016)

- Assassin Creed: Islamic Architecture

The series of Assassin Creed (AC) is considered a scholarly source for history as it was developed with the aid of history scholars, manuscripts, history web, documentaries, old medieval encyclopedias, paintings, and novels. In AC 2007, the plot takes place in three different cities, Jerusalem and Damascus.

Figure 37: Birdview from minaret over Damascus. Source: assassinscreed.wikia.com.

The Architecture was a unique blend of Byzantine, Sasanid (Persian), and vernacular architecture styles. "*This eclectic style featured engaged columns, horseshoe arches, colorful spandrels, intricately corbeled domes, Corinthian capitals, iconographic inscriptions, and stucco decorations*" (Edelson 2015)

Figure 38: Assassin Creed view over Dome of the Rock Source: https://www.pinterest.com/pin/463237511650187544/

Five visual patterns can sum up the environments of AC which are :

- *"zigzagged, narrowing paths called darb*
- *Edges that are seldom right-angled*
- *Districts that are occupied by certain ethnic groups or occupations*
- *Nodes that are occupied by city squares and markets*
- *Most importantly, landmarks such as mosques, churches, and castles*." (Seif El-Nasr Magy 2008)

- Assassin Creed: Roman Architecture

The events folded in the era of the Renaissance, during which the city of Rome was divided into four districts: Antico, Campagna, Centro, and Vaticano.

Assassin Creed presented the golden age the roman empire was witnessing at the time under the Nerva-Antonine. The emperor Trajan, along with his architect Apollodorus, built the infamous monuments which represented roman glory: Market, Column, and public baths.

Figure 39: AC Valhalla. Roman Amphitheatre. Source: https://www.artstation.com/artwork/18Rllo

Despite the architectural similarity between Florence and Rome back in that time period, AC designed Rome emphasizing its baroque style. (Assassin Creeed Wiki 2010)

The AC franchise develops a rich historical environment full of details demonstrating its grandeur and immerging role as an official scholarly source. Other architecture styles in other AC series were AC Brotherhood / Revelations: Renaissance Rome and Constantinople, AC III: Colonial North America (Boston, NY), while AC unity travels back to the French Revolution. (Spring 2015).

Figure 40: AC Brotherhood. Source: https://assassinscreed.fandom.com/wiki/Rome

Figure 41: AC Brotherhood. Source: https://assassinscreed.fandom.com/wiki/Rome

- Assassin Creed : Scholar source

On the evening of April 15, 2019, the historic infamous church Notre dame was burnt to the ground. Ubisoft, the AC's mother company, pledged to assist in bringing back the monument by not only financially supporting the rebuild but also, and most importantly, offering its own 3D model, recreated in AC's Unity in 2014, as the guiding model to revive the monument and stay Fidel to its detailed ornamentation and complex decoration.

Figure 42: Notre Dame Church Fire. Source: https://www.mercurynews.com/2019/04/22/letter-the-notre-dame-cathedral-fire-was-certainly-suspicious/

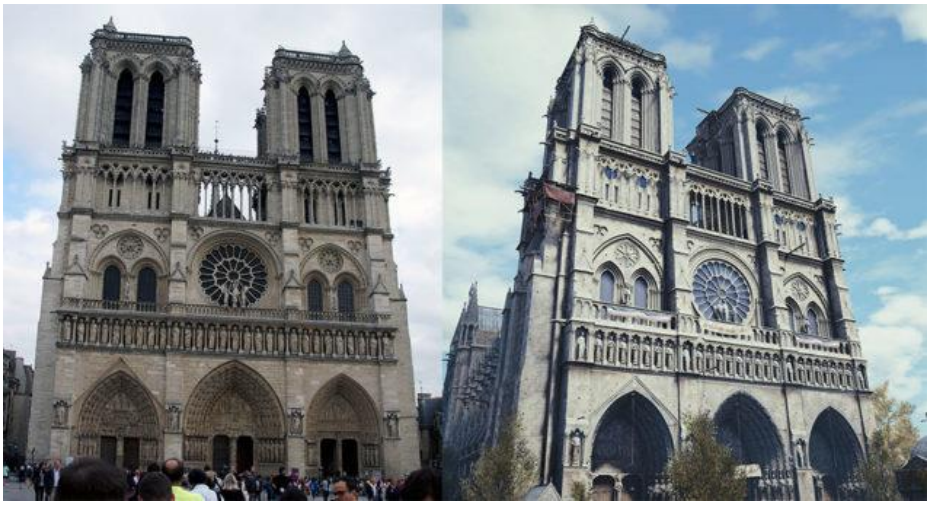


Figure 43: Comparison between actual and digital Notre dame church. Source: https://wccftech.com/assassins-creed-unity-ingame-paris-real-life-comparison/

- Diablo III: Architecture of High heavens

In this infamous Blizzard franchise, the player gets the privilege to travel to the most honorably places to exist: The High heavens. The Architecture of the latter has an emphasis on slim, vertical, central, and monumental scale elements. These features constitute a unique ensemble of Highness, sophistication, and Exaltation. Serene tranquility with immense inner peace and calmness is experienced while wandering through this enchanted arc. Details like the emphasis on, Pure white and bright gold colors, glass, and textile help translate the architectural style in this realm.

Figure 44: High Heavens imagined by Mortals. Source: https://diablo.fandom.com/wiki/High_Heavens

The High heavens architecture is a bastion of light and harmony. The environmental design concept gives a strong presence of divinity and high power through the miraculous theme of floating architecture.

Figure 45: High heavens imagined by Mortals. Source : https://diablo.fandom.com/wiki/High_Heavens

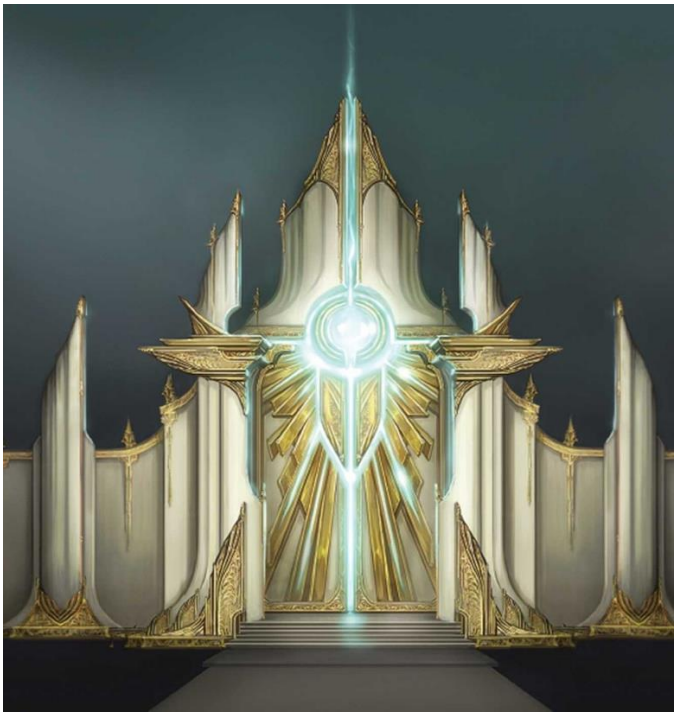


Figure 46: Diablo III High heavens. Source: https://diablo.fandom.com/wiki/High_Heavens

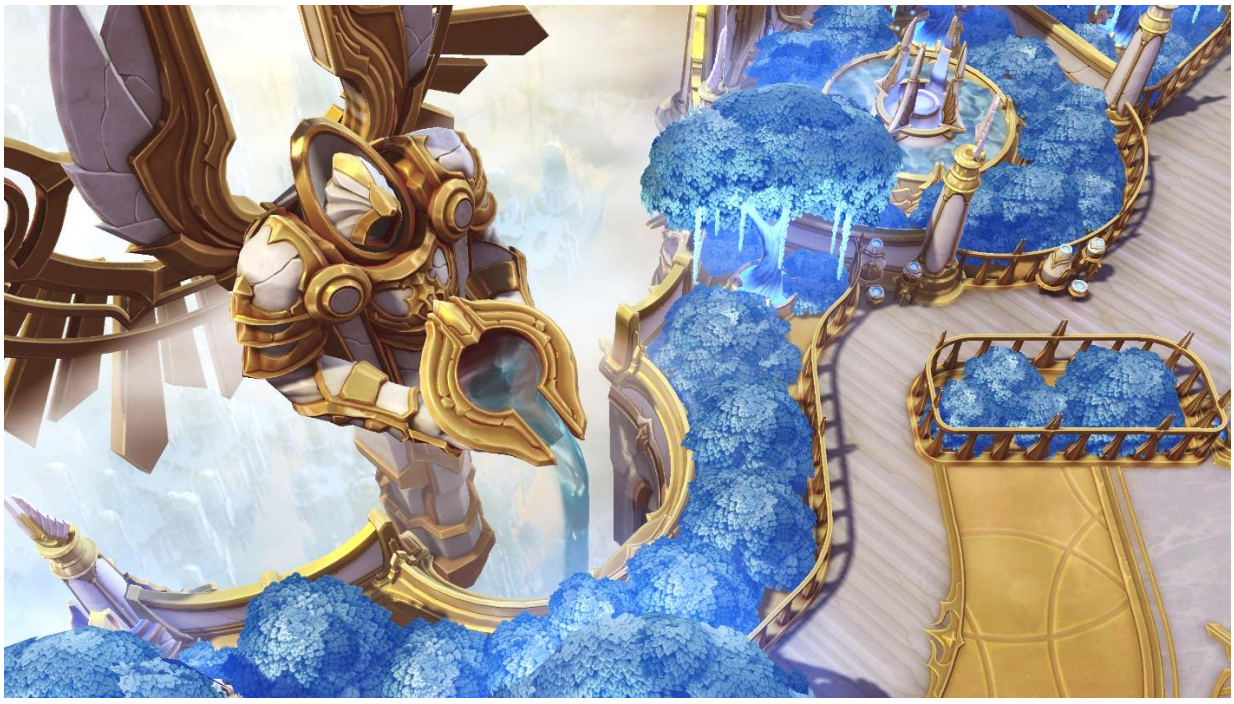


Figure 47: New Dawn on High Heavens.Source: https://diablo.fandom.com/wiki/High_Heavens

- Devil May Cry (DMC) / God of War (GoW): Architecture of Hell / Underworld

The DMC and GoW franchise series are well known for making their players experience a unique sense of thriller and heart-racing voyage by unfolding its events in a grim treacherous environment as a demon world with a hellish realm that hosts the demons of the underworld. The Architectural environment, as shown in Figure 48, Figure 49, Figure 50 Figure 51, relies on sharp, edgy geometrical structures, with an emphasis on figures of skeletons and skulls, invoking the theme of Death and Hellfire. The color palette is Black, grey, red, magenta, and orange.

Figure 48: Doom "hell gate" Concept Art. Source: https://www.reddit.com/r/Doom/comments/bpwq2s/new_concept_art_titled_hell_gate_from_the_doom/

The Architecture usually introduces the demon world either through a Hell Portal or an architectural entity that serves as the medium between the actual and the beyond world. The sources of light in the gloomy, cloudy environment are usually kept to a minimum, coming from a single source.

Figure 49: God of War. Source: https://www.pinterest.com/pin/305400418478729359/

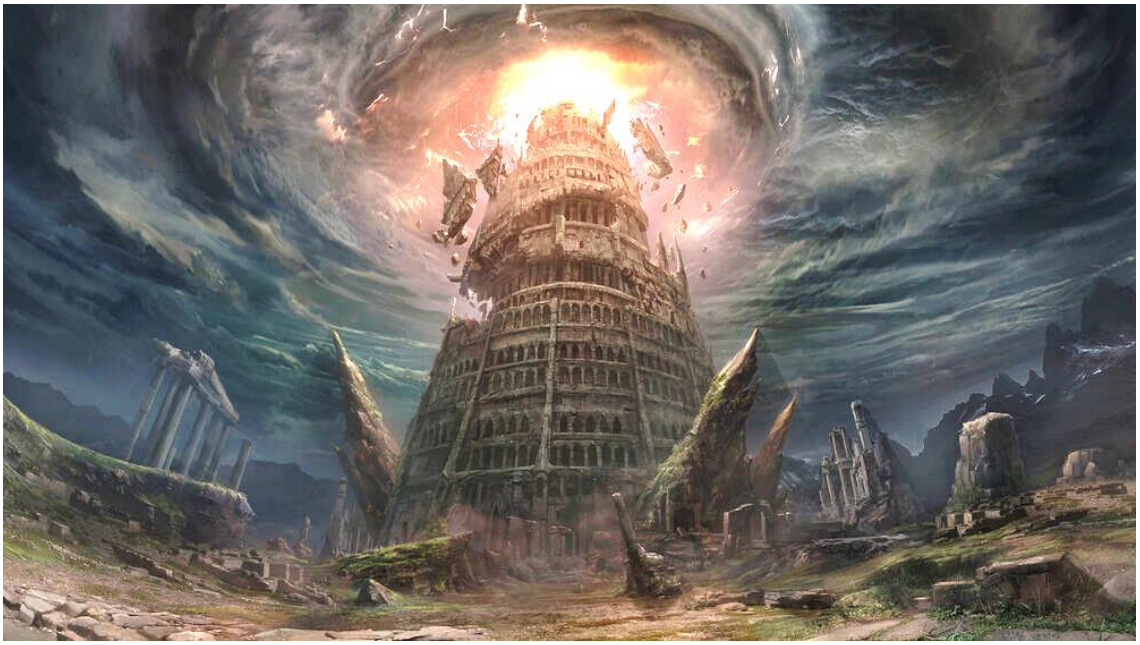


Figure 50: DMC's Temin-Ni-Gru Tower. Source:https://imgur.com/r/DevilMayCry/RkwX8tB

Figure 51: God of War. Source: https://www.deviantart.com/nichtelf/art/God-of-war-Hades-Temple-243435126

- Devil May Cry (DMC) / Tera Online / Destiny : Architecture of Impossible

A reality-defying surrealist world with no physics boundaries and constraints. In Figure 52, Figure 53, and Figure 54, each environment is a plastic frenzy of imagination with multidimensional monumental volumes. This Abstract approach confuses the player with its "*inverted gravity, ceilings serving as floors and self-rearranging environments*." (Devil May Cry Wiki 2021)

Figure 52: DMC's demon world. Source: https://devilmaycry.fandom.com/wiki/Demon_World

Figure 53: Tera Online floating island. Source: https://www.wallpaperflare.com/floating-island-chains-anime-tera-online-digital-art-landscape-wallpaper-upbro

Figure 54: The traveler, Destiny. Source: https://www.wallpaperbetter.com/games-wallpaper/destiny-the-traveler-night-hd-49134

Chapter II: Analytical Approach: Measurements and investigations

Figure 55: Assassin's Creed Origins. Source: https://www.wallpaperflare.com/assassin-s-creed-origins-video-games-assassin-s-creed-origins-wallpaper-cmkxa

" If Pac-Man had affected us as kids, we'd all be running around in dark rooms, munching pills and listening to repetitive electronic music."[3]

- Marcus Brigstocke

[3] https://www.goodreads.com/quotes/tag/video-games

- **Investigating the Sustainable Architecture in video games**

  - **Questionnaire :**

In order to investigate and understand the basic relationship between Architecture and Video games, how each interacts with the other and whether the impact is quite significant, the following is a questionnaire that targets participants with basic knowledge in both fields (Architecture, Video games). This choice is mainly to verify how evident the link between the two fields is for individuals who had a previous/basic architecture background along with some exposure to video games on any type of digital entertainment.

The questionnaire includes participants' age, education level, familiarity with video games, architecture within video games, and what they think about the learning curve videogames elaborate on architecture in any aspects (History, technologies…)

For each question, there will be a short text explaining the objective of the inquiry. This explanation is only provided in the thesis and not in the questionnaire handed out, which will be found in the Annex.

1-What is your age ? *

- Under 15
- Between 15 and 30
- Between 30 and 50
- Above 50

A general inquiry about the age of the participant is essential to pinpoint from which generation he/she is. Those who were born in the 70//80s do have a different videogames mindset from those born in the 90/the 20s.

2-what is your education level? *

- High School
- Undergraduate
- Masters
- PhD
- Other:

The question about the educational level is important to analyze how it could affect the choice of video games/opinion about the role of its architecture.

3-How often do you play video games? *

1	2	3	4	5	
Not much					Very often

The question targets the daily time spent by participant playing video games, the more frequent/long the time is the more relatable the understanding of the architecture within and its role is. Players spending over 2 hours tend to memorize the environment much more and get to experience the game on a profound level. (Association 2013)

4-How strong is your familiarity with the video games genre? *

1	2	3	4	5	
Very weak	◯	◯	◯	◯	◯ Very strong

The purpose of the question is to verify the proportionality of cases in which the more genre the participant has experienced, with the amount of consciousness he/she is about different architecture, environment, and notion of space.

5-What is your favorite video game genre? *

- ◯ Strategy
- ◯ Action
- ◯ Survival Horror / Thriller
- ◯ Open-world Adventure
- ◯ Role-Playing Games
- ◯ Simulation Games
- ◯ Sports Game
- ◯ Puzzle games
- ◯ Idle games

This question enumerates the different game genres the participant has experienced. It is important to investigate whether the case of a high number of genre experiences would improve the opinion of what is the role of architecture within video games.

6-What is your ideal video games console? *

- PC
- Xbox
- PS
- Wii
- Switch
- Other:

The mean of entertainment affects the players' experience and how the environment / Architecture is perceived through the digital screen; thus, understanding the participant's choice of console helps to verify a potential affinity between the latter and the digital world.

7-How do you play video games? *

- Story Mode
- Online Single
- Online multiplayer

The gameplay mode does affect how much a player would take time to recognize the surrounding architecture and environment in general. Solo / Story Mode gives the player more freedom to wander off through the game. So, it is important to verify this condition.

8-How many hours do you spend playing video games on a daily basis? *

- ◯ Less than 1 hour
- ◯ Hour - 2 Hours
- ◯ Hours - 4 Hours
- ◯ More than 4 Hours

Players with a high amount of hours spent playing video games have the chance to explore and try more games and thus would have a better all-around knowledge when it comes to the fundamental relation between Architecture and video games.

9-How much attention do you pay to your surrounding map/buildings in-game? *

- ◯ Not much
- ◯ A little
- ◯ Fair
- ◯ A lot
- ◯ Very attentive

Playing a game is entertaining itself, but paying extra attention to the environment, architecture and details scattered throughout the map is nothing but an exploring journey full of mystery and discoveries. Video games tend to have ‘Easter eggs’ hidden in their maps.

10-Any specific video games in which architecture/environment caught your attention?

_____

Some of the games tend to stand out among the rest when it comes to their architectural visualization and emphasis on sustainability and urban, development.

11-What exactly caught your attention?

Each person, there is a different point of view regarding a specific area or aspect in the video game, so it is important to hear multiple feedback on this matter.

12- From an architectural / environmental perspective, how do you rate the learning curve of video games? *

	1	2	3	4	5	
Very weak	◯	◯	◯	◯	◯	Very strong

One of the fundamental points of Architecture evolution in video games is the increase of the learning curve of the architectural subject along with its emphasis on a more applicable and sustainable model.

13-From a general perspective, how do you rate the learning curve of video games ? *

	1	2	3	4	5	
Very weak	◯	◯	◯	◯	◯	Very strong

Generally speaking, video games, from the first to the last, provide an interactive digital platform that provides the players with visual information. Each player interprets this information and gives feedback unique to his experience.

14-In a short answer, what additional role could video games have in the future ?

Video games have been a revolutionary interactive medium challenging its time and proving more and more daring and evocative. What would they hold and what role will they be playing ?

Questionnaire results, analysis, and conclusion:

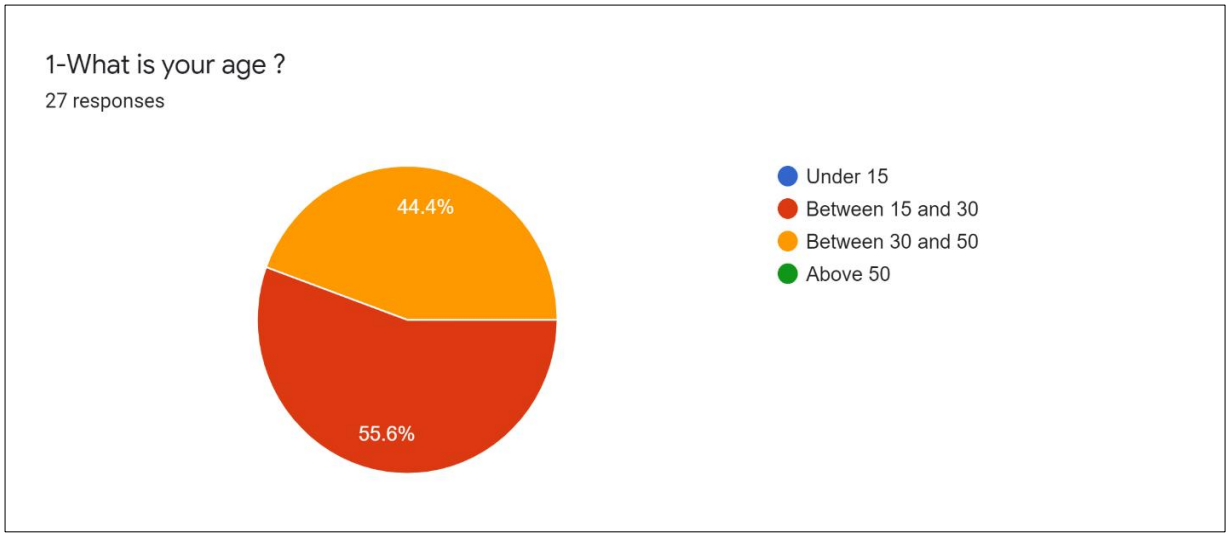


Figure 56: Age. Source: Author

The participant's age in the survey is mainly divided into two categories: 15 and 30 / 30 and 50.

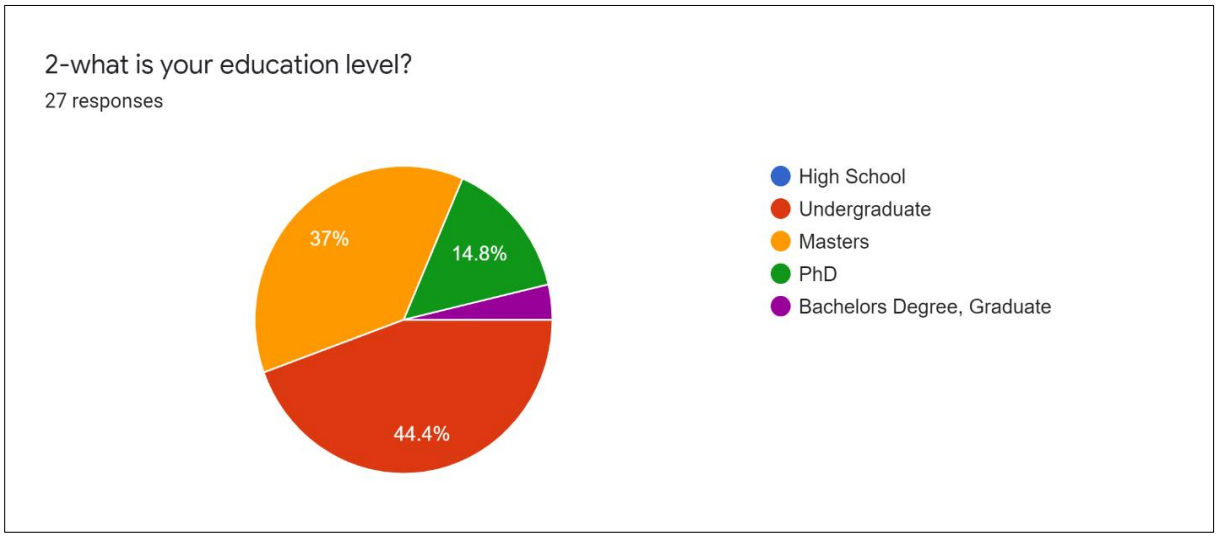


Figure 57: Education level. Source: Author

The participants' educational level is pretty diverse: Mostly undergraduate 44% and masters 37% with few Ph.D. 14%.

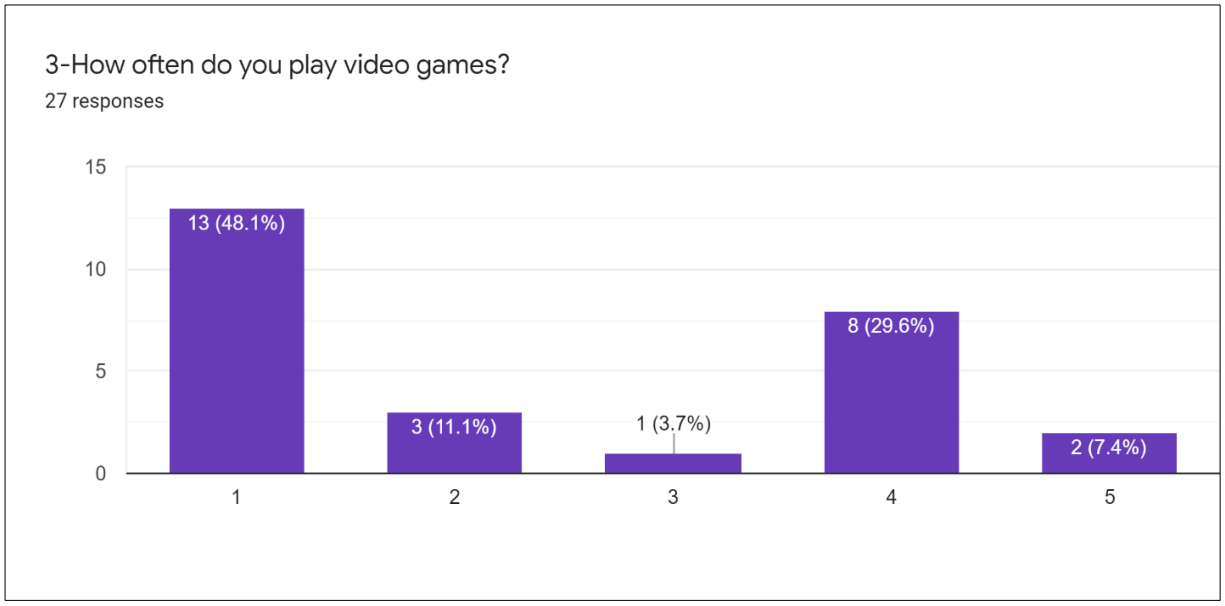


Figure 58: Frequency. Source: Author

The participant spends mostly 1 (48%) to 4 (30%) hours daily playing video games. Playing for four hours is more than enough time to have participants get familiar with the architectural environment and thus explore the full potential of video games as a scholarly source in this matter.

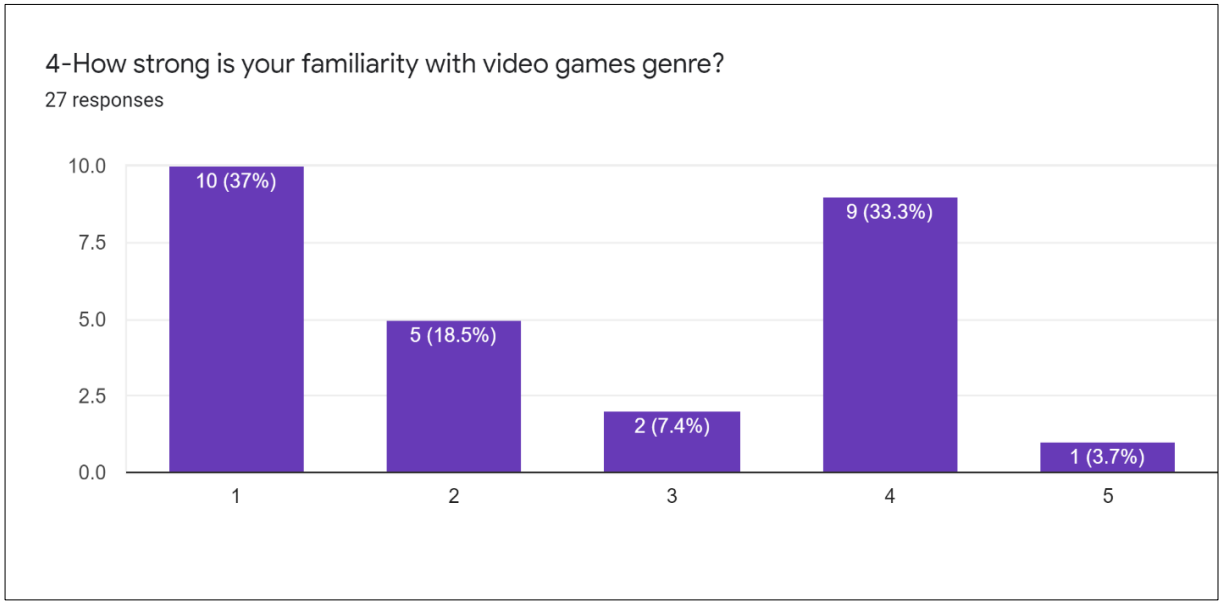


Figure 59: Familiarity. Source: Author

Participants tend to be split between unfamiliar 37% and quite familiar 33% with different video games genre. The common knowledge of the video games genre develops the players' overall in-game consciousness with a better understanding of the digital space around them.

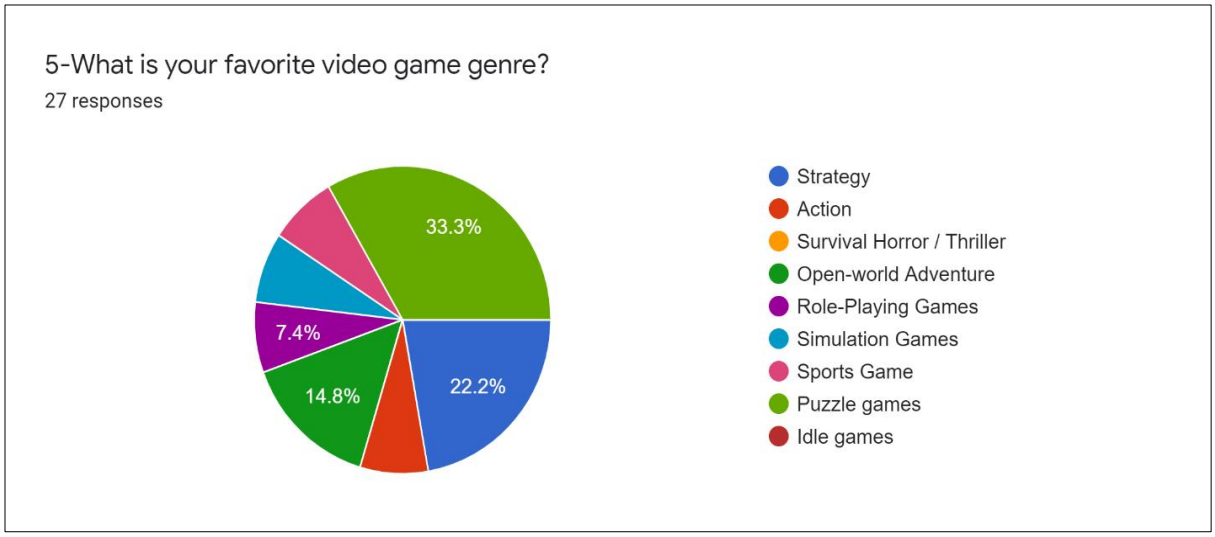


Figure 60: Favorite game. Source: Author

The highest choice of the genre among participants was Open-World Adventure (33%), followed by Strategy (22%) and then Puzzle games (14%). This is an interesting hint that shows how open-world maps games, in which architectural environments tend to be the most developed, are starting to attract more audiences.

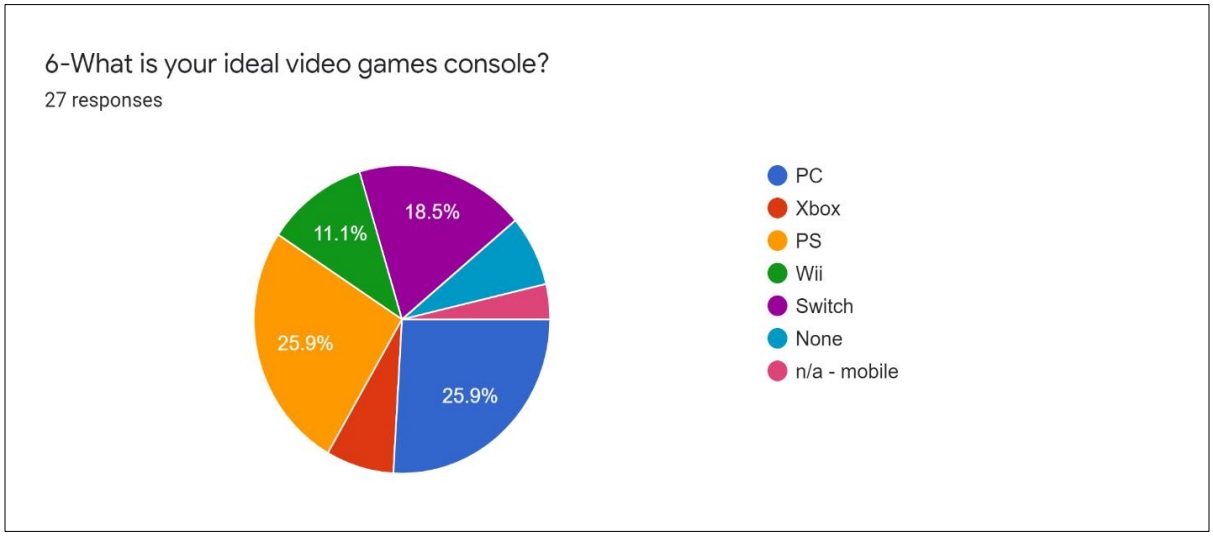


Figure 61: Ideal console. Source: Author

The participants use mostly PC (25%), PS (25%) and Switch (18%) as their main means of video game consoles.

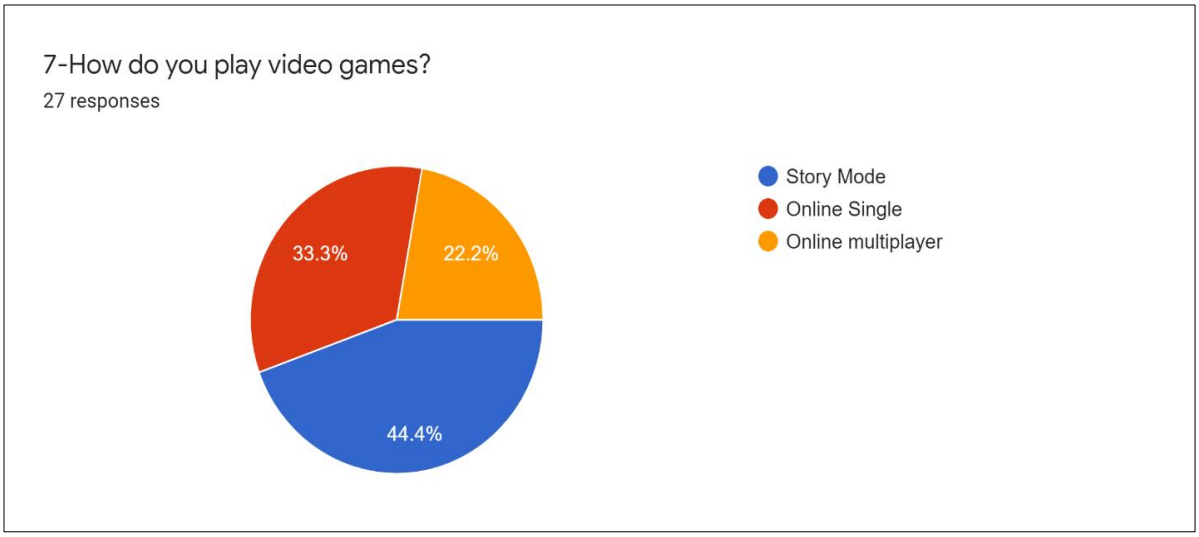


Figure 62: Gameplay. Source: Author

The most common gameplay mode among participants is the single story mode(44%), followed by the Online single mode (33%). This is the most convenient gameplay mode to be able to grasp the architectural scholarly content presented in video games.

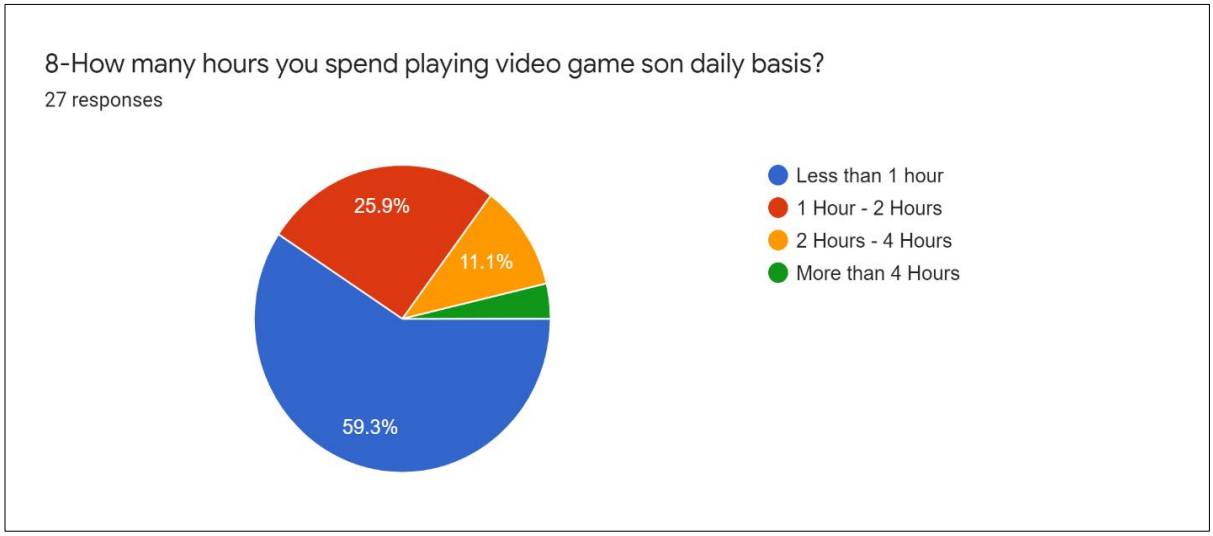


Figure 63: Time spent. Source: Author

The most time spent on video games is Less than one hour (up to 60%) followed by one to two hours (25%). This is relative to how much content the participant could grasp and identify the architectural prowess residing in these virtual worlds.

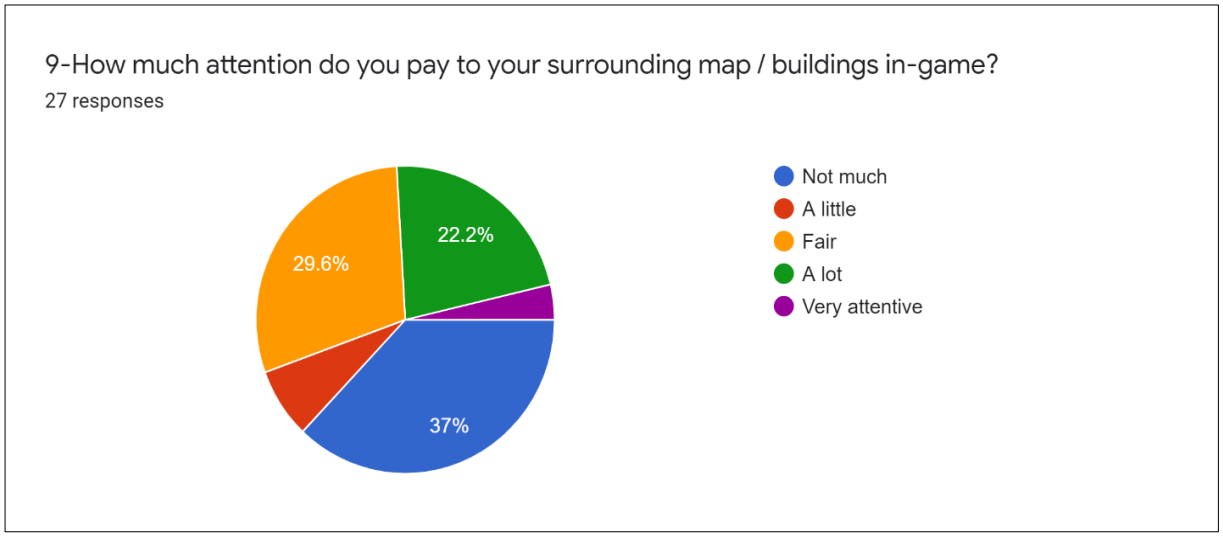


Figure 64: Attention to surroundings. Source: Author.

37% of the participants tend to not pay attention to the surrounding environment, 30% do fairly, and only 22% pay a lot of attention to it.

10-Any specific video games in which architecture/environment caught your attention?

The most common answers were Cyberpunk (20%), Minecraft (14%), and The Sims(11%). The three of these games do focus on offering architectural environment enhancements and provide an engaging experience for players.

11- What exactly caught your attention?

The traits that most caught the attention of the participants were : Building design (38%), Building details (21%), Shapes and colors (20%), and Graphics and scenery (15%).

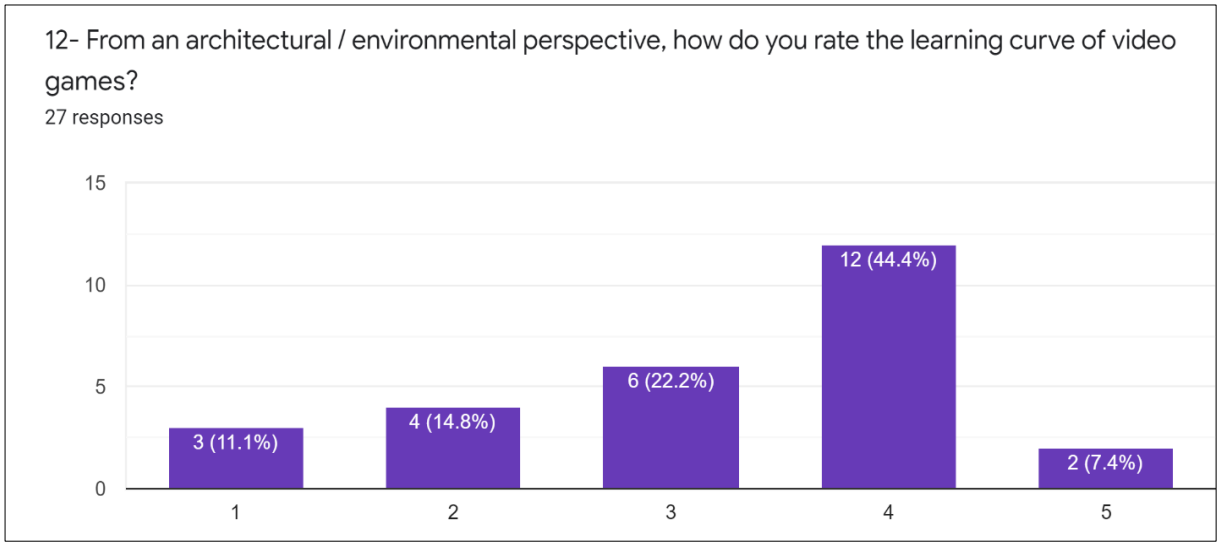


Figure 65: Architectural Learning curve. Source: Author

44% of the participants think that the learning curve from an architectural/environmental perspective can be high. 33% think it is fairly average.

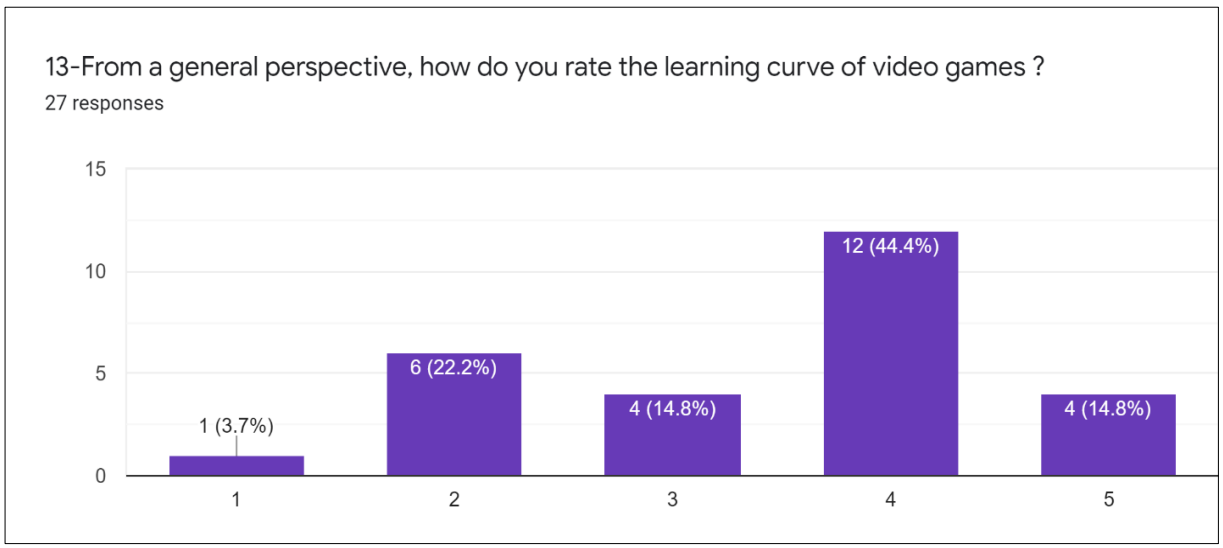


Figure 66:General Learning curve. Source: Author

44% of the participants think that the learning curve from a general perspective can be high. 22% think it is average.

14-In a short answer, what additional role could video games have in the future ?

Accelerated learning(24%), educative content(21%) and scholarly sources(18%) are the main answers of the participants. This is clear evidence that video games have a strong potential of fulfilling an informative, educational role that provides insights into a different proposition than the current means.

Conclusion:

The investigation of the questionnaire provided an informative set of data from which are drawn the following points:

- The video games genre does tend to affect the learning curve of the latter. Thus, the importance of open-world maps which provides the player with the freedom of exploring the space at their own pace.
- Considering video games as a scholarly source for History, Sociology, psychology, and science has the potential to propose a different approach to the box learning methodology, which is at once both realistic but daring and provocative.
- Architecture and video games are intertwined. The latter has been using the former in producing an ever-increasing realistic environment. Add to that; futuristic cities have been the subject of the environment for quite some video games which have nurtured the idea of architectural and urban futurism in a very scientifically provocative manner.
- Video games that shocking/provocative buildings/architecture and environment, in general, tend to stick as pioneers of visionary future. How imminent or far it would be a question to be answered only through exploring the possibility of applying such an approach in real-life settings.

- **Video games reference through an urban and sustainable way**

Video games are based on no constraint. The abstract nature of its world untangles its reality from any sense of logic or actuality. Therefore, video games are daring, edgy and provocative. Metaphors are often concretely visualized and shape the virtual environment. The purpose is this section is to dissect some of the controversial conceptual worlds presented in the following examples and examine their aspects, evaluate their mechanism in an approachable way to our reality.

- **Bioshock Rapture : Life Under Sea :**

  https://www.youtube.com/watch?v=p2SpC-Wq_no (1:50 mins to 3:00 mins)

Figure 67: Bioshock series. Source: https://steamcommunity.com/sharedfiles/filedetails/?id=764197488

Bioshock is a culturally and commercially first-person shooter video game and is often regarded as a “Blockbuster game” with enormous success due to its large audience and market share in the

gaming industry. It is a statement that aesthetics, narrative, and gameplay mechanics could deliver a very strong medium of social, psychological, scientific research, and visionary innovation.

In one of the series of Bioshock, Bioshock Rapture, the storyline unfolds entirely undersea in the city of Rapture, also known as the "North Atlantic Project." This Art deco-style self-sufficient metropolis is forged upon the wishful dream of the main antagonist. The main purpose was to flee the political and religious sufferings/woes of a Post W-W II life on earth. The construction of the city lasted five years, was completed in 1951, and is located 500 kilometers west of Reykjavik, Figure 68, Figure 69 capital of Iceland. (63o 2'N, 29o 55'W = google earth coordinates)

Figure 68: Earth North Pole. Source: Google Earth

Figure 69: Iceland Distance to Rapture

Figure 70: Depth of Rapture. Source: Author

The city of Rapture is established at a depth of 2094m / 6800 Feet as shown in Figure 70. Access to the city is via a lighthouse as shown in Figure 71. Once inside the lighthouse, there is an elevator that has a bathysphere big enough for three at once. The lighthouse entrance is the only known access to the city, Figure 72, which is kept hidden from the outer world.

Figure 71: Entry Medium to Rapture. Source: https://www.telegraph.co.uk/gaming/what-to-play/bioshock-the-collection-review---a-wonder-to-revisit-rapture/

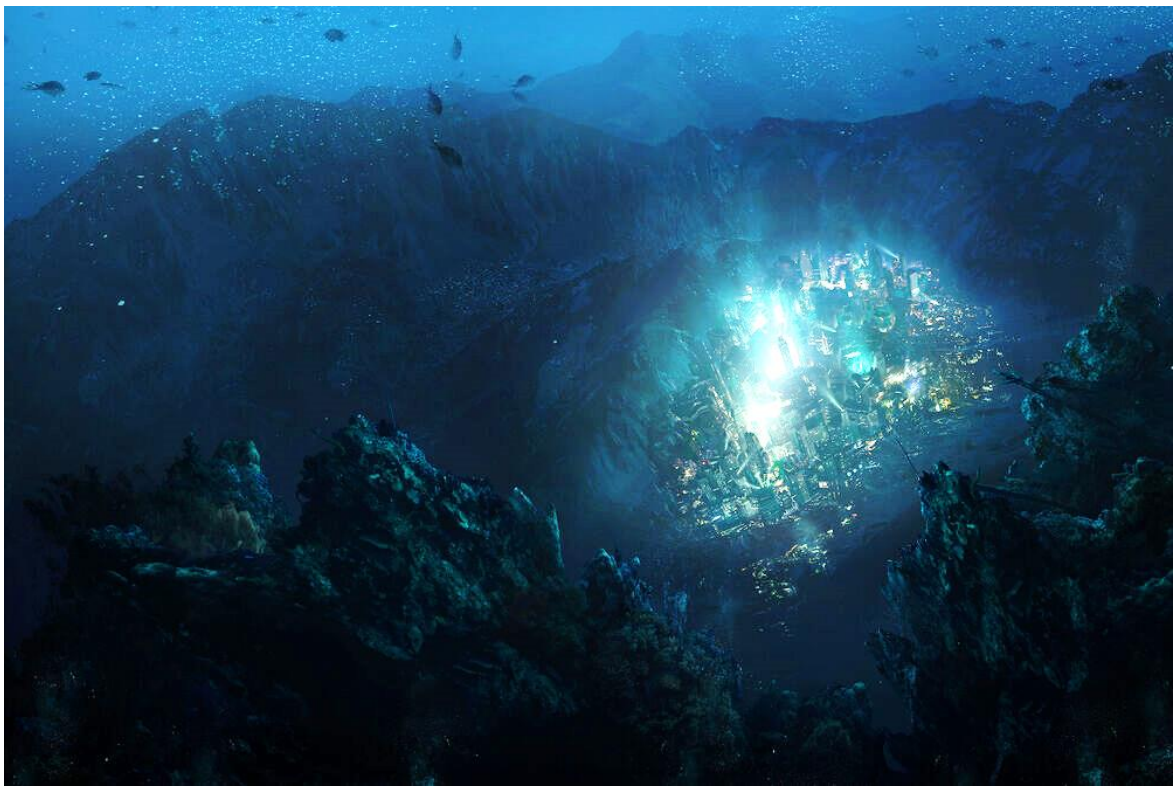


Figure 72: City of Rapture. Source: https://bioshock.fandom.com/wiki/Rapture

- Construction

" *These resources were then transported by ships like the Olympian thousands of miles across the North Atlantic to the project site. There, the materials were submerged to the ocean floor via a giant State-of-the-Art submersible platform nicknamed "The Sinker." Deep sea welders and mechanics created a foundation for the city by sinking pilings and girders deep into the rock and silt. Eventually, "The Sinker" was permanently anchored on the sea bottom. Pre-fabricated buildings with frames of aluminum were assembled near the surface, submerged and lowered using lunette rings, and anchored into the foundations, thus creating the Art Deco metropolis. By November 5, 1946, Rapture began receiving its first residents. The major construction period continued until the end of the 1940s, with smaller projects continuing in*

and around the city until Rapture's construction was fully completed by 1951" (Fandom: Bioshock wiki 2020)

Figure 74 below is a work of art sketch illustrating the construction process of the underwater city. It can be seen that giant balloons filled with air were playing the role of formwork increasing the stability of the newly built entities.

Figure 73: Andrew Ryan, the founder of Rapture. Source: https://9gag.com/gag/a57POXV

Figure 74: Bioshock Construction of Rapture. Source: (Fandom: Bioshock wiki 2020)

- Transportation

The city of Rapture is a self-sustainable organism, with transportation being ensured through a network of suspended glass bridges with metal reinforcements connecting pedestrians in the city from one building to the other as shown in Figure 75.

Figure 75: Glass tunnels connect the city. Source: https://bioshock.fandom.com/wiki/Rapture

The vehicular transportation system is ensured through two main systems: The Rapture metro and the Atlantic express.

For the first one, and as aforementioned, the bathysphere, shown in Figure 76 is also found in different locations throughout the city, thus facilitating transportation across different districts.

Figure 76: Rapture's Bathysphere. Source: https://bioshock.fandom.com/wiki/Rapture

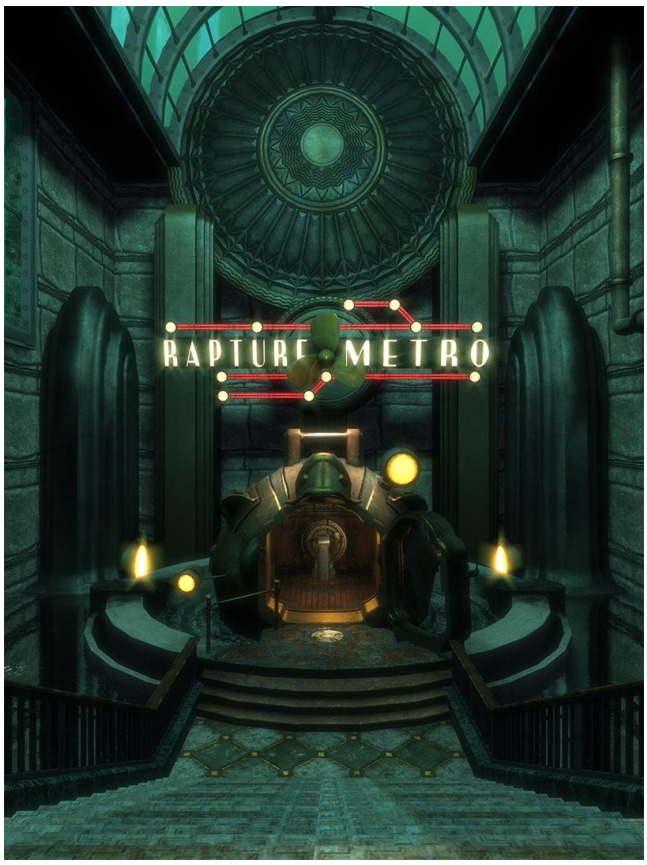


Figure 77: Rapture Metro station. Source: https://bioshock.fandom.com/wiki/Rapture

Figure 78: Bathysphere path. Source: https://bioshock.fandom.com/wiki/Rapture

Figure 79: Rapture Metro station. Source: https://bioshock.fandom.com/wiki/Rapture

As for Atlantic express, this system could be most likely compared to an actual metro station. There is Rapture metro / Atlantic express stations, Figure 79, scattered around the city. Each station has many destinations connecting the city as a whole. The transportation system is known to be mega-fast due to the high speed of the bathysphere generated by the water/air pressure which would eventually replace the Atlantic express one.

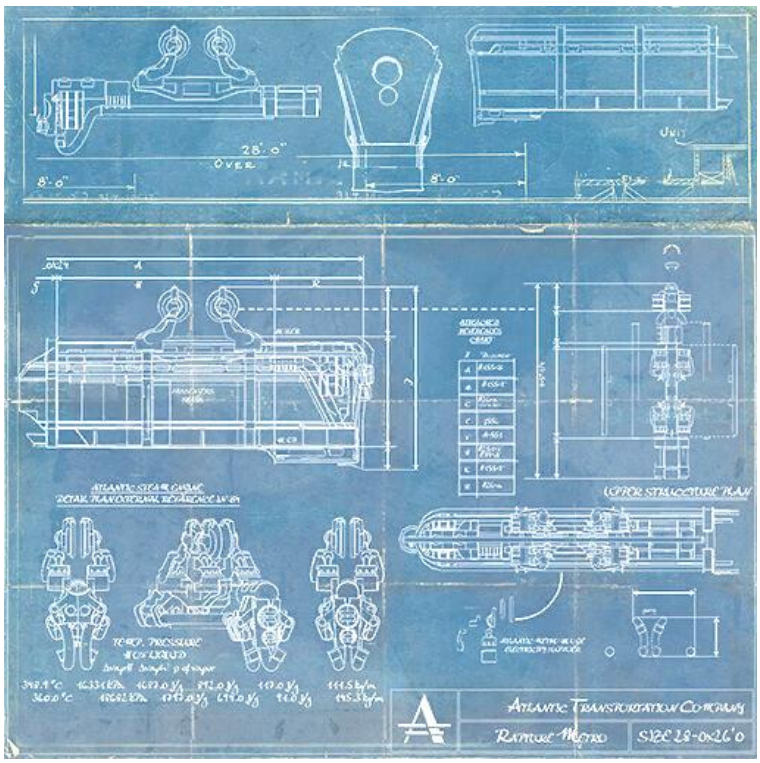


Figure 80: Atlantic express unit concept drawings. Source: https://bioshock.fandom.com/wiki/Rapture

Figure 81: Unit of Atlantic express. Source: https://bioshock.fandom.com/wiki/Rapture

Figure 82: Transportation network of Rapture. Source: https://bioshock.fandom.com/wiki/Rapture

- Arcadia : Alimentation of food and oxygen

The Living heart of Rapture. Arcadia, Figure 83, Figure 84, is the lungs of the underwater city. Quite literally. As it provides the entire inhabitants (15k) with oxygen, food, and resources.

Figure 84: Arcadia entrance. Source: https://bioshock.fandom.com/wiki/Arcadia#Tea_Garden

Figure 85: Arcadia Logo. Source: https://bioshock.fandom.com/wiki/Arcadia#Tea_Garden

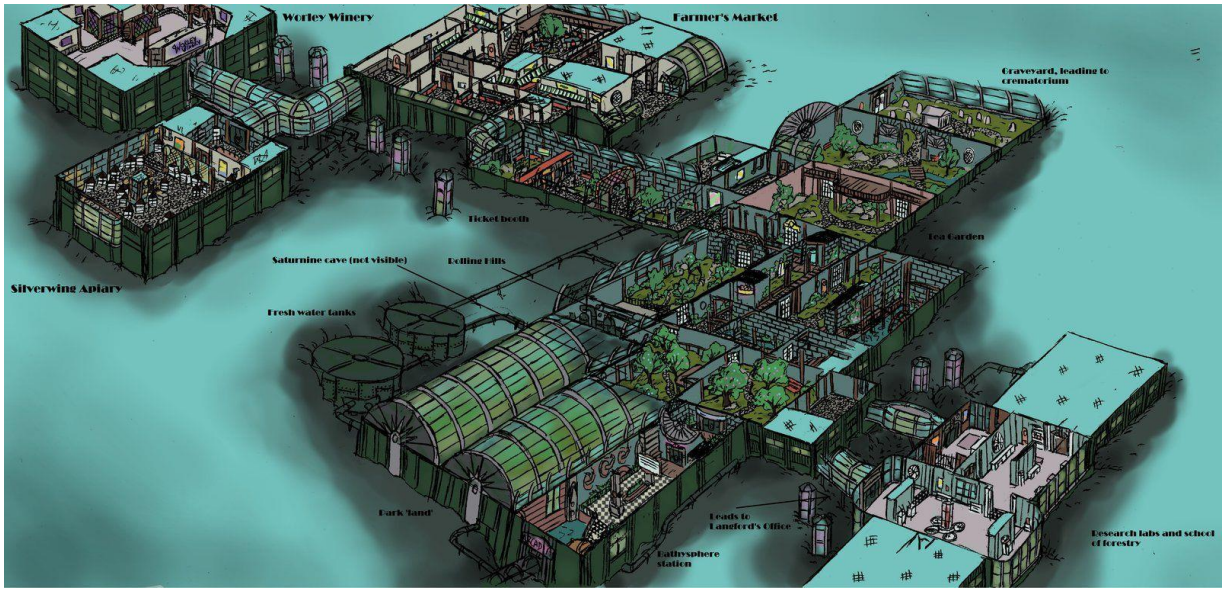


Figure 83: Axonometric view of Arcadia. Source:https://bioshock.fandom.com/wiki/Arcadia#Tea_Garden

Figure 86: Arcadia Farmer market. Source: https://bioshock.fandom.com/wiki/Arcadia#Tea_Garden

The main components of Arcadia are :

A. Tea Garden: "*Gently rolling hills, admirable waterfalls, a calm stream, dim light, and a perfect atmosphere were all part of the Garden's allure"* (Fandom: Bioshock wiki 2020)

B. Tree Farm: Where citizens grow plants and trees and farm their resources.

   Waterfall Grotto: "*The area served as the perfect symbolic union of industry and nature. The space's multiple water wheels evoked man's ability to harness the raw forces of nature for power while the free-flowing water created a serene atmosphere"* (Fandom: Bioshock wiki 2020)

C. Rolling Hills: *"features a smooth hilly landscape. In addition, it also boasted an abundance of trees and foliage, a trickling waterfall, and a set of naturally-carved*

caves erected from the deep-sea mountain bed upon which Arcadia and the rest of Rapture were built" (Fandom: Bioshock wiki 2020)

D. Rapture Metro Station

E. Research Laboratories

- Hephaestus : The Energy Core.

Hephaestus is a power facility that uses the real-life natural occurring geothermal vents found in the region to produce electricity. Due to the depth of location of the city, no natural light is reachable, and the water temperature is subzero. The geothermal heat is used to produce steam, and run power plants but also to be piped to produce space heating.

Figure 87: Hephaestus Hub. Source: https://bioshock.fandom.com/wiki/Rapture

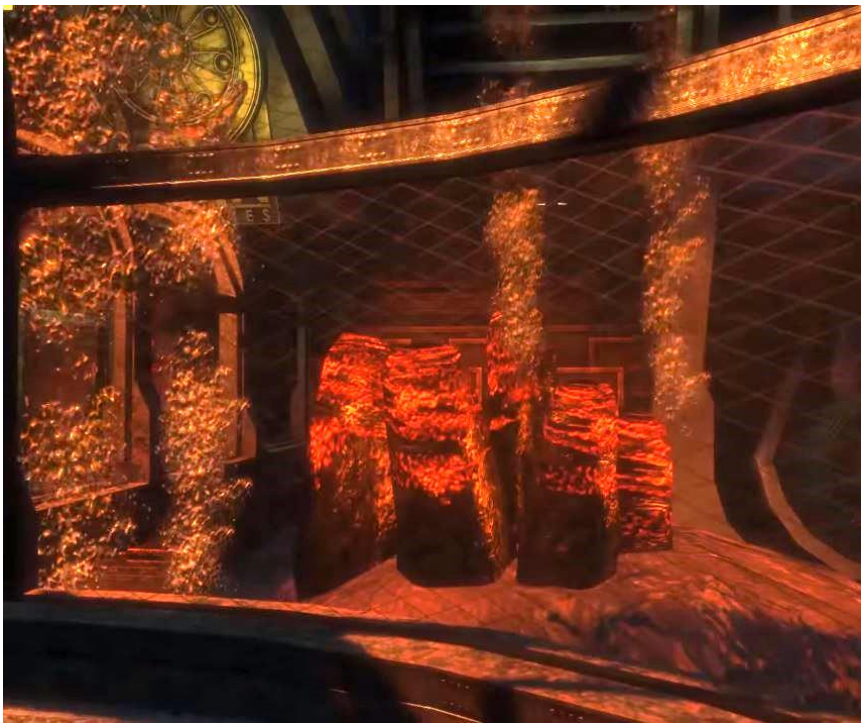


Figure 88: Volcanic space heating. Source: https://bioshock.fandom.com/wiki/Rapture

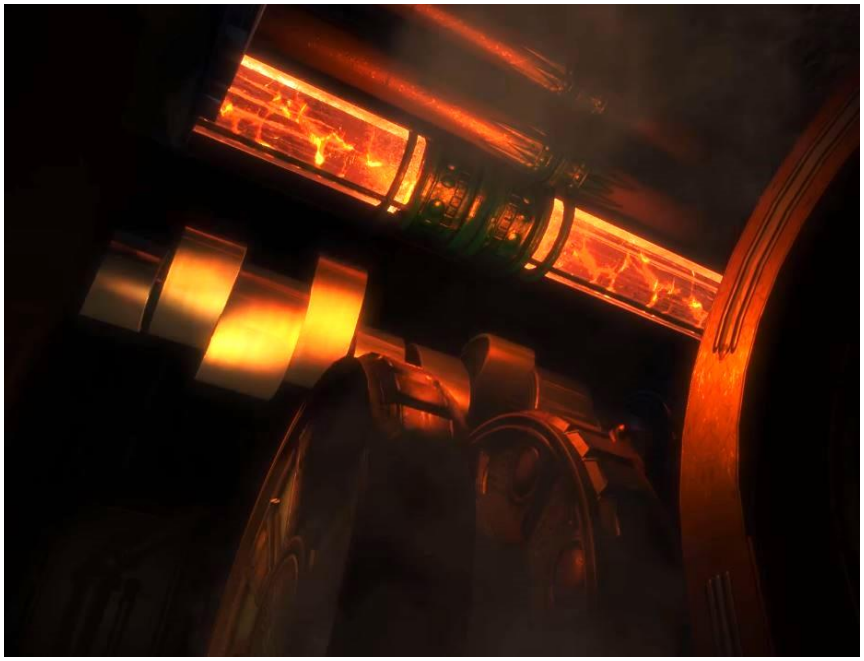


Figure 89: Transforming geothermal to electricity. Source: https://bioshock.fandom.com/wiki/Rapture

a) Constraints and opportunities :

a. Constraints:

Due to its 2094m / 6800 Feet depth, the city of Rapture faces a plethora of constraints. Water Pressure and damage, Subzero temperature, Absence of sunlight, and Oxygen.

i. Water Pressure

At this specific depth, the water pressure is estimated to be 21.570 Kpa / 204 Atmospheres of pressure, nearly 3000 pounds per square inch. Using Archimedes' Principles, the water pressure above the tower plus the force of gravity is more than that of the buoyant force. This means that the structure would be two third lighter than if it were on the surface. However, the lateral forces would be huge and end up overpowering the structure. This extreme pressure is too much to be handled by the structural design of Rapture or any current design technology.

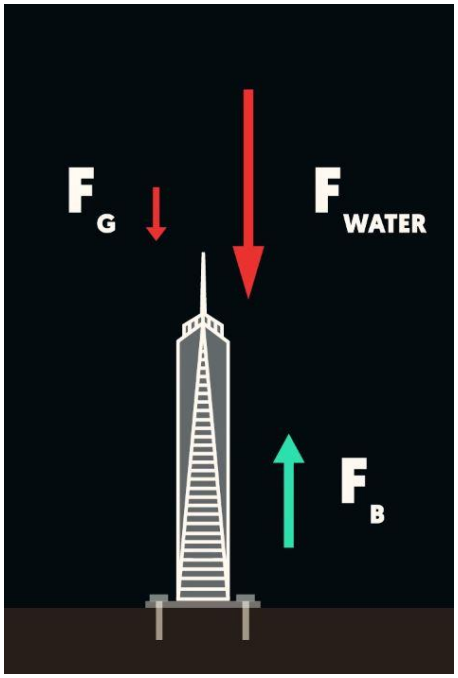


Figure 90: Archimedes principle.

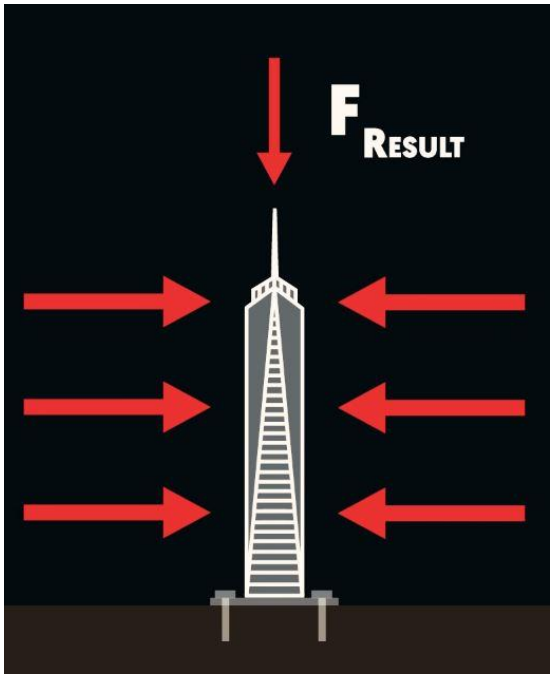


Figure 91: Excessive Lateral forces

ii. Water damage

At a depth of 2094m , corrosion is inevitable and would lead to deteriorating structures and eventually water leakage. In Rapture, the materials used are metal, glass and concrete. It is observed that corrosion has already been eating up metal and glass surfaces. In other parts, specifically at the entrance of the Hephaestus core, there is a waterfall from the roof coming from the leakage sustained from the corrosion damage.

Figure 92: Hephaestus Core. Source: https://bioshock.fandom.com/wiki/Hephaestus

iii. Subzero Temperature

The estimated temperature of the water at 2094m depth is estimated to be around 36F / 2.4C. This is a very harsh environment to be able to establish an underwater city. This latter will need to constantly provide spatial and water heating for all its existence. A constant, reliable, and infinite source of energy is thus a must to have.

Figure 93: Subzero temperature. Source: https://bioshock.fandom.com/wiki/Rapture

b. Opportunities:

i. Ocean crops

Being underwater, is an enormous challenge for any building. Food is a primary resource, and the vast ocean has plenty of it. Add to that; its deepest levels contain even more exotic marine creatures. In Rapture, the main food resource, in addition to the abundant seafood, is vegetables grown in Arcadia and sold in the Farmers' market. (Apples, melons, tomatoes, and vegan cheese).

Figure 94: Farmers' market. Source: https://bioshock.fandom.com/wiki/Farmer%27s_Market?file=Market_stands.png

ii. Water Oxygen

Being underwater, brings another ultimate constraint and that is oxygen. In order to establish an entire city, the oxygen production source must be constant, infinite, and reliable. In modern technology, there is a scientific procedure to produce oxygen off of water, by decomposing the two molecules of hydrogen H2 from the molecule of oxygen in the process known as the

electrolysis of water. The oxygen is used to breathe, and the hydrogen is used either in desalination plants to produce fresh water or as hydrogen fuel.

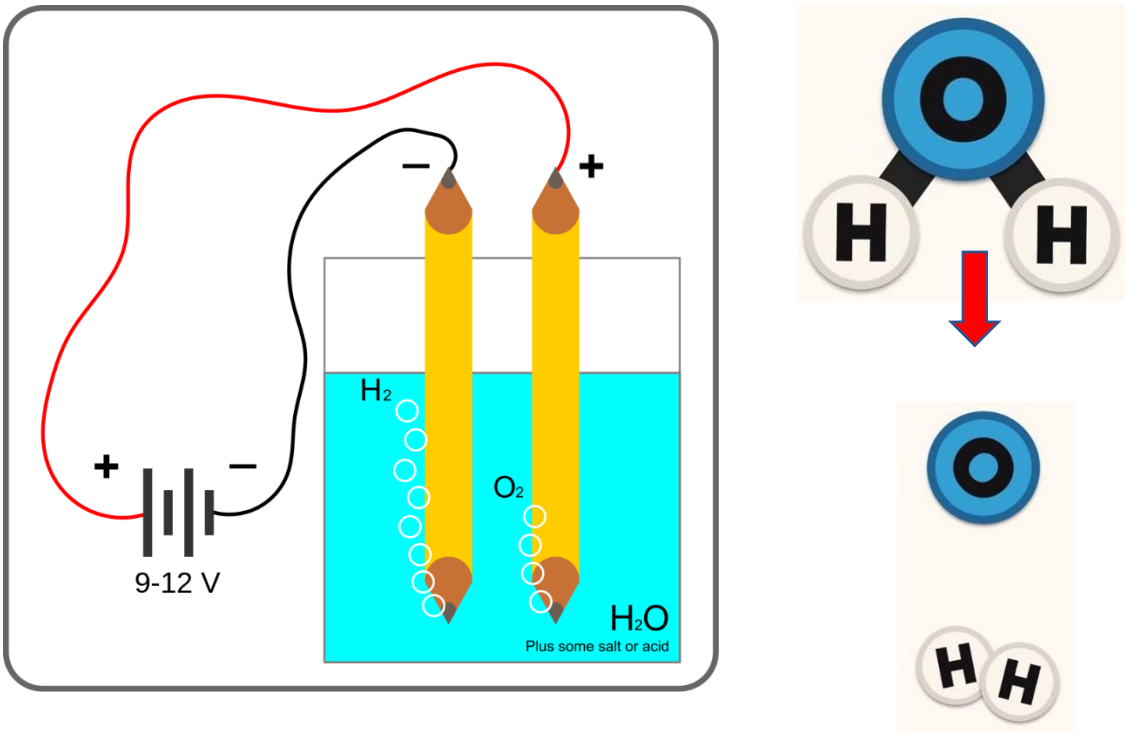


Figure 95: The process of electrolysis. Source: https://en.wikipedia.org/wiki/Electrolysis_of_water

iii. Tide currents to electricity

The constant pounding of the waves and the ebb and flow of tidal currents, as well as other properties of the ocean, if harnessed, could produce 20,000 to 80,000 terawatt hours of electricity, according to the International Energy Agency. That is more than the world's current energy consumption of almost 20,000 TWh.

Energy is inherent in the movement of ocean waves, in the difference in temperature between warm surface waters and cooler deep waters, in the disparity in salinity between fresh water and salt, and in marine currents and tides. The International Energy Agency estimates that wave power could potentially produce 8,000 to 80,000 TWh yearly; ocean thermal energy could produce

10,000 TWh; osmotic power (from salinity differences) could produce 2,000 TWh and tides and marine currents could produce 1,100 TWh. Ocean thermal energy, osmotic energy, marine currents and some types of wave energy could produce baseload power, the electricity that is consistent and reliable.

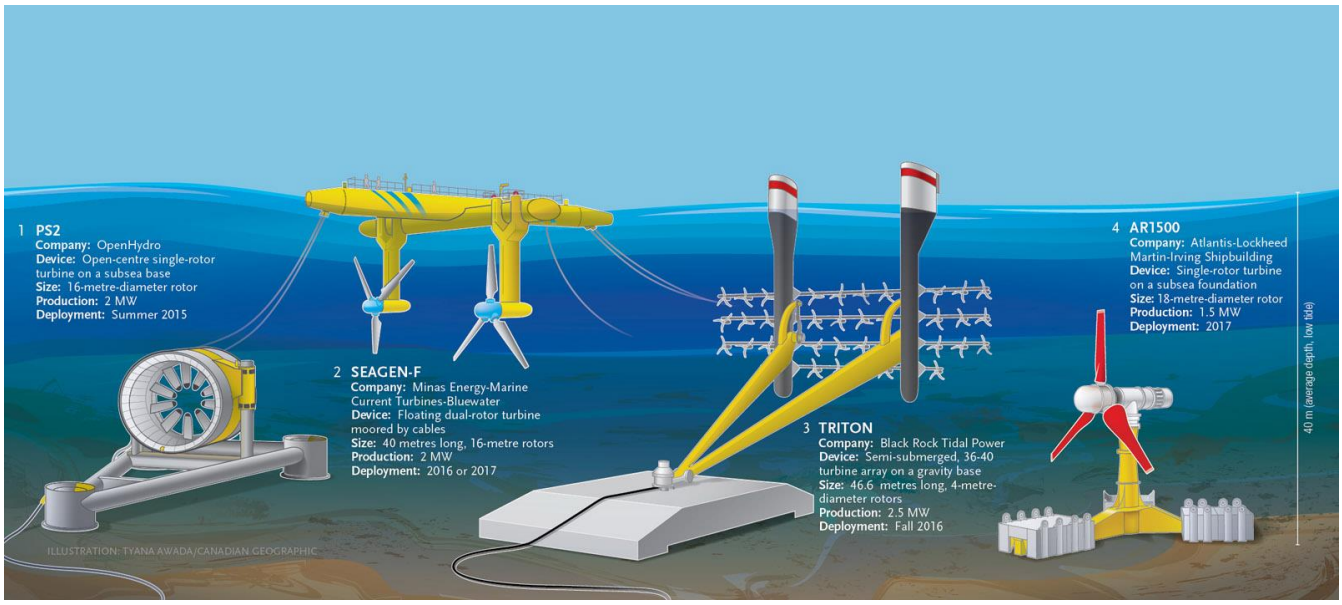


Figure 96: Different types of tidal turbines. Source:https://www.canadiangeographic.ca/article/nova-scotias-first-stream-tidal-turbine-starts-producing-power

If the ocean power industry is to be scaled up, devices must not utilize hard-to-obtain materials or be too complex; they must be easy to maintain and economical. According to the Northwest National Marine Renewable Energy Center, which researches wave energy technology, “The key technical challenges are associated with not only electrical generation and output, but mechanical systems, mooring and anchoring, survivability and reliability, predictability (wave forecasting), and integration of the generated power into the existing electrical grid.”

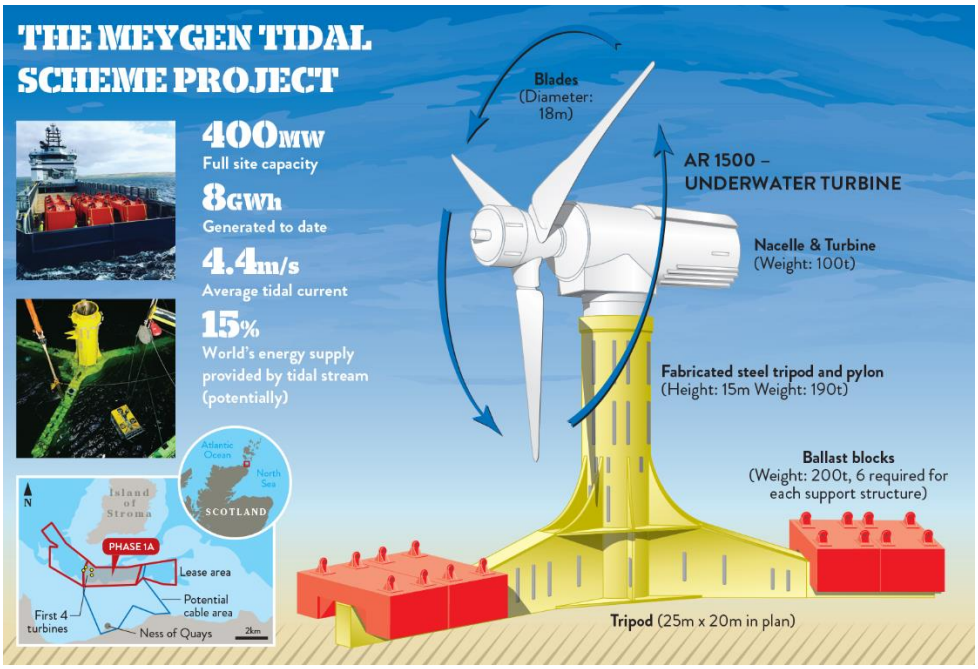


Figure 97: Tidal turbine. Source: https://www.newcivilengineer.com/archive/future-of-energy-catching-the-flow-13-12-2018/

Ocean power has significant potential as a renewable energy resource, yet it is decades behind other forms of renewable energy because it faces numerous financial challenges. Devices of steel or structures of concrete must stand up to the constant pounding of waves and the corrosion of salt water.

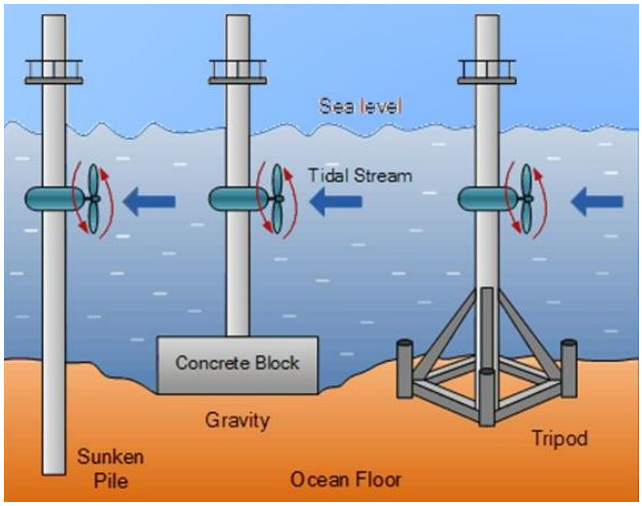


Figure 98: Different foundation types for tidal turbine. Source: https://www.sciencedirect.com/science/article/pii/S1364032121007759

iv. Tide waves to electricity

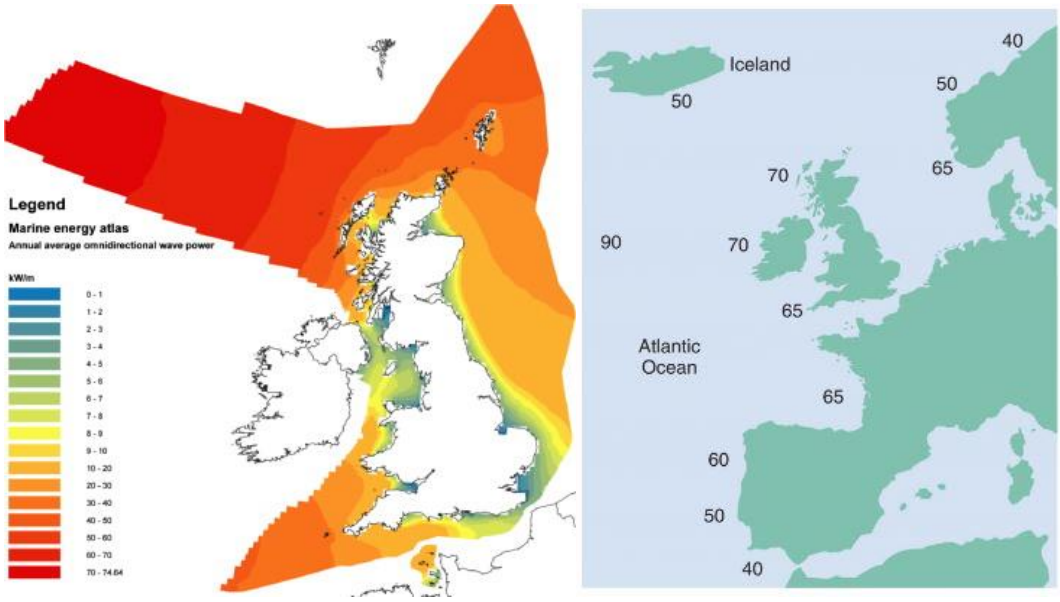


Figure 99: Annual average omnidirectional wave power. Source : https://www.sciencedirect.com/science/article/pii/S1364032111001900

Recent studies have shown that wind-generated waves make a crucial source of infinitely renewable energy in order to generate electricity by utilizing wave energy converters. As the ocean covers more than 70% of the Earth's surface, this is quite a valuable resource. The figure above shows how much ocean wave energy could be converted to electricity. It is notable that the energy of the tidal wave is higher well offshore deep in the ocean and the closer to the offshore the more it loses its value. In the Atlantic Ocean, where Rapture has situated the value of the electricity converted could reach up to 90 kwm-1 which is an extremely high value far greater than anything generated from airstreams harnessed by wind turbines. (A. Bahaj 2011)

v. Water pressure to electricity

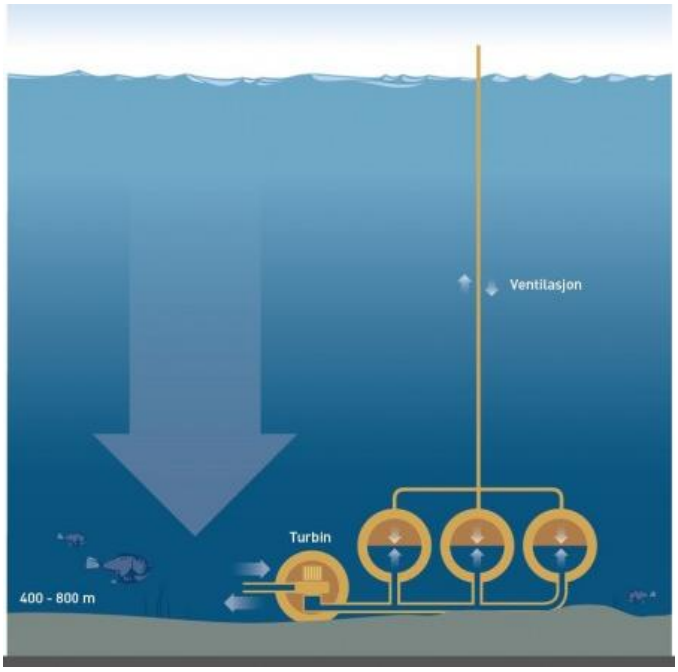


Figure 100: Using water pressure at the bottom of the ocean to store energy. Source : https://oilprice.com/Energy/Energy-General/Using-Water-Pressure-at-the-Bottom-of-the-Ocean-to-Store-Energy.html

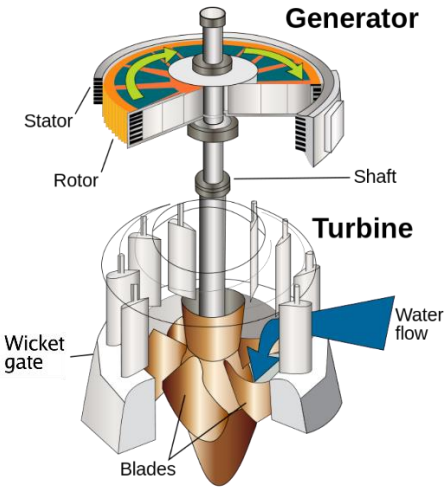


Figure 101: Water Turbine Source: https://www.sciencedirect.com/topics/engineering/water-turbine

The water pressure at the seabed of the ocean increases with depth. The deeper the seabed the higher the pressure. Recent research has acknowledged a potential leading electricity generating method based on the mechanical force of the water at the seabed of the ocean.

In order to achieve that, the mechanical energy is converted by a reversible pump turbine.

The turbine system contains a battery that connects to the power grid, which transmits the collected energy into several tanks. The estimated seabed depth is at a 400-800 meters range. The estimated electric storage efficiency averages approximately (60- 80%) per tank. This plant system of the size of one tank is estimated to produce around 300 megawatts for a 7–8-hour period of time, which is more than enough to supply electricity to 200,000 households. (Westenhaus 2013). This system of energy production is relative to the depth of the sea; the deeper the installation is, the more water pressure, which results consequently in more energy stored per tank.

The city of Rapture is located at a depth of 2000m which means the potential energy to be produced would be three times the aforementioned per tank.

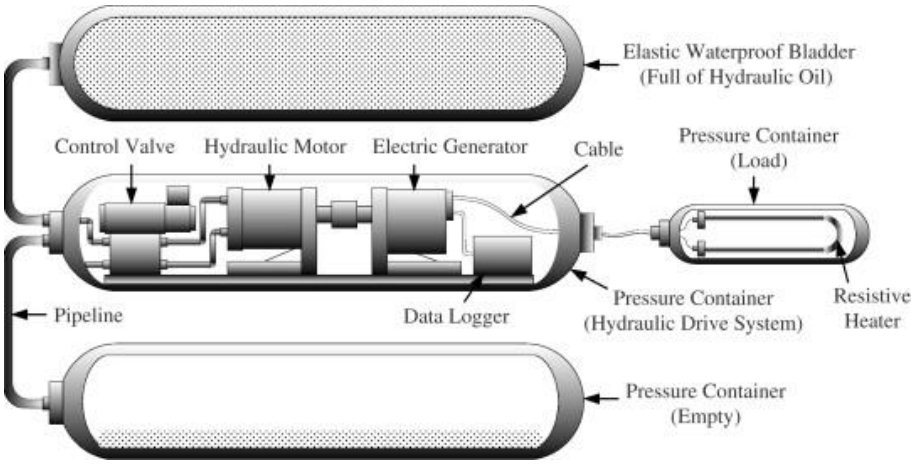


Figure 102: Schematic diagram of an ocean pressure turbine. Source: https://www.rite.or.jp/system/en/learn-energy/energy-use/hatsuden/

i. Water temperature to electricity

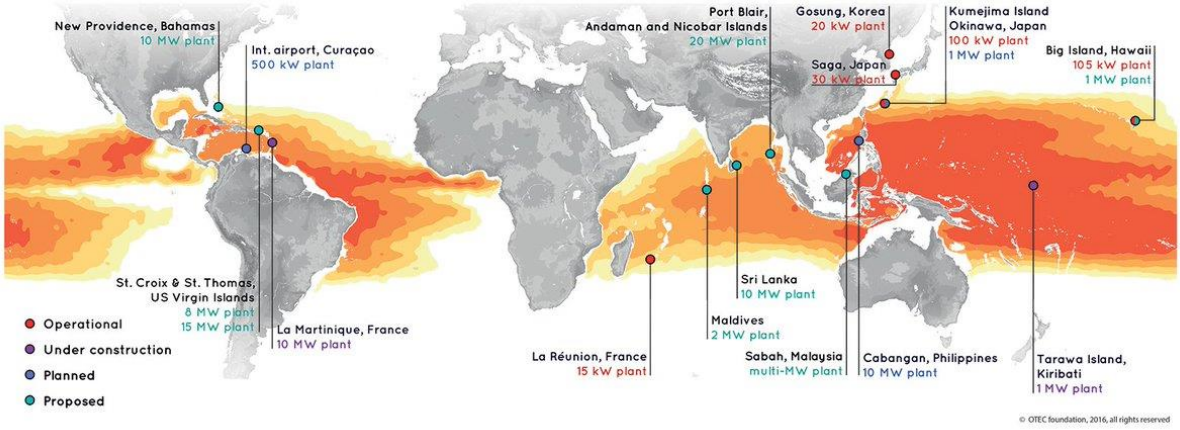


Figure 103: Ocean energy. Source: https://oceanconference.un.org/index.php?page=view&type=20000&nr=1979&menu=3327

The “water temperature to electricity” is one of the renewable energy conversion technology which is scientifically referred to as Ocean thermal energy conversion (OTEC), which is basically the production of energy from temperature differences in ocean water. The systems of OTEC consist mainly of a turbine once powered by a temp difference of at least 77° Fahrenheit produces electricity.

The system consists of having warm water from the surface of the ocean pumped through an evaporator which contains a mechanical fluid. Once vaporized, the latter drives the turbine. Then, the vaporized fluid goes back to a liquid state through a condenser absorbing the cold temperature of the water from the deep ocean. This system also produces desalinated water. (U.S. Energy Information Administration : Hydropower explained 2021)

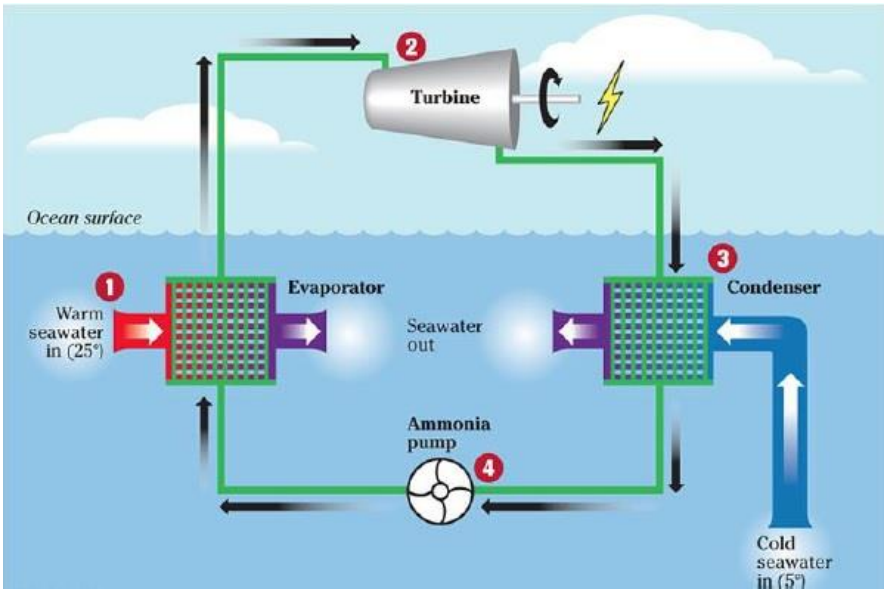


Figure 104: Ocean thermal energy conversion. Source: https://www.chegg.com/homework-help/questions-and-answers/ocean-thermal-energy-conversion-otec-shown-renewable-energy-conversion-technology-makes-us-q11009899

Due to the ever-rising electricity consumption and costs, and alarming sign of global warming, the OTEC is a very ideally suitable source of clean and environmentally sustainable renewable energy.

OTEC has numerous advantages listed as follows:

- OTEC is a constant 24/7 steady all year long with no required storage source of energy.
- OTEC does not occupy any land as it is located offshore.
- OTEC is seeing a rise in global investment exceeding $100m spent on OTEC research and implementation since 2009.
- 12 OTEC commercially scaled plants would provide all of Hawaii's electricity needs.
- Once applied globally, OTEC would be four times sufficiently covering the worldwide electricity needs.
- Electricity produced by OTEC would cost as low as $0.20 / Kw/hr.
- Lowers CO2 emissions of more than half of a million tons per year.

(Makai Ocean Engineering: The future of Ocean innovation 2022)

- **Bioshock Colombia: Life over clouds**.

  https://www.youtube.com/watch?v=pFGnBoS95SU (1:50 mins to 2:50 mins)

While the city of Rapture was immersed 2000m deep in the ocean, the Bioshock city of Columbia is floating well over the clouds at a 5,500m altitude. As stated by the game, " *The city was commissioned by the United States government and founded by Zachary Hale Comstock as a symbol of American political and religious ideals. Columbia, capable of flight due to the scientific discoveries of physicist Rosalind Lutece, was completed in 1893 and seceded from the United States in 1902"* (Bioshock wiki 2022)

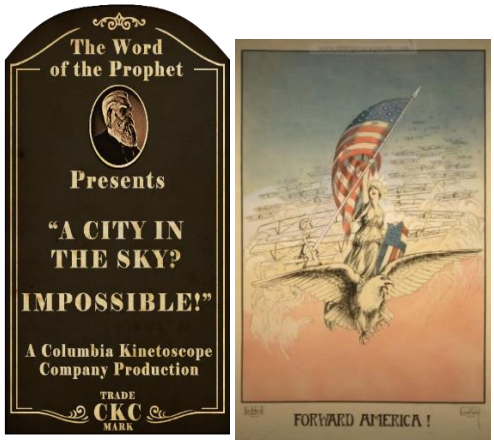


Figure 105: Columbia's Transcripts. Source: https://bioshock.fandom.com/wiki/A_City_in_the_Sky%3F_Impossible!

Figure 106: Columbia Route Map. Source: https://bioshock.fandom.com/wiki/Columbia

- Overview of City

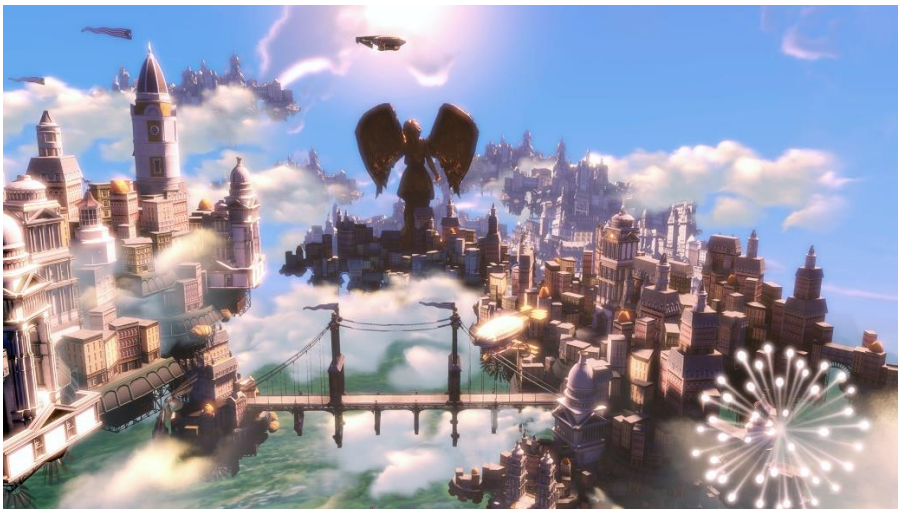


Figure 107: Columbia. Source: https://bioshock.fandom.com/wiki/Columbia

Figure 108: Columbia. Source: https://bioshock.fandom.com/wiki/Columbia

The city of Columbia is floating in a continuous circular route above the North American continent and is mainly consisting of neoclassical / Colonial Architectural influenced buildings. The principal means of transportation are "*zeppelins, cargo barges, hovercrafts, gondolas, and skylines."* (Bioshock wiki 2022)

- Science and Technology

The city, in order to float, relied on the phenomenon of “quantum levitation” and was designed with “*docking stations and propulsion devices to allow sections of it to move about independently*.”

The following is an overview of the different propulsion / floating devices used in the city:

1. Propulsion through combustion: using Fire Barrels (Rocketship style)

Figure 109: Propulsion. Source: https://bioshock.fandom.com/wiki/Columbia#Overview

2. Propulsion through Air balloons: typically, four balloons for each building entity.

Figure 110: Air Balloons: Source: https://bioshock.fandom.com/wiki/Columbia#Overview

3. Propulsion through Windmills

Figure 111: Windmills. Source: https://bioshock.fandom.com/wiki/Columbia#Overview

In the following section, an analysis of the different mechanism of propulsion aforementioned in order to verify the floating hypothesis.

1. Fire barrels Rocket ship style (REFUTED)

The focus of the analysis will target mainly the energy required to propel the combined amount of weight of multiple buildings composing a city regardless of the shape of the building itself.

The same building which was used in the previous analysis of the City of Rapture will also be used as follows: The total weight of the Empire state building is 365000 tons. (sheet 2022)

Figure 112: Empire state building. Source: https://en.wikipedia.org/wiki/Empire_State_Building

Figure 113: Rocketship propulsion. Source: www.nasa.gov)

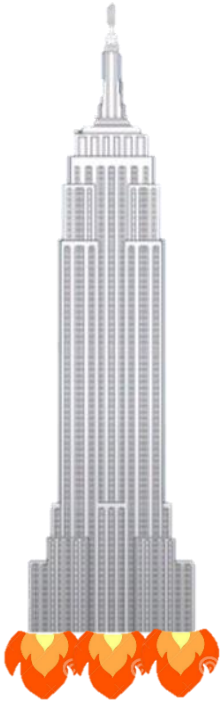
In order to test this hypothesis, it is crucial to compare the heaviest load a rocket ship could support the weight of a sizeable mass and weight like the Empire state building. In this case, Saturn 5 holds the record for the heaviest payload launched, which is 310.000 lbs.

Saturn 5 consumes (Refined Petroleum) RP-1 = 1.400.000 lbs. and

(Liquid of oxygen) LOX = 3.178.000 lbs.

X 420 = 1.922.760.00 lbs. of chemical substances

= Unsustainable hypothesis



In this case, there would be a need for approximately 420 rocket ships of chemical substance consumption in order to be able to propel the weight of the Empire state building. (Cradle of Aviation Museum 2022)

This would be an unsustainable hypothesis even if it was to be executed.

Hypothesis refuted.

2. Air Balloons: (REFUTED)

What makes Balloons float is helium due to its density of 0.2kg/m3,

inferior to the ones of oxygen =1.2kg/m3 (lenntech.com 2022)

In order to lift 1kg of MASS, 1m3 of helium is needed.

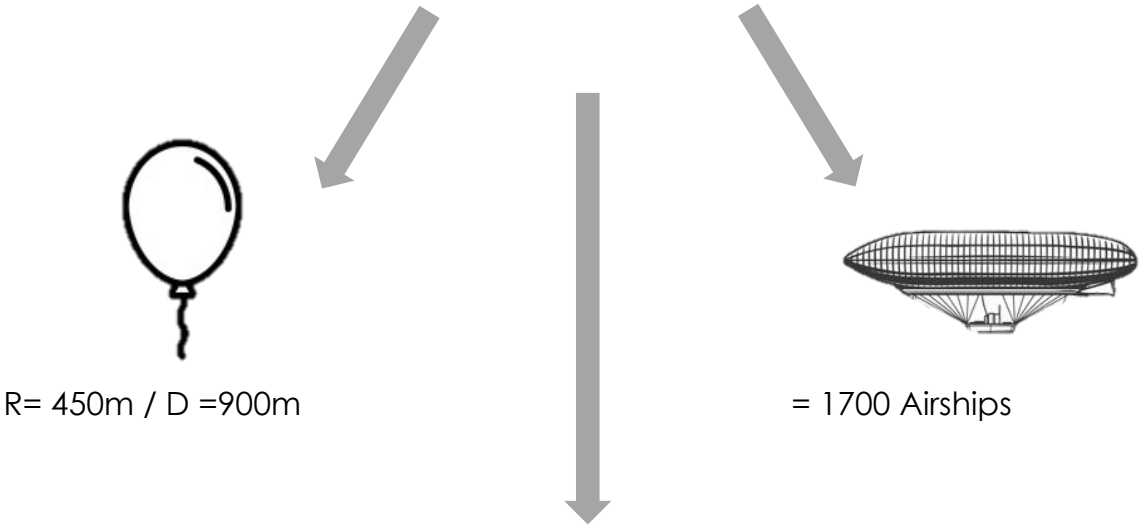
In total, to lift 365000 tons (330 million Kg), it is needed to have

330 MILLION CUBIC METERS OF HELIUM

The aforementioned quantity of Helium translates to either an Air balloon

With the Radius of 450m /1476 feet or the amount of 1700 Airships.

330 MILLION CUBIC METERS OF HELIUM



There isn't that much quantity of Helium available.

The Air Balloons floating hypothesis is refuted on three different levels.

3. Quantum physics (APPROVED)

Quantum Physics is the theory of physics that analyses the nature and behavior of matter and energy on the atomic and subatomic levels. (Piron 1976)

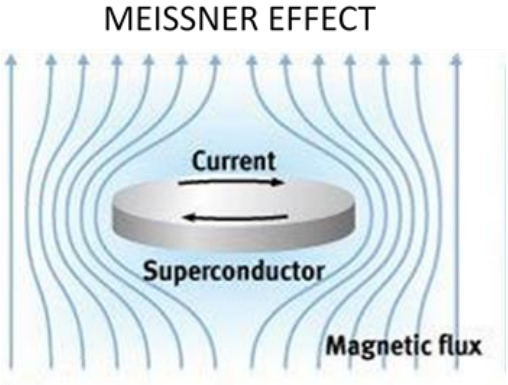
In this specific case of the city of Columbia, the in-game scientific research claims that the building is floating due to quantum physics through Quantum locking.

The experiment below highlights two concepts of quantum physics. The first one is called the Meissner effect, which is *" the expulsion of a magnetic field from the interior of a material that is in the process of becoming a superconductor, that is, losing its resistance to the flow of electrical currents when cooled below a certain temperature, called the transition temperature, usually close to absolute zero*" (Britannica 2022)

In this case, two types of superconductors are presented:

The Superconductor, once cooled down to a certain Temp, its properties are :

1. Displays Zero electrical resistance (0 current loss = charged up forever)
2. Rejects any Magnetic Field



Superconductor Type I

Figure 114: Superconductor Type I. Source: https://physicsmindboggler.co/superconductors-for-beginners/

Thinner Superconductor, once cooled down to a certain Temp, its properties are :

1. Displays Zero electrical resistance (0 energy loss = charged up forever)
2. Gets locked/pinned to its core molecules

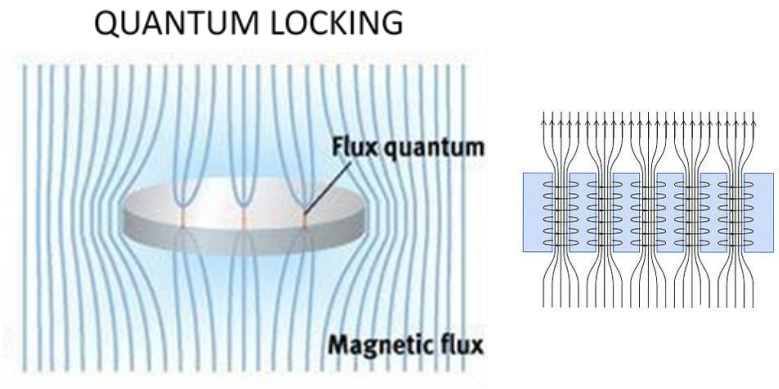


Figure 115: Quantum Locking. Source: https://physicsmindboggler.co/superconductors-for-beginners/

Quantum Locking experiment :

The Quantum Locking experiment consist of placing a Magnet Array on a solid neutral surface, this magnet array is charged up ,emitting a magnetic field.

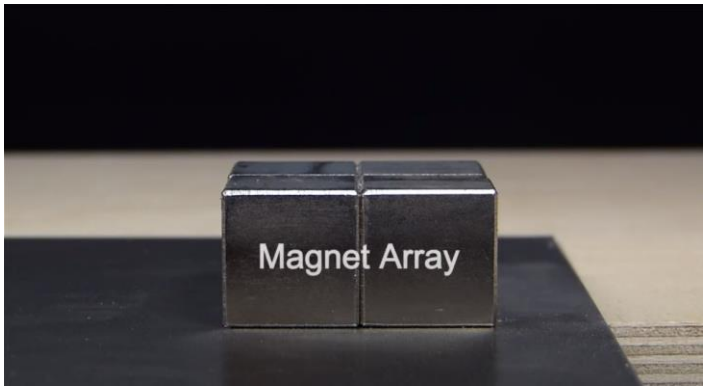


Figure 116: Magnet Array. Source: https://phys.org/news/2011-10-quantum-levitating-video-viral.html

In the Second phase, using a tong we place a Superconducting Disc on top of the Magnetic Array. It is notable that the disc called superconductor has to be at a certain temperature.

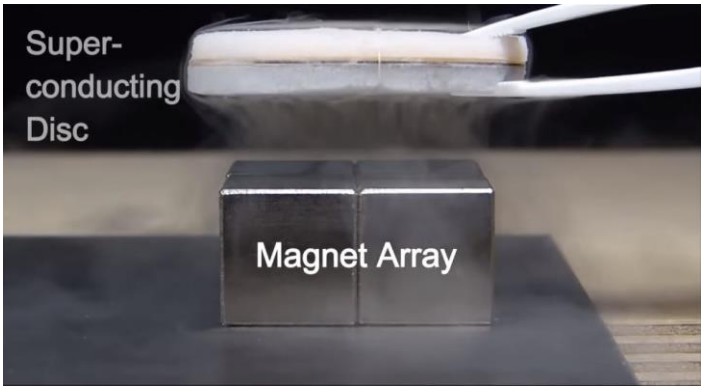


Figure 117: Magnet Array + Superconductor. Source: https://phys.org/news/2011-10-quantum-levitating-video-viral.html

Once placed above the Magnetic Array, the superconductor disc would be in a state called Quantum Locking, during which the Disc is locked to its core molecule to the magnetic flux emitting from the magnetic field.

As shown here, the disc even when tilted downward, it would not budge from its original place. Even when applying pressure exceeding the weight of the disc. In other words, as long as there is a magnetic field + the disc at a certain temp, the latter would infinitely be suspended.

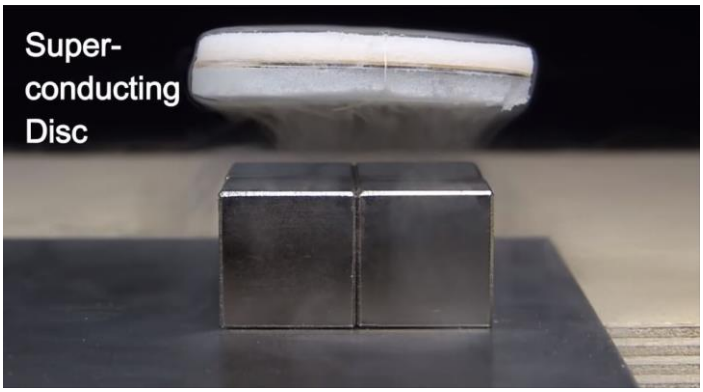


Figure 118: Superconductor Disc locked to the magnetic flux. Source : https://phys.org/news/2011-10-quantum-levitating-video-viral.html

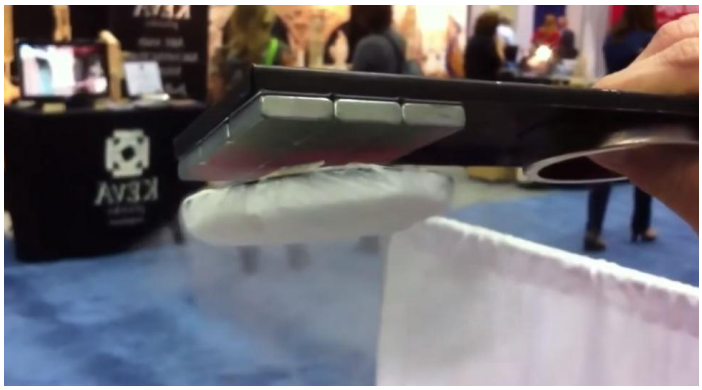


Figure 119: Superconductor Mid-air locked to its core molecule. Source : https://phys.org/news/2011-10-quantum-levitating-video-viral.html

Depending on the magnetic field size, it could hold up to 70.000 times its own weight

Figure 120: Gigantic Superconductor magnet. Source: https://www.bnl.gov/newsroom/news.php?a=25500

Figure 121: Liquid Nitrogen. Source: https://pixels.com/featured/liquid-nitrogen-being-poured-charles-d-winters.html

Another Aspect to help establish the Quantum locking physics hypothesis is using super-light construction materials as follows:

Ashe Crete, Bamboo, and bio-composite are eco-friendly light construction materials.

Figure 122: Biocomposite Materials. Source: https://elemental.green/10-eco-building-materials-revolutionizing-home-construction/

Figure 123: Bamboo. Source: https://elemental.green/10-eco-building-materials-revolutionizing-home-construction/

Figure 124: Ashcrete. Source: https://elemental.green/10-eco-building-materials-revolutionizing-home-construction/

Figure 125: Mass timber. Source: https://elemental.green/10-eco-building-materials-revolutionizing-home-construction/

Chapter III: Conceptual Approach: Bathysphere Colony

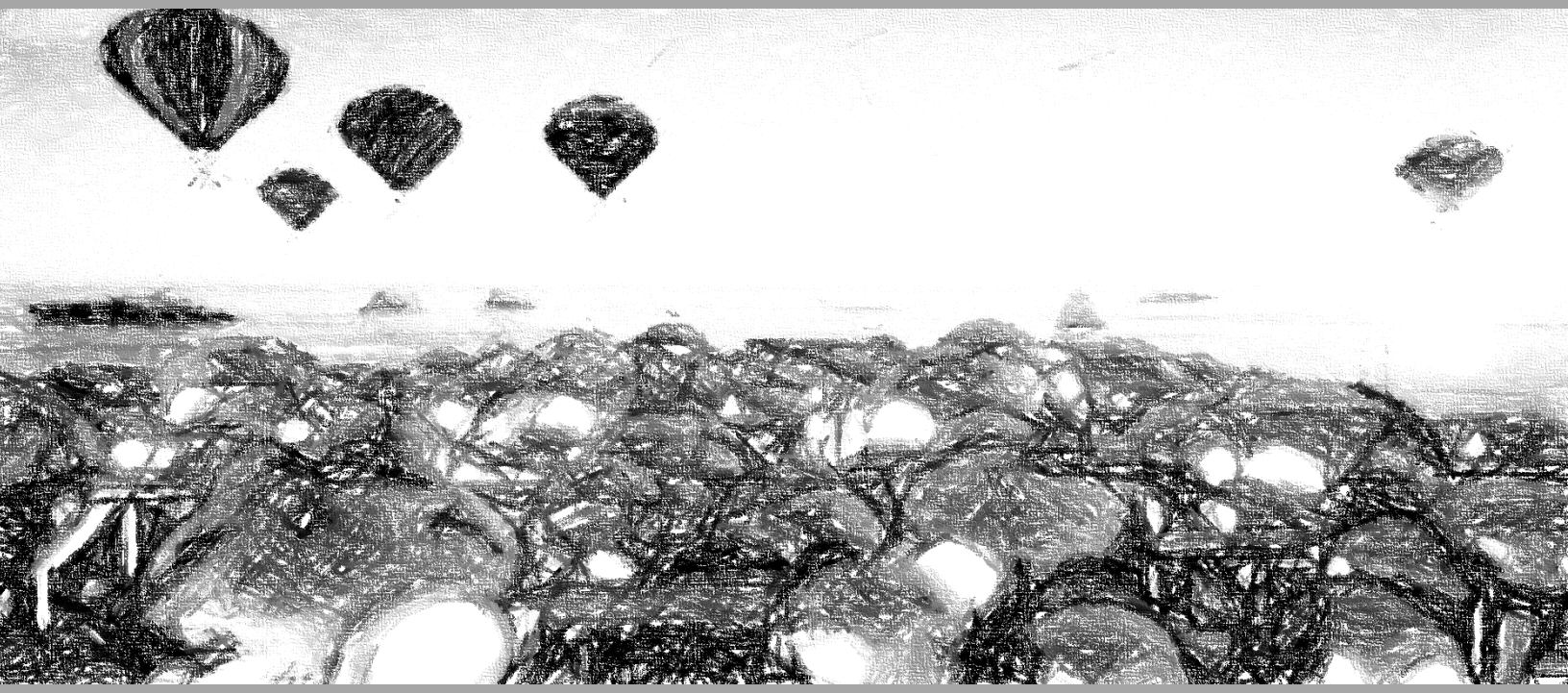


Figure 126: Design Proposal Overview. Source: Author

"It is not always about how hard you try …

Sometimes, the solution might be right in front of you.

Just think differently !"

Author

- Sources of design Inspiration

Two main sources of design inspiration.

The first one is Rapture ‘s “Big Daddy.”

The second one is: Rapture’s Metro Bathysphere

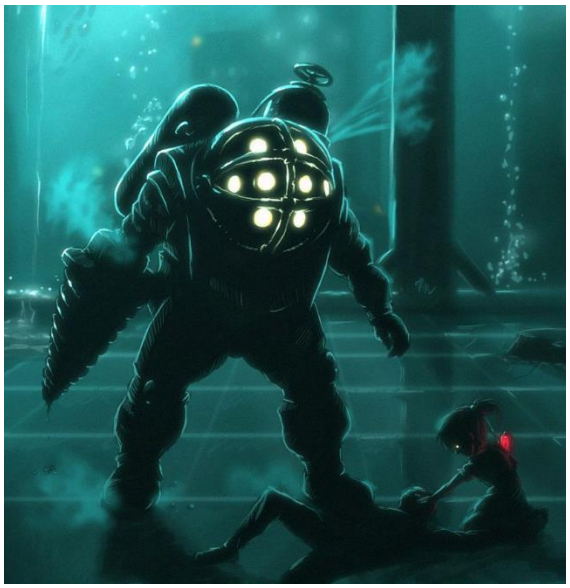


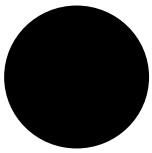
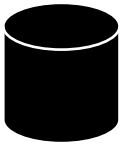
Figure 127: Big Daddy. Source: https://bioshock.fandom.com/wiki/Big_Daddy

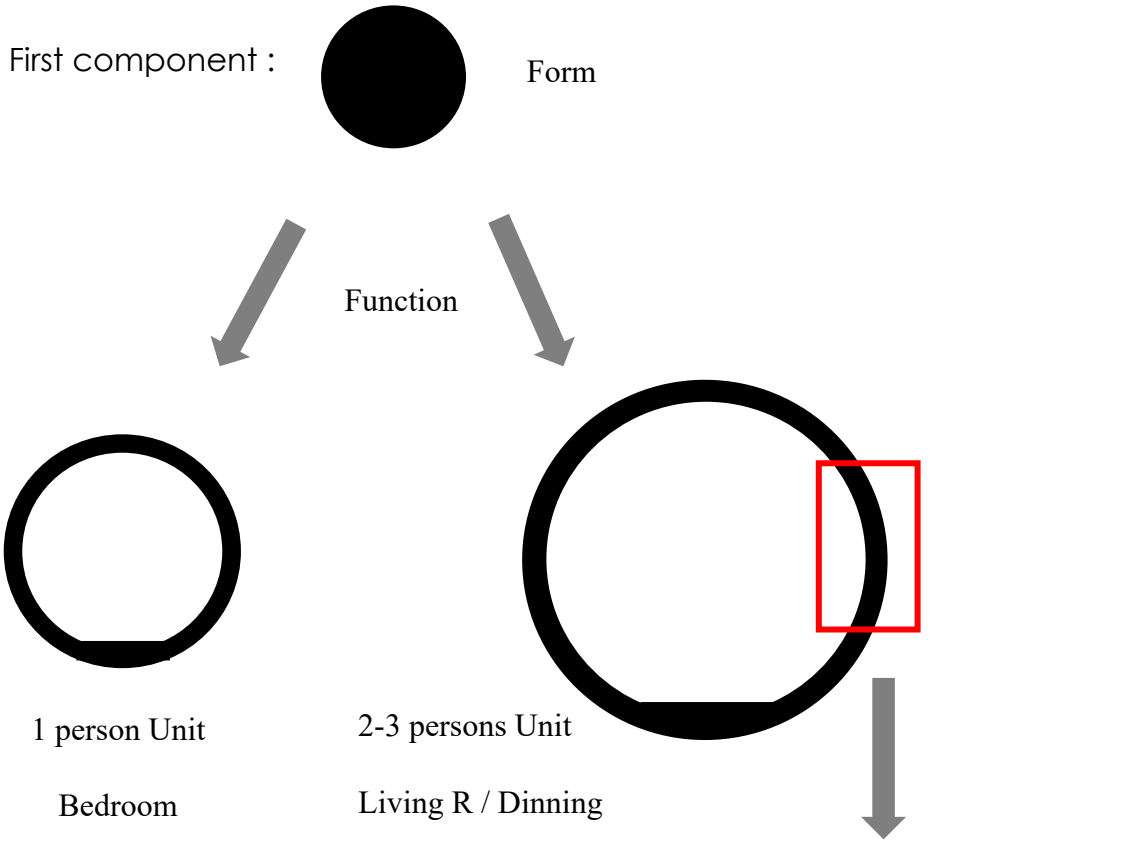
Figure 128: Bathysphere Rapture Metro station. Source: https://bioshock.fandom.com/wiki/Rapture_Metro

The design proposal combines these two figures, one as a main aesthetic concept and the other’s concept’s functionality through its method of transportation.

The design seeks to establish a reference of the city of Rapture on a realistic threshold.

- Conceptual Design Approach

	1st component	2nd component	3rd component
Form			
Function	Living Space	Circulation Structure	Foundation
Dimension	2.5 / 3.5m Diam	1m W – 3 / 4 m L	1.5 / 2m Diam
Materials	Acrylic glass or Rayotek Glass (Used in Triton 36k)	Porous Steel sheets Steel	Concrete Butyl rubber Steel – Steel scales



Materials used in this composition:

<u>From exterior to interior</u>

2” Steel Scales

3-5” Steel layer

5-7” Acrylic Glass (Thermal / Electrical Barrier)

Acrylic insulation: 0.19 W/mk

<u>For window opening</u>

14” inch Acrylic Glass / Rayotek Glass

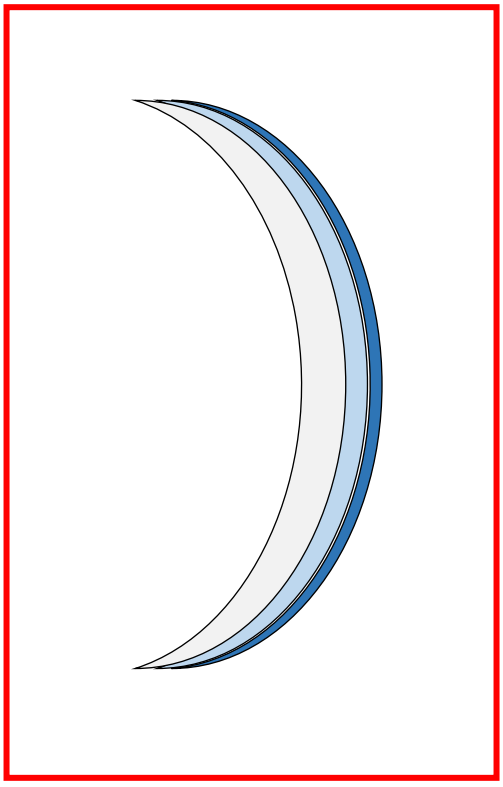


Figure 129: Steel Scales. Source: https://asknature.org/strategy/scales-provide-penetrative-protection/

Figure 130:Deepsea challenger. Source: https://www.design-industry.com.au/deepsea-challenger

Figure 131: Rayotek Glass. Source: https://rayotek.com/marine-molded-glass-domes-spheres.htm

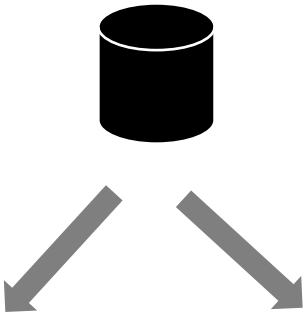
Fish scales on striped bass provide high resistance against water pressure and even predators. Thus, the design adopted a similar exterior layer in the form of steel scales. (Thomas-McAuley-Biasi. 2021)

Deepsea challenger has a 14” inch thick Acrylic Glass window to withstand high water pressure deep in the ocean. The Deepsea challenger has a record of successfully diving nearly 11 Kilometers deep to the bottom of the Mariana Trench. (DeepseaChallenge 2022)

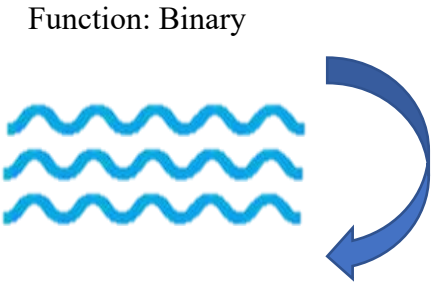
Rayotek Glass has the highest properties of Water pressure resistance among most glass materials. It is the main type of glass used in all submarines.

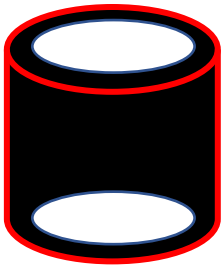
Second component

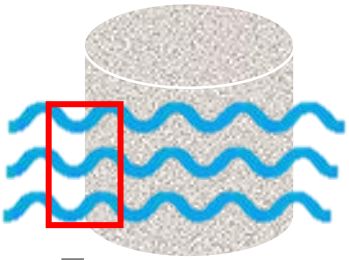
Form:



Function: Binary







When in use

- Impermeable
- under Pressure

Not in use

- Permeable
- Free of pressure

Materials :

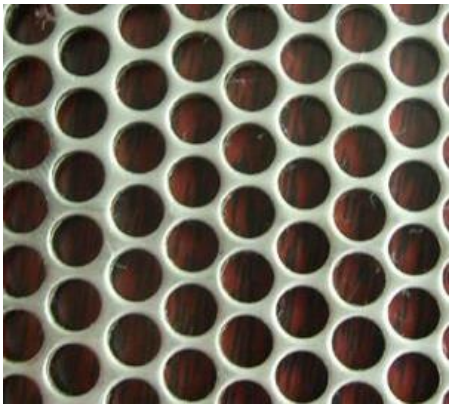
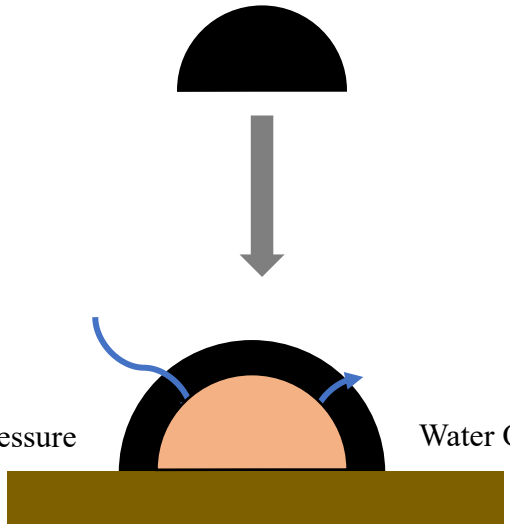


Figure 132: Porous Steel sheet. Source: https://www.vikramsteelindustries.com/new-items.html

Third component

Form:

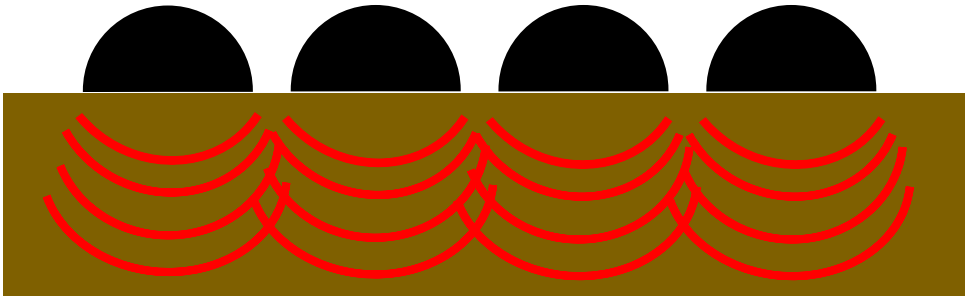


Function : Binary

Water In : Release Internal pressure

Water Out : Increase Internal pressure

The suction cups apply pressure beneath them for stability and to resist seabed erosion

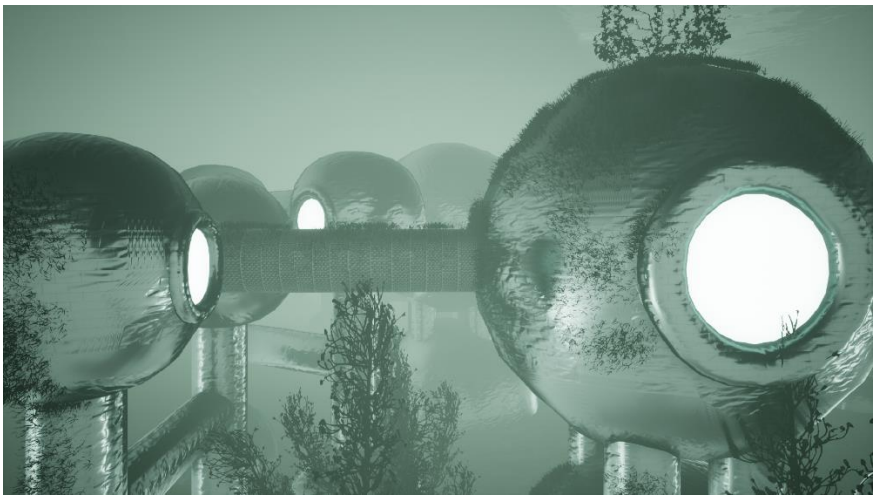


"*The sucker forms a seal at the rim and reduces the pressure in the acetabular cavity. The attachment force of the sucker (perpendicular to the surface) is the product of the area of attachment and the pressure differential between the ambient pressure and the pressure inside the sucker*"

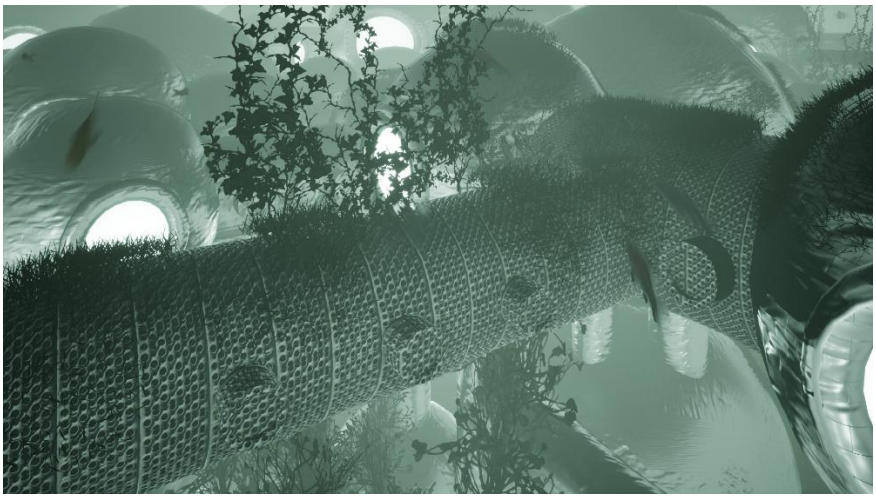
The Structure and Adhesive Mechanism of Octopus Suckers

Figure 133: Octopus suction cups. Source: https://www.shutterstock.com/video/clip-2692076-octopus-suction-cups-description-water

- Conceptual Design Proposal



Habitation



Transportation

Support Structure

- Assessing the Hypothesis

The goal is to determine the validity of the hypothesis. Therefore, an assessment is conducted valuating each city in numerous criteria scaled with different coefficient as follows:

1. **Location:** Is it conveniently located where it should be?(Coef x1)
2. **Density:** Does the number of inhabitants justify the area occupied? (Coef x2)
3. **Environment**: What is the impact on the ocean? (Coef x2)
4. **Accessibility**: How easy / hard finding your way back to earth surface? (Coef x1)
5. **Affordability**: How much it would cost (Coef x3)
6. **Renewable Energy concept** (Coef x1)
7. **Energy consumption** (Coef x2)
8. **Energy Production** (Coef x2)
9. **Maintenance** (Coef x2)

All these criteria scheduled into a table, are evaluated according to an assessment of (1 to 10), with 1 the lowest and 10 the highest.

Below is the results:

	Columbia	Score	Rapture	Score	Bathysphere Colony	Score
Location	15000 feet / 5000m Above USA	5	500 km west to Iceland /2km deep	1	200 km west to Iceland 700m deep	6
Density	66000 inhabitants in 11 Acres = 1.49p/m2	10	50000 inhabitants in 37 Acres = 0.1 P/m2	2	132 Inhabitants in 1100m2 = 0.12 P/m2	4
Environment	Very harmful	0	Filters Co2	12	Revives coral life	14
Accessibility	Rocket ship	7	Lighthouse	4	Bathysphere	10
Energy consumption	No accurate data	NA	No accurate data	NA	690 KWh/year	NA
Renewable Energy	Solar panels / Wind turbines	10	Geothermal based	10	Tidal current based	10
Energy Production	Consumption overloads production	0	"Infinite Source"	20	1.5 MW/year (One tidal turbine)	20
Cost	No accurate data – Still grossly expensive	0	$60 – 65 trillion (estimation)	3	$49 million ($1.2m per sphere)	15
Maintenance	No accurate data		$20 billion per year (estimation)	2	$320k per year	12
Total		32		44		91

Figure 134: Syntheses Table. Source: Author

- **Rapture** Summary result and conclusion

The City of Rapture highlights the challenges of building a city in a hostile environment deep down 2000m in the ocean. While it falls short in terms of adapting the design of the city to the depth, it still provides a learning curve through thoughtful, sustainable design solutions such as :

1- Geothermal vents as a renewable energy source topping the city‘s energy needs.

2- Biophilic design through an approach connecting nature with the city.

	Rapture	Score
Location	500 km west to Iceland /2km deep	1
Density	50000 inhabitants in 37 Acres = 0.1 P/m2	2
Environment	Filters Co2	12
Accessibility	Lighthouse	4
Energy consumption	No accurate data	NA
Renewable Energy	Geothermal based	10
Energy Production	“Infinite Source”	20
Cost	$60 – 65 trillion (estimation)	3
Maintenance	$20 billion per year (estimation)	2
Total		44

- **Columbia** Summary result and conclusion

The City of Columbia highlights the challenges of building a floating city at a 5,500m altitude. While it falls short in terms of adapting the design to the freezing suffocating altitude, and overwhelming energy demands, it still provides a learning curve through thoughtful, sustainable design solutions such as :

1- Solar Panels as a renewable energy source are more efficient at the city's altitude.

2- Wind turbines as a renewable energy source are more efficient at the city's altitude.

	Columbia	Score
Location	15000 feet / 5000m Above USA	5
Density	66000 inhabitants in 11 Acres = 1.49p/m2	10
Environment	Very harmful	0
Accessibility	Rocket ship	7
Energy consumption	No accurate data	NA
Renewable Energy	Solar panels / Wind turbines	10
Energy Production	Consumption overloads production	0
Cost	No accurate data – Still grossly expensive	0
Maintenance	No accurate data	
Total		32

- **Bathysphere Colony** Summary result and conclusion

The Bathysphere Colony proposal is an adaptation of creating life in a hostile environment deep 700m in the ocean. The proposal draws its opportunities and constraints from the previously analyzed City of Rapture and provides additional sustainable design solutions and ecological approaches such as :

1- Coral life protection by using an environmentally friendly design proposal through organic forms and structures and ecological construction materials.
2- Tidal current-based renewable energy production topped twice the energy needs and stored an excessive amount.
3- Using a water pressure turbine system generates energy up to 300 megawatts (per plant) through the immense water pressure at a 700m depth and sends the energy, enough to supply 200.000 households, back to offshore storage tanks.
4- Ocean thermal energy conversion (OTEC) would cost as low as $0.20 / Kw/hr.
It lowers CO2 emissions by more than half of a million tons per year.

Thus, the hypothesis of Referencing Rapture is deemed Valid based on results of the application of bathyscaphe colony in real-life settings.

	Bathysphere Colony	Score
Location	200 km west to Iceland 700m deep	6
Density	132 Inhabitants in 1100m2 = 0.12 P/m2	4
Environment	Revives coral life	14
Accessibility	Bathysphere	10
Energy consumption	690 KWh/year	NA
Renewable Energy	Tidal current based	10
Energy Production	1.5 MW/year (One tidal turbine)	20
Cost	$49 million ($1.2m per sphere)	15
Maintenance	$320k per year	12
Total		91

Summary

Based on the results of the analysis and the proposal, it is undeniably crucial to point out the intertwined relationship between Architecture, sustainable design, and video games.

The latter, considered one of the biggest communication mediums, with around 2.6 billion people who play video games, aims not only to propose and support sustainable design within its digital worlds environment but also to push its boundaries to new heights by allocating its cities in extreme environment and explore unprecedented ways of harvesting Earth’s energy resources.

The edgier and thought challenging the digital environment is, the more creative the sustainable methods would be in order to ground the fantasy on a real spectrum.

Innovation starts with a series of trials, and that is what video games do best.

Bathysphere Colony Animation Walkthrough

Bathysphere colony Overview

https://drive.google.com/file/d/19_Orn-wyRyhJGNJwGGRNZXTqOA_h_QU/view?usp=sharing

Bathysphere Transportation

https://drive.google.com/file/d/1y4QZLs9cNfuGw7RDs_49ArS1lamG6-fA/view?usp=sharing

References

n.d. "14 Architecture Games to Unleash Your Creative Mind." *Arch20.* https://www.arch2o.com/14-architecture-games-unleash-creative-mind/.

Adams, Paul C. 2007. "Teaching and Learning with SimCity 2000." *Journal of Geography* 47-55.

Allen, Tim. 2015. *Metal Gear Solid: Ground Zeroes PC Impressions.* 1 17. https://gizorama.com/2015/computer/pc/metal-gear-solid-ground-zeroes-pc-impressions.

Arenas, John. 2014. "The inspired Worklife." *Serendipity Labs.* 4 9. Accessed 12 2, 2019. https://serendipitylabs.com/architect-design-present-awareness-past-future-essentially-unknown-norman-foster/.

Arif, Fahad. 2014. "GTA V In-Game Los Santos vs Real-Life Los Angeles Screenshot Comparison Shows Several Similarities." *wcctech.* 12 27. https://wccftech.com/gta-v-los-santos-vs-los-angeles-comparison/.

2010. "Assassin Creeed Wiki." *Fandom.* https://assassinscreed.fandom.com/wiki/Rome.

Association, American Psychological. 2013. *Video Games Play May Provide Learning, Health, Social Benefits.* https://www.apa.org/news/press/releases/2013/11/video-games.

Astbury, Jon. 2014. "Playing the Architect: Why Video Games and Architecture Need Each Other." *The Architectural review.* 06 25. Accessed 11 14, 2019. https://www.architectural-review.com/essays/playing-the-architect-why-video-games-and-architecture-need-each-other/8664135.article.

2020. *Autralian Academy of Science.* https://www.science.org.au/curious/technology-future/ocean-power#:~:text=The%20most%20common%20oscillating%20bodies,a%20generator%20to%20produce%20electricity.

Bahaj, Abubakr S. 2011. "Generating electircity from the oceans." *Renewable and Sustainable Energy reviews* 3399-3416.

Bahaj, AbuBakr.S. 2011. "Generating electircity fromt he oceans." *ScienceDirect* 3399-3416.

2022. *Bioshock wiki.* https://bioshock.fandom.com/wiki/Columbia.

n.d. "Block'hood." *gog.* https://www.gog.com/game/blockhood.

Britannica, The Editors of Encyclopaedia. 2022. *Encyclopaedia Britannica.* https://www.britannica.com/science/Meissner-effect.

2020. *Brookhaven National laboratory.* https://www.bnl.gov/about/history/firstvideo.php.

Brouchoud, Jon. 2013. "The Importance of Architecture in Video Games and Virtual Worlds." *Archivirtual.* 2 13. https://archvirtual.com/2013/02/09/the-importance-of-architecture-in-video-games-and-virtual-worlds/.

Buday, Richard. 2015. "Video Games and Architecture Converge." *The Daily Kent Stater, Kent State University, Kent OH.* UWIRE.

channel, ItalianGuy videogame and arcade's. 2017. "Arcade '70s and '80s Gratest Hits Top Games ." September 21.

Cho, Renee. 2017. *State of the planet.* 2 14. https://news.climate.columbia.edu/2017/02/14/tapping-into-ocean-power/.

2022. *Cradle of Aviation Musuem.* https://www.cradleofaviation.org/history/history/saturn-v-rocket.html.

2022. *DeepseaChallenge.* http://www.deepseachallenge.com/.

2021. *Devil May Cry Wiki.* https://devilmaycry.fandom.com/wiki/Demon_World.

Dušan Stamenković, Milan Jaćević ,Janina Wildfeuer. 2017. "The persuasive aims of Metal Gear Solid: A discourse theoretical approach to the study of argumentation in video games." *Discourse, Context & Media* 11-23.

Edelson, Zachary. 2015. *Summer video games series , Assassin Creed.* https://architizer.com/blog/inspiration/collections/summer-video-game-series-assassins-creed/.

Editors, History.com. 2017. *History, Video game history.* 9 1. https://www.history.com/topics/inventions/history-of-video-games.

Eic, Ksenia. 2016. "Spatial Design in Architecture and Video Games." 9 25.

Encyclopedia, New World. 2009. *Japanese folklore and mythology.* https://www.newworldencyclopedia.org/entry/Japanese_folklore_and_mythology.

essexmyth. 2018. *Trees in Japanese Mythology: Noh Theatre, Shinto Traditions, and the Takasago Pines.* 2 21. https://essexmyth.wordpress.com/2018/02/21/trees-in-japanese-mythology-noh-theatre-shinto-traditions-and-the-takasago-pines/#:~:text=According%20to%20Japanese%20mythology%2C%20Takasago,were%20planted%20by%20the%20kami.&text=According%20to%20legend%2C%20an.

2020. *Fandom: Bioshock wiki.* https://bioshock.fandom.com/wiki/Rapture.

Ferreira, Becky. 2016. "How Games Are Changing the Museum Experience." *Vice.* 5 1. https://www.vice.com/en_us/article/yp3wwj/how-games-are-changing-the-museum-experience.

Fletcher, David. 2017. "How modern architecture is being influenced by video games." *Narratively.* 10 7. Accessed 11 14, 2019. https://theweek.com/articles/728018/how-modern-architecture-being-influenced-by-video-games.

French, A.P., & Taylor, E.F. n.d. "An Introduction to Quantum Physics (1st ed.)." *Routledge.*

Gerencser, Aron. 2020. *gtaboom. How Well Does GTA V's Map Emulate Los Angeles?* 2. https://www.gtaboom.com/gta-v-map-los-angeles/.

Giovannini, Charles Desmarais / Joseph. 2004. *Zaha Hadid Space for Art.* Baden, Switzerland: Lars Muller.

GTAwiki. 2020. "Architecture in video games : The satirical urban commentaries of GTA." *Architizer.* https://architizer.com/blog/practice/details/architecture-in-video-games-grand-theft-auto/.

Gumiska, Anna. 2017. "Sustainability Trends Reflected in the Architecture." *iopscience.* Accessed 2019. https://iopscience-iop-org.ezproxy.rit.edu/article/10.1088/1757-899X/245/6/062027/pdf.

Half-LifeWiki. 2018. *The Half-Life & Portal Encyclopedia.* https://half-life.fandom.com/wiki/City_17.

Jane Pinckard, Clara Fernandez-Vara. 2015. *Well Played.* https://pullias.usc.edu/wp-content/uploads/2015/10/WellPlayed-v4n3-15-web.pdf#page=35.

Kate. 2011. "Urban Kaleidoscope." *Shelter and Pleasure : Zaha Hadid.* 09 28. Accessed 12 2, 2019. http://www.urbankaleidoscope.com/shelter-and-pleasure-zaha-hadid/.

khan, Imran. 2019. "Assassin's Creed Unity Could Help Rebuild Notre Dame Cathedral." *ganeinformer.* 4 16. Accessed 11 15, 2019. https://www.gameinformer.com/2019/04/16/assassins-creed-unity-could-help-rebuild-notre-dame-cathedral.

Kunkel, Patrick. 2015. "Which Video Games Have the Best Architecture?" *Archdaily.* 5 27. https://www.archdaily.com/769250/which-video-games-have-the-best-architecture.

L.C, Pearson. 2018. "Architecture of the 'Half Real' : exploring the videogame as a new medium for architectural expression." *Ethos e-theses online services.* Accessed 12 17, 2019. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.747584.

2022. *lenntech.com.* https://www.lenntech.com/periodic/elements/he.htm#:~:text=Helium%20has%20many%20unique%20properties,for%20filling%20balloons%20and%20dirigibles.

Long, Kieran. 2013. *The Architecture of Grand Theft Auto V.* 10 2. https://www.disegnodaily.com/article/the-architecture-of-grand-theft-auto-v.

2022. *Makai Ocean Engineering: The future of Ocean innovation.* https://www.makai.com/ocean-thermal-energy-conversion/.

Murray, Janet. 1997. *Hamlet on the Holodeck: The future of Narrative in Cyberspace.*

museum, MIT. 2011. *Analog / Digital MIT.* http://museum.mit.edu/150/25?xid=PS_smithsonian.

2020. *Musuem of electronic games and Art.* https://www.m-e-g-a.org/research-education/research/t42-tennis-for-two/.

Ng, Benjamin Wai-ming. 2006. *Game Studies.* 12 1. http://www.gamestudies.org/0601/articles/ng.

Nicolas, Marc. 2018. *Pinterest.* https://www.pinterest.com/pin/508203139194262710/.

Pearson, Luke. 2015. "Architectures of deviation." *Exploring the spatial protocols if contemporay videogames* 269-282.

Pearson, Luke. 2018. "Worlds that are given, How architecture speaks through videogames." *Thresholds 46* 264-275.

Pedersen, Chris, Julian Togelius, and Georgios N. Yannakakis. 2009. *IEEE Xplore, Modeling Player experience in Super mario bros.* 9 10. https://ieeexplore.ieee.org/abstract/document/5286482/citations#citations.

Piron, C. 1976. *On the Foundations of Quantum Physics.* Springer, Dordrecht.

Politopoulos, Aris, Csilla Ariese, Krijn Boom, and Angus Mol. 2019. "Roman and Rollercosters : Scholarship in the digital playground." *Journal of Computer Applications in Archaeology.*

2016. *Prince of Persia: Architecture in The Sands of Time.* 4 15. https://ultracoolfella.wordpress.com/2016/04/15/prince-of-persia-architecture-in-the-sands-of-time/.

Rachel Kowert, Thorsten Quandt. 2016. *The video game debate.* Routledge.

Roelf Kromhout, Charles Forceville. 2013. "LIFE IS A JOURNEY: Source–path–goal structure in the videogames “Half-Life 2”, “Heavy Rain”, and “Grim Fandango”." *Metaphor and the Social World* 100.

Seif El-Nasr Magy, AL-Saati Maha. 2008. "Assassin’s Creed: A Multi-Cultural Read." *Diva.* https://www.diva-portal.org/smash/get/diva2:1397979/FULLTEXT01.pdf.

sheet, Empire State Fact. 2022. *Empire State .* https://www.esbnyc.com/sites/default/files/esb_fact_sheet_4_9_14_4.pdf.

Shin, Terry Hon-Tai. 2012. "Waterloo's institutional repository." *Architecture at play: The magic circle and flow in video games spaces.* Accessed 2019. https://uwspace.uwaterloo.ca/handle/10012/6660.

Simon P Neill, M.Reza Hashemi. 2018. *Fundamentals of Ocean renewable Energy.* Joe Hayton. https://www.google.com/books/edition/Fundamentals_of_Ocean_Renewable_Energy/t6RBDwAAQBAJ?hl=en&gbpv=1&dq=water+pressure+in+ocean+to+electricity&pg=PP1&printsec=frontcover.

Smoltz, Randy. 2019. "Can Video Games Make You a Better Architect?" *STRXUR.* 6. Accessed 11 15, 2019. an Video Games Make You a Better Architect?

Stulir, Mike. 2016. *ACAM : American Classic Arcade Museum.* https://www.classicarcademuseum.org/breakout.

Suprapti, Atiek. 2018. "The 2nd International Conference on Sustainability in Architecture,." *iopscience.* Accessed 2019. https://iopscience-iop-org.ezproxy.rit.edu/article/10.1088/1755-1315/213/1/011001/pdf.

Theodor, Zetterten. 2010. "Parallel Architecture for Real-Time Video Games." *Publikationsdatabas Diva.* Accessed 2019. http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A346443&dswid=-2970.

Thomas-McAuley-Biasi. 2021. *AskNature.* https://asknature.org/strategy/scales-provide-penetrative-protection/.

2021. *U.S. Energy Information Administration : Hydropwer explained.* 09 23. https://www.eia.gov/energyexplained/hydropower/ocean-thermal-energy-conversion.php#:~:text=Ocean%20Thermal%20Energy%20Conversion%20(OTEC)%20systems%20use%20a%20temperature%20difference,fluid%20drives%20a%20turbine%2Fgenerator.

Ubisoft. 2019. "SUPPORTING NOTRE-DAME DE PARIS." *Ubisoft.* 4 17. https://news.ubisoft.com/en-us/article/348227/Supporting-Notre-Dame-de-Paris.

Westenhaus, Brian. 2013. *Oilprice.* 05 18. https://oilprice.com/Energy/Energy-General/Using-Water-Pressure-at-the-Bottom-of-the-Ocean-to-Store-Energy.html.

Wilson, Ewan. 2019. "The impossible architecture of video games." *EUROGAMER.* 02 12. Accessed 11 11, 2019. https://www.eurogamer.net/articles/2019-02-12-the-impossible-architecture-of-video-games.

Zach Whalen, Laurie N. Taylor. 2008. *Playing the Past: History and Nostalgia in Video Games.* Nashville: Vanderblit University Press.

Table of Figures