University of West Attica

Department of Industrial Design & Production Engineering

Serious Games for Energy Transition

MASTER'S THESIS

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Last but not least, I thank God for everything.

Abstract

This thesis talks about Serious Games, sources of energy and energy transition. The dissertation is divided into two main parts (A. INTRODUCTION and B. METHODOLOGY). The first part is completely theoretical and it consists of four chapters. The first chapter is referring to Serious Games and has six main units and three subunits. The topics that are written are definition of Serious Games, categorization, history, application areas, psychology of games, future and perspectives. The second chapter is more generic and talks about the energy. This chapter has four units and three subunits. The main units are the definition of energy, how mankind used energy through the years, statistics about energy uses and consumption, and different sources of energy. The most used non-renewable energy is petroleum, whereas the most common renewable energy is hydropower. Solar power has made a rise these later years and it is expected to be one of the main sources of power.

Chapter three discusses the topics of climate change and environmental pollution. It consists of four main units and three subunits. First unit talks about the evidence of climate change, how scientists know and then the next unit refers to the causes. Environmental pollution is also a major global problem along with the climate crisis humanity is facing. There are different types of pollution such as air pollution, water, land, light, etc. The next units extensively talk about the effects of the earth's pollution and climate change. There are impacts on the ecosystems, animals, human's health, societal and economical. Finally, the last chapter of the first introductory section refers to energy transition. The negative impacts of pollution and climate change are no longer a minor issue, thus governments, scientists, businesses, and societies want to make a change for a better and sustainable future. The energy transition and its pillars are the solution to this global matter. The use of renewable sources, the electric vehicles, smart grids, energy efficiency and new ways of energy distribution and management are the main strategies for success.

The second part of the thesis, the methodology, refers to the Serious Games that my team and I developed for this project. The first chapter is an overview of the application. It explains the game while depicting images from different levels. The second chapter talks about the technology that has been used for the development and design of the Serious Game. Unity and C# were the tools for programming and construction of the levels, whereas Photoshop was used for the game's art and animation. The last chapter explains how the game was made and shows parts of the code that I wrote.

Table of Contents

A. INTRODUCTION

In our days' video games are pretty known to the public. They are grouped according to the device which can be played and the nature of the game itself. Computers, gaming consoles such as PlayStation and Xbox, smartphones, and so on are some of the devices that accommodate electronic games. As for the nature of the games, there are many categories such as RPG (role-playing games), sports, MMO (massively multiplayer online games), and many more. But what is a Serious Game? How can a game combine global matters like energy and power sources? Step by step answers will unfold throughout this dissertation.

Chapter 1: Serious Games

1.1 Definition of Serious Games

Many definitions exist for the term Serious Games, but whatever type of games they are, all have something in common. They combine entertainment and a serious purpose together. That purpose could range from education to researching. The initial idea behind those games was to camouflage daunting or time - consuming tasks under the friendly and engaging environment of electronic games. Although the above definition is widely accepted by many, some others believe that a serious game is nothing more than a typical video game, and its terminology is just used for marketing purposes. However, researchers believe that the adjective "serious" stands for digital games that convey knowledge, skill, or a message to the player. Therefore, a Serious Game is an application consisted of three different elements: experience, multimedia, and entertainment.

Image 1.1. Differentiation of a typical game with a Serious Game

1.2 Categorization of Serious Games

In 2008 Sawyer and Smith classified Serious Games into two main categories: market-based and purpose-based. Market-based games are designed according to the target group of people, hence the term market. An article named Zyda (2005) grouped Serious Games into five different sectors such as Defense, Training and Education, Healthcare, Public Policy, and Strategic Communication. Into 2008 two researchers named Alvarez and Michaud divided the Serious Games into similar categories as mentioned above, but they also added three more groups: Advertising, Activism, and Culture. To sum things up, market-based categorization shows the uses of Serious Games and not their content. This is quite limiting considering that the boundaries of Serious Games continue to broaden due to uncovering new markets.

On the other hand, the purpose-based classification of Serious Games focuses on the intention or the goal that developers intend to deliver. An examples of this type of categorization is: In 2006 Bergeron's book included seven goal-oriented categories: Political Games, Health and Medicine Games, Business Games, News Games, Activism Games, Advergames (games that promote a product or a service), and Exergaming (games that require physical activity to get played). Although the above classification has divided the Serious Games according to a single criterion, there is still a misconception on the categories. For instance, Business Games can be considered market-based since they target a specific market group, while Exergames belong clearly into the purpose-based classification because they have a purpose, exercising besides entertainment. Fortunately, these two types of classification shed light on the creation of different models and analyses of the Serious Games. Researchers included four dimensions in the classification data of Serious Games, which are: Primary Educational Content, Target Age Group, Primary Learning Principle, and Platform.

Primary Educational Content includes six areas such as marketing, military, health, occupation, social change, and academic education.

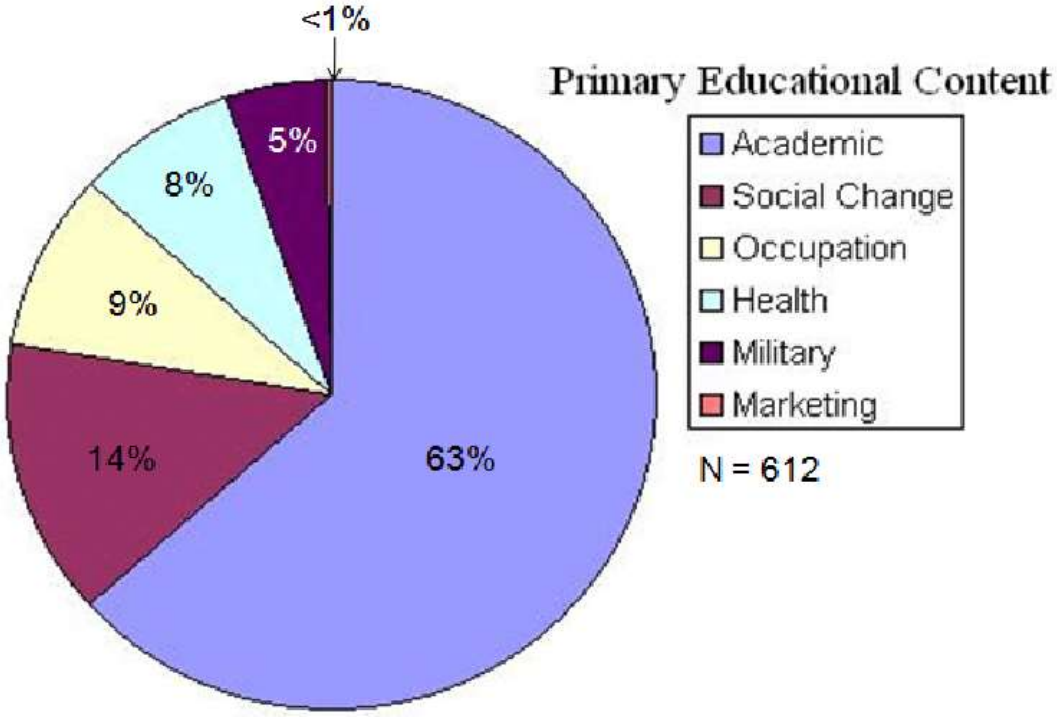


Image 1.2 Proportions of the areas in Primary Educational Content

Primary Learning Principles are games that focus on exploration, experimentation, and problem-solving skills.

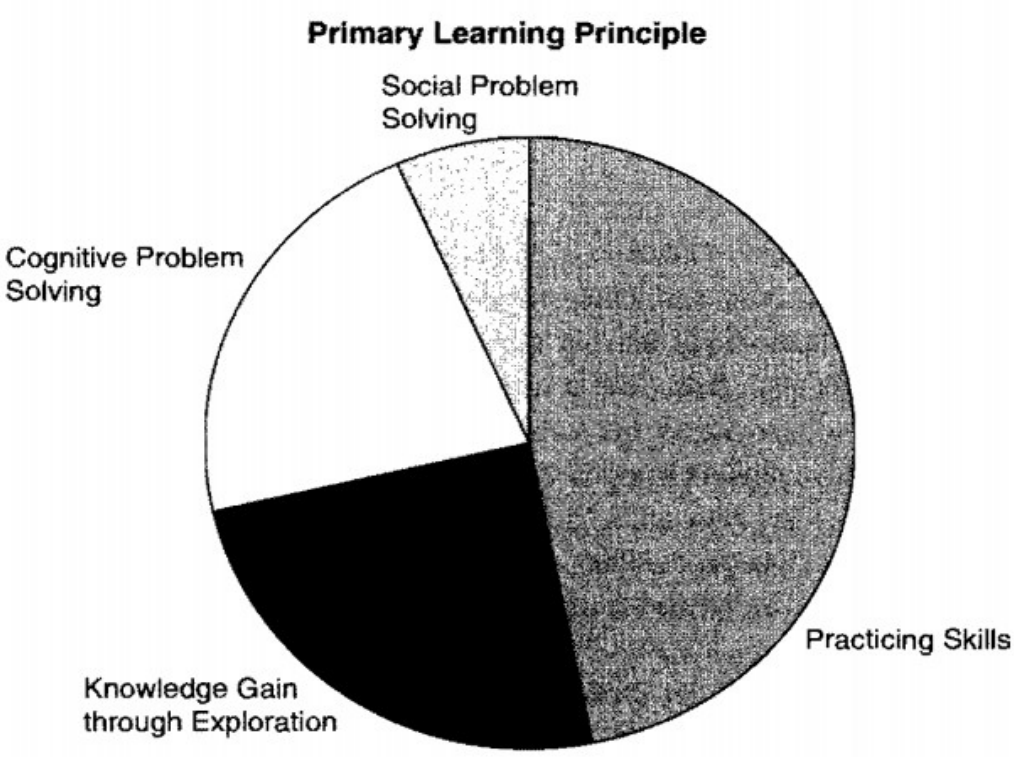


Image 1.2.1 Proportions of Primary Learning Principle

According to the above diagram, 48% of the games focus on practicing skills, 24% on cognitive problem-solving skills, 21% on knowledge gained through exploration, and 7% use the social problem solving primary learning principle.

Target Age Group divides games into four categories such as preschool and below, elementary school, middle school and high school, and college or adult. According to statistics, 39% of the Serious Games target the age of elementary, middle school and high school respectively. College, adult Serious Games were 16%, and much more below, 5% were the games targeting preschool kids. As it seems, Serious Games addresses more on the younger audience since most of them are centered on the academic/educational content.

Game Platform: As was mentioned previously, games can be played on different electronic devices. As reported by the dataset, 90% of Serious Games have been designed for computer platforms and the remaining 10% is for PlayStation, Nintendo and so on.

To combine the "serious" and "game" dimension a new model has been developed, called G/P/S (Gameplay/Purpose/Scope). The Gameplay refers to the structure of the game, in few words how it is played. The Purpose accounts for the final goal/message that developers intended to deliver to the player apart from the entertainment aspect. Finally, Scope includes the uses of the game such as the market and the audience. The G/P/S model is suitable for the categorization of every kind of electronic game.

1.3 History of Games and Subsequently of Serious Games

The origin of games starts at the very beginning of human civilization. Since ancient times, people created different ways to spend their day. Around 40,000BC, India used sheep's knucklebones for fortunetelling. Knucklebones were also found in various places in Asia, like Afghanistan or Tibet. The earliest dice have been discovered in Iran at approximately 3,000BC.

Image 1.3 Knucklebone found in Afghanistan.

Image 1.3.1 Ancient dice from Iran

Between the period of 1,500BC and 1,200AD, a game named Liubo was played among the Chinese. It was a battle-strategic type of board game. In ancient Egypt, 1,400BC, traders were using a stone-made tool, named Mancala, for trading goods like animals and food. Mancala was found on the roofs of Kurna Temples. Later this trading tool evolved into a gambling game wagering on food supplies, sheep and cattle. This form of entertainment spread to many places in Africa and also the Middle East, like Syria. 5,000 years ago game mechanics appeared such as board games, rules and strategies.

Image 1.3.2 Liubo game from China

Image 1.3.3 Mancala, a game from Egypt

The first electronic game was developed by a physicist named William Higinbotham in October 1958. William was responsible for showing scientific exhibitions at Brookhaven National Laboratory to the visitors that came for a tour. Wanting to catch people's attention, William decided to make exhibitions more interactive. In this way, scientists would easier convey their message to the visitors. Having experience from many electronic devices such as oscilloscopes, analog computers and radar systems, William, in a short time came up with an

idea of a tennis game. With the help of a technician named Robert Dvorak, they spend two weeks building the first "gaming-console" which was for the tennis game. The graphics were simple, just two lines. One represented the field and the other was the tennis net. A dot was used for showing the ball. Their efforts to attract people's attention were successful since many visitors came only to play the game, standing in long lines.

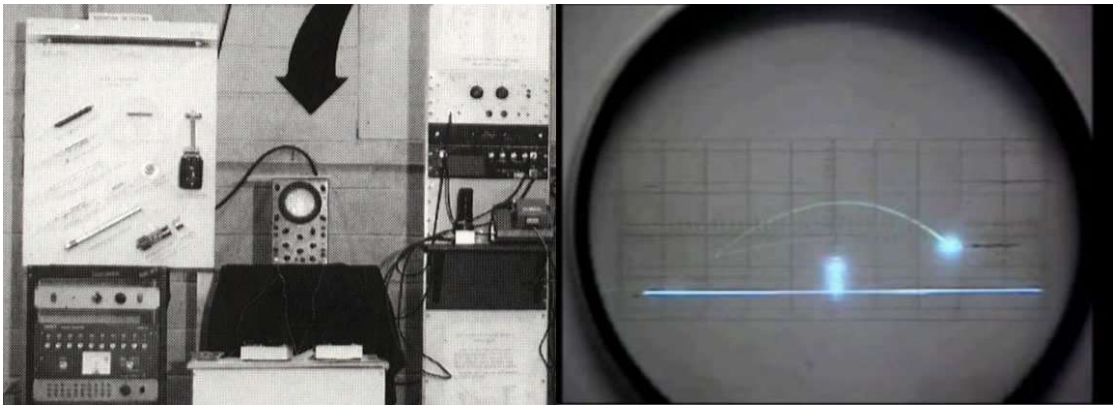


Image 1.3.4 The first electronic game, called Tennis for Two

The developers of Sanders Associates in 1967, developed the first video game that could be played on television. They called it the "Brown Box." A company named Atari, in 1977, built a more advanced gaming console featuring joysticks and providing colored games. The video game industry boomed from the late 70s to the 80s. In 1979, it was launched the first third-party game developer which means without the need of making consoles. Microsoft also released the first flight simulator game.

With the aid of computer technology, video games entered the "era of 3D gaming". In 1995, Sega published its own gaming system, the first that could play video games on CDs. The next year Nintendo released the Nintendo 64. Many companies crashed with each other in the gaming industry, but the strongest of all was, and it's still nowadays, Sony with the PlayStation. The PlayStation 2 was the first console that games could be played on DVDs.

From 2005 and beyond, games enter the "modern age", having high-definition and advanced graphics. At the beginning of the 2010s and later, games started to appear on social media and smartphones, making gaming among people even more popular. In those last years, Sony and Microsoft elevated the gaming experience through virtual reality.

Image 1.3.5 VR Goggles, Virtual Reality Headset

As indicated, games had always been a part of a serious purpose: fortune-telling, divinations for the weather, politics, or diseases, battle planning, gambling and later for educational purposes like science.

In the late 19th and early 20th century, Stewart Culin, an American author and ethnographer, studied the art of games, and he considered them as something significant for research. Unfortunately, at that time, many didn't share his view. The Director of the Bureau of American Ethnography, W. H. Holmes, showed appreciation in Culin's work and said that games are part of human culture. Culin's research promoted the academic study of games.

The first person who used the term "serious" in gaming was an American researcher named Clark Abt. He aimed to develop games for education and training. One of his computer games was T.E.M.P.E.R. (1961), which was used by the military to evaluate the Cold War conflict. Clark Abt also mentioned in his book (1970) non-electronic Serious Games such as math games to be used by students at school. His definition of Serious Games was that those games are not meant to be played primarily for amusement but for learning. Nonetheless, Serious Games do not exclude the entertaining aspect.

Abt saw Serious Games as a chance to address the inadequacies of the educational system and as an engagement in different organizational or political systems. He suggested that Serious Games offer safe means for experimentation. During the 1970s and onwards, the research field of Serious Games was raised alongside the video game industry.

The first non-analog Serious Games were developed for scientific research, especially in the field of computer science and artificial intelligence. Such a game was chess, released for the IMB 704 computer in 1958. The first Serious Games were not only for research and training professionals but also to convey a message. Ferranti made a math-based game named NIM (1951). Although his work was of great importance for computer science, his only aim was to advertise his constructor.

It is worth to mention that the first games were not commercial. The first game console, the Magnavox Odyssey (1972), had both entertainment games (Tennis, Roulette) and educational games (Analogic, States). It could be said that both Serious Games and amusement games were shown to the public, but entertainment video games appeared only after the first Serious Games made by scientists for research.

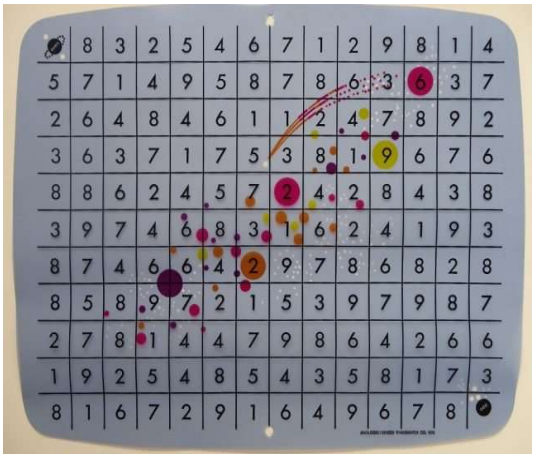


Image 1.3.6 Analogic, a Serious Game from 1972

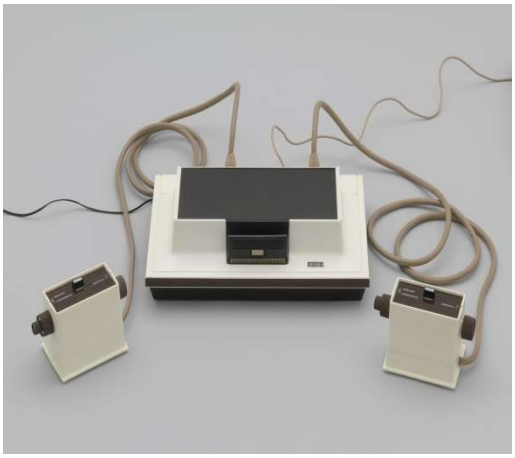


Image 1.3.7 First game console, 1972

1.4 Application Areas of Serious Games

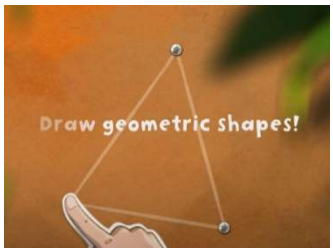
Serious Games can be found in a variety of domains, ranging from educational games to simulation, health, tourism, marketing and sociopolitical games. As was mentioned in section 1.2 (Categorization of Serious Games), most Serious Games have been developed for educational purposes. Those types of games belong in Edutainment applications.

1.4.1 Educational Games

Most educational games focus on teaching a particular subject such as history, astronomy, health and many more. It is worth to mention that games like chess do not belong in educational games because they do not deliver educational material, but they improve logic skills and reasoning (Yue and Zin, 2009).

It has been shown that games in education provide many advantages. According to Boyle (2011), they have a great impact on students' self-confidence. Students are encouraged to engage and participate in the learning process. Furthermore, they assist students in remembering critical points that they can later apply in school and real-world situations. Also, students can hone their visual and problem-solving skills. Researchers have proved that Serious Educational Games can help students with attention disorders improve their study due to the fun nature of games. With gaming, pupils can acquire other sets of skills such as problem-solving, critical thinking, interaction with peers and sportsmanship.

Examples of educational games: 1) Dragon Box Elements. It's designed to teach young kids basic geometry. 2) Pulse: a game that focuses on the healthcare sector. Players have to identify patient's problem and act accordingly. 3) Pacific: a game that teaches players the virtues of a good leader and team management skills.

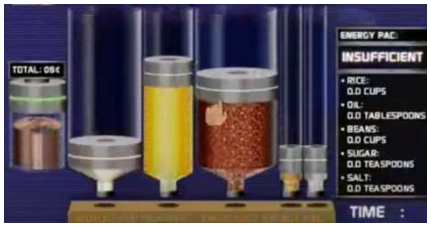


Img 1.4 Dragon Box Elements

Img 1.4.1 Pulse

Img 1.4.2 Pacific

Another example of how serious games can be is "Food Force". Promotes social awareness and teaches players different ways to fight world hunger. The game is set on a Pacific island where civil war has occurred. Due to famine, the player's goal is to distribute food supplies to people in need and in the long term, to make this island stand again self-sufficient. Bionigma, is a game for Bioinformatics where players have to solve protein multiple sequence alignments and Ludvig is a game that teaches physics.



Img 1.4.4 Food Force

Img 1.4.5 Bionigma

Educational Serious Games are not only great for students and young kids but for adults too. They have played an important role in the industry. With the evolution of the production networks, companies are faced with the difficulty of continuously teaching their personnel, aiming to increase competition. Games provide hard skills, like understanding the complexity of systems, but also convey soft skills such as collaboration and communication. Some companies use Serious Games to teach and train their employees to handle difficult negotiations and make tough decisions without dealing with errors that can cost a fortune. Such a game is "Merchants," which prepares employees to resolve conflicts and negotiate.

Img 1.4.3 Merchant

Some other games that have been used inside industrial contexts are: 1) Glotrain: A game that teaches employees the characteristics of a manufacturing system. 2) SHARE: This game focuses on the organizational development and production of a product in one company. 3) Logtrain: deals with the area of logistics for e-learning. 4) Supply Net Game: is a game on inventory control. Participants impersonate a factory scheduler by controlling the inventories to the factory.

Serious Games have been proved to be an exceptional tool for learning necessary skills such as:

1) Professionalism: Competence to solve technical problems and specialist skills.

2) Method competence: Ability to discover ways and means for overcoming the problems (project management, presentation, etc.)

3) Social competence: Ability to be in a team and to solve problems cooperating with the other members. Further social abilities are communication, negotiation and integration.

4) Self-learning and self-reflecting competence: Ability to identify learning resources, to select sufficient learning strategies and to value learning results. Other abilities include flexibility, creativity, taking initiative and self-criticism.

5) Self-organization competence: Refers to the ability to self-organize and take action in private, professional and social situations.

6) Decisive competence: It is the ability to make decisions under pressure and possible consequences.

7) Transition competence: Focuses on the ability to cope with different surroundings. The importance of this competency is shown when the employee is involved in many projects and must adjust himself or herself to different surroundings and partners.

Some other benefits of Serious Games in the workforce include the rise in engagement of the employees.

As stated above, Serious Games have many advantages in education, but also disadvantages should not be omitted. The negatives will be divided into two parts, in the academic context and in the industrial/workplace context.

The video game designer Jesse Schell points out some of the problems that make education through gaming hard to integrate into the current school system. The first problem that he mentions is the time to complete a game. Teachers will have it difficult to integrate Serious Games as a method of teaching because they do not know how long a classroom unit should take. If a deadline is set to finish a particular unit, students will get discouraged due to not completing the game on time. This also will create a gap between students, as some of them will be behind others. The second major problem is that through gaming, each student has different experiences and learning, and this will burden the teachers with the task of tracking the progress of every student. The third and most important disadvantage is the excessive use of Serious Games to learn the material. There is a risk for addiction and losing social skills, thus making students less adequate to face the real world.

Another issue is the limited material that games can cover. Furthermore, the cost of developing a game is massive because of the work that is required to be put. This applies especially to AAA games, which means they are high-quality and can be compared to movies. Although high cost does not necessarily indicate that a game will be successful. Some low budget Serious Games can work well in the educational context. However, there should be a careful and professional design in order to teach students effectively at school.

The drawbacks of Educational Serious Games in the industry / workforce include:

1) The generalization of the process: This means that if employees do not put effort into making a thoughtful plan will risk omitting processes that matter more in the industry.

2) Forcing the members of the workforce: Some employers oblige their employees to participate in those Educational Serious Games, making them resentful.

3) Due to the competitive environment inside a company, some workers through gaming will try to thrive arbitrarily. Thus, causing personal issues between the staff as they are trying to get rewards and progress.

4) Not everyone can learn through gaming. Others are better in pure memorization and some others learn better through practice. To put it another way, employees should have the choice to opt for their preferred learning style.

Nonetheless, if Serious Games have been developed adequately and they are used in the best way possible with careful planning either in the academic context or in the education of workers, they have the potential to revolutionize the learning process and bring new benefits to the people.

1.4.2 Simulation Games

Simulations usually resemble real-world situations that most of the time, aim to increase situational awareness. Situational awareness is the ability to focus on specific details, make conclusions based upon them and take the appropriate action in order to have the desired outcome. Simulation games offer the opportunity to explore new materials and subjects, provide challenges like emergencies and give experience to the users. Those experiences might be something that the players would never try or go through in real life. An example of this is a VR simulation, where the player can explore planet Mars and walk on its surface.

In former times, simulation technology was used only in industrial and military contexts. With the evolution of computers and electronic devices, advanced simulation environments can be used in a variety of fields, such as commerce and training. The result of this was the creation of simulation video games. Simulation games are a complex structure consisted of a game of skills, opportunities and strategies. There are four categories of simulation games: Participatory, Procedural, Situational and Iterative.

Participatory simulation games require a form of physical activity. The player is often exposed to a fake environment or under fictional situations. Usually, this type of game is offered by virtual reality and augmented reality technologies.

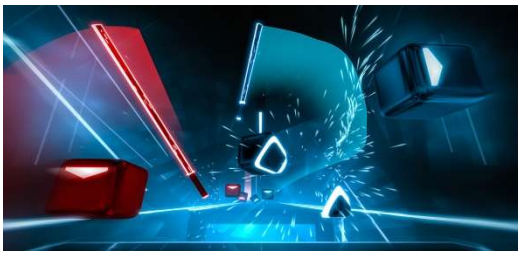
Procedural simulation games are based on real-life situations where players can take action and receive the consequences of their decisions.

Situational games are built around different circumstances and behaviors of people.

Iterative games give the player the capacity to create a result such as a business model by inputting variables and observe the iterative changes.

Examples of simulation games are, 1) Beat Saber: It is a VR game set in a futuristic-neon environment where the players are required to slash the upcoming blocks with their lightsaber. It is great for exercise as players go through physical activity. This game can be considered part of the participatory simulation games. 2) Vehicle Simulator: It is a flying and sailing simulation game where the player can fly fighter aircraft and sail small boats. This game represents the real world, including precise flight physics and marine dynamics. This game belongs to the procedural simulation category. 3) The Sims: Belongs to the group of situational simulation games where the players can create their own virtual characters, build their dream houses, make friends, find their love and get a job. Players respond to the emotions and behaviors of the other characters inside the game. 4) Capitalism Plus can be assumed to belong in the iterative simulation games. The player impersonates a businessman who can build his or her own company, develop new products and services, and create different scenarios.

Img 1.4.6 Capitalism Plus



Img 1.4.7 Beat Saber

Simulation games, excluding entertainment purposes, are an excellent tool for education, research and training. Specifically, they are suitable for inquiry-learning. In order for the students or trainees to learn something, they need to interact with the environment. A simple form of the inquiry-learning process is when learners via experimentation and manipulation of the variable's value, observe the outcomes. Zacharia and de Jong, in their studies, have concluded that students had a better grasp of knowledge through computer-based simulation rather than the real environment. One reason for this is that students are physically safe. They cannot hurt themselves or destroy types of equipment. Having this in mind students get more convenient and are less afraid to make mistakes, thus enhancing motivation and engagement in the activity.

Other advantages of using simulation in education or training:

1) The ease in demonstrating abstract or difficult concepts.

2) Provides immediate feedback to the users allowing them to improve their skills.

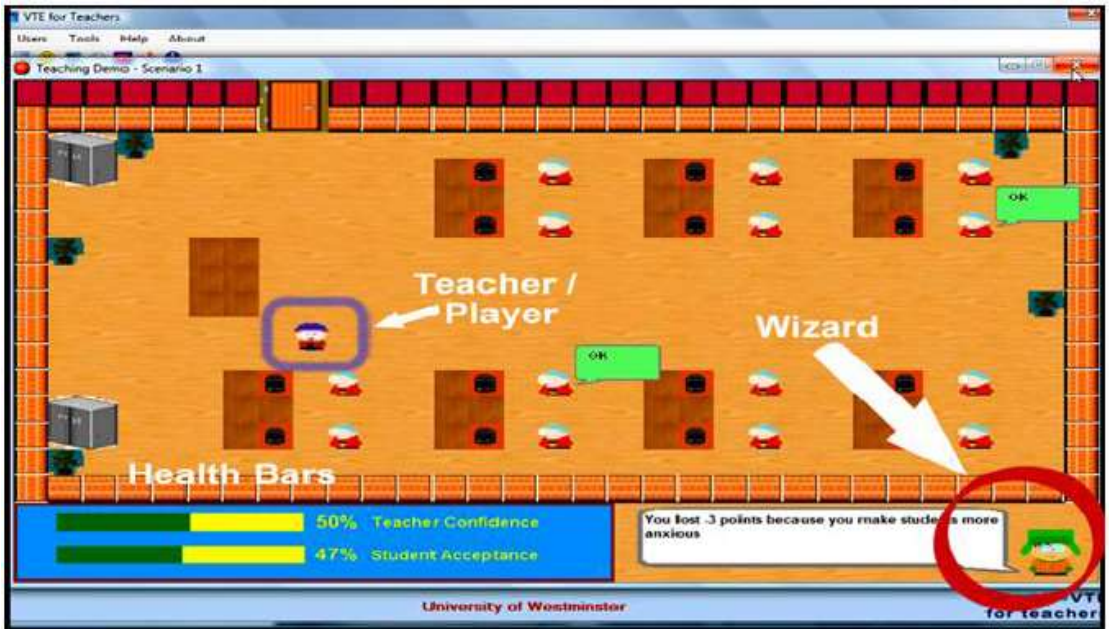
3) It is cheaper since there is no need to construct expensive training environments or equipment for the practitioners.

4) Variety of situations accessible to students to experiment in and later apply what they have learned in the real world.

5) It can be easily updated or developed to the current students' needs.

6) The practice or learning can be done anywhere.

An example of using a simulation game for training is for the preparation of the new teachers. The "Teaching Game" made by Vassiliki Bouki, Markos Mentzelopoulos and Aristidis Protopsaltis aims to prepare new teachers in classroom management and also trains them how to confront unexpected situations.



Img 1.4.8 The Teaching Game. Teacher's confidence and student's acceptance

Simulation games have also entered the medical field. Students can be trained and practice their skills before being occupied as a real doctor or nurse in the hospitals or clinics. The game SICKO (Surgical Improvement of Clinical Knowledge Ops), designed by Stanford University, simulates real-world experience as a surgeon. The game's purpose is to train surgeons and surgical trainees on making the right decisions.

Img 1.4.9 SICKO

Engineers as well, they get trained by simulation games. A mobile game named Bridge Construction Simulator can be used to tutor students by improving their skills in civil engineering. With real physics and challenges that require a thought process and logic, engineers have to design and construct bridges across different locations.

Img 1.4.10 A simulation game for civil engineers

According to a survey, 90% of the 434 residency program directors supported games in residency education, and 80% of medical students were of the opinion that digital games provide an educational value (Stevenson's article). As it is shown, teachers and students prefer learning and training through gaming over conventional methods.

However, a successful simulation required for teaching must include:

1) The option to give feedback to the users so they can learn from their mistakes.

2) Continuously practice for the students or trainees to improve their skills.

3) Curriculum integration.

4) Variety in difficulty levels.

1.4.3 Games for Therapeutic Purposes

The wide varieties of video games make them a useful tool in the field of psychotherapy and other therapeutic purposes such as rehabilitation. However, Serious Games developed for the mental health field are still at their initial level (2017). Studies show that they have some benefits in symptom relief and psychological or behavioral changes.

There are three reasons why games have the potential for mental health. First, there might be an increase in mental health preventions. Many people do not receive treatment even though they experience mental distress. Due to the popularity of video games, people have access to help. Second, video games are engaging and are seen as enjoyable by users. Third, Serious Games provide an opportunity for behavioral and learning changes. The reason is that the rich sensory environment of games reinforces learning and allows users to try new skills and behaviors in a safe environment.

Electronic Games for Psychotherapy (EGP) and Electronic Games for Entertainment (EGE) have been used to increase motivation, knowledge, attention, and to provide emotional expression. The improvement of physical activity in children and diet has been implemented by the EGP, while EGE have been used to fight anxiety, cognitive rehabilitation and physical therapy. Games with gross motor interfaces, such as DDR (Dance Dance Revolution), are used in rehabilitation therapies to increase fitness, reduce pain and improve the cognitive function of people who have been diagnosed with multiple sclerosis, stroke, or other brain injuries.

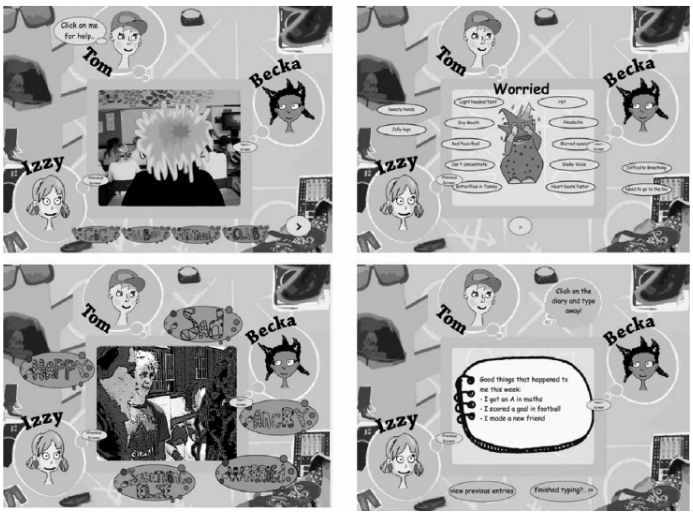
Games that focus on the psychotherapy aspect have been developed to fight anxiety, mood swings, enhance self-controlling skills, social skills, increase motivation and many more. An example of such a game is PlayMancer, which has been created to assist individuals with impulse-related issues. Virtual Reality (VR) has been used to treat stress disorders like PTSD, arachnophobia, fear of flying and other related problems. It has been proved that Virtual Reality Therapy was as useful as the conventional methods of treatment.

Img 1.4.11 DDR Mat

Img 1.4.12 PlayMancer

A common mental disorder that affects more than 264 million people around the world, according to the World Health Organization (WHO), is depression. Although treatments exist, most people do not receive assistance due to costly or inconvenient services. Furthermore,

some of them believe that they will not benefit from the therapy. To combat these issues, Serious Games have been developed to treat or even prevent depression. Researchers from 2011 to 2012 developed a Serious Game named Think Feel Do, which was given to 54 participants, specifically young people with mild or moderate signs of depression. The goal of this game was to learn thoughts and actions that lead to positive outcomes. Players had to distinguish between negative and positive thoughts and feelings. The game's music was altered by the player's mood, which also determined the results. Throughout this research, users were encouraged to write down in a diary the positive things that happened to them while playing. The conducted research in 2012 showed that participants had a significant improvement in depression, anxiety and self-esteem.



Img 1.4.13 Think Feel Do

Serious Games that have been used for depression treatment are in their early stages. Unfortunately, there is no standard method to tend to all kinds of mental disorders. Thus, there is a need to have a wide range of tools and techniques in order to treat different circumstances and also to give the option to the specialists and patients to choose their preferred method of treatment.

Other application areas of Serious Games include:

- Tourism
- Marketing
- Culture
- Public Awareness
- Religion
- Energy and Climate
- Security
- Government
- Military
- Management
- Science
- Strategic Planning and many more.

1.5 The Psychology Behind Game's Engaging Nature

The aim of the game developers is to make a game fun. To do this, they create a friendly user interface, game mechanics such as rules and skills that a player can acquire throughout the gameplay and an interesting story. In 2003, Klimmt proposed a model that depicts game enjoyment. The enjoyability of the game can be determined by three levels. At the first level, players receive direct feedback from the game, enabling an effective experience. At the second level comes the player's curiosity to unfold the next steps of the game in conjunction with suspense and increment of self-esteem. At the last level, the game is viewed as a whole, including the player's perception of reality, experience gained from the entire process and the feelings that were formed during and after gameplay.

Some fun factors that have been identified by the scholars are: 1) Game duration, 2) Desire for the players to play again the game, 3) Storyline, 4) Characters, 5) Humor, 6) How much the game approaches reality (environments, situations, interactions), 7) Fantasy.

Researchers of the University of Essex investigated the reason why so many people around the world enjoy playing video games. According to the study, people are intrigued by the idea of trying on characteristics that they would like to have themselves. In other words, the projection of the ideal self. Also, scientists found that the adoption of a new personality in a game, be it a hero, villain, or even a different gender, reduced players' negativity towards themselves. In addition, when there is no big difference between the actual self and the ideal self, players enjoyed the game even more. Dr. Przybylski came into conclusion that people do not want to escape from themselves but they want to run towards their ideal self.

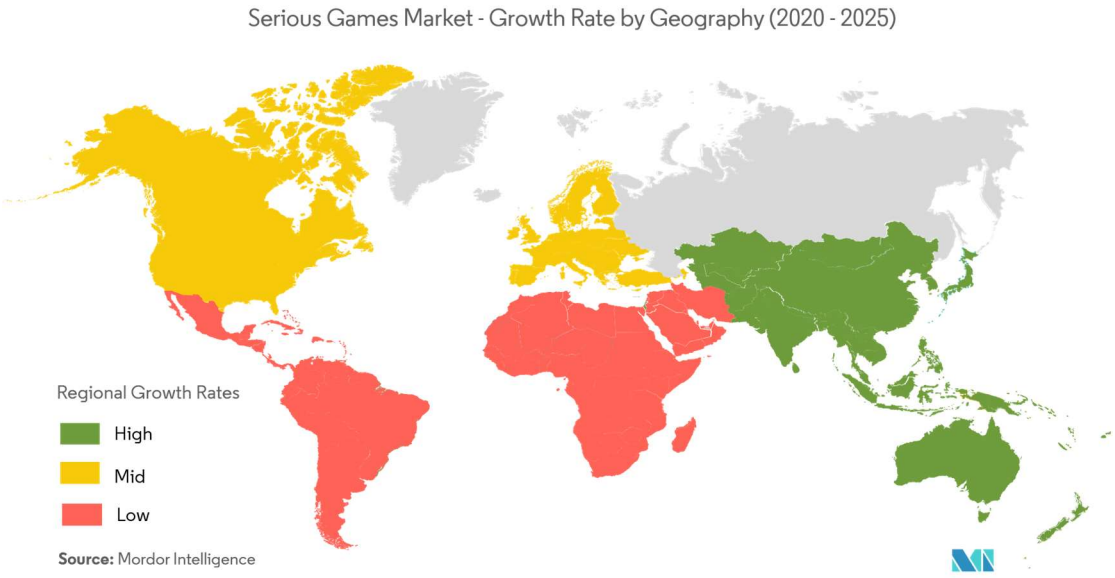
The reasons mentioned above are not the only ones that make a game entertaining. Nowadays, electronic games have been developed so much that they provide a new world, a different reality, ideal to escape stress and ordinary life. This digital world provides a route of escapism, where players are free to act and achieve whatever they desire without confronting judgment. While achieving something, players feel they have total control and success, which helps in raising self-esteem and the feeling of being powerful. Also, games are a great tool for bonding people with each other. They can play with family and friends and have a good time. Last but not least, the challenging nature of video games, appeal to people and make them want to solve the problem. It is a chance to prove their worthiness to themselves. Even simple games without extraordinary graphics or story like Sudoku can keep the mind preoccupied and entertain people for many hours.

5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

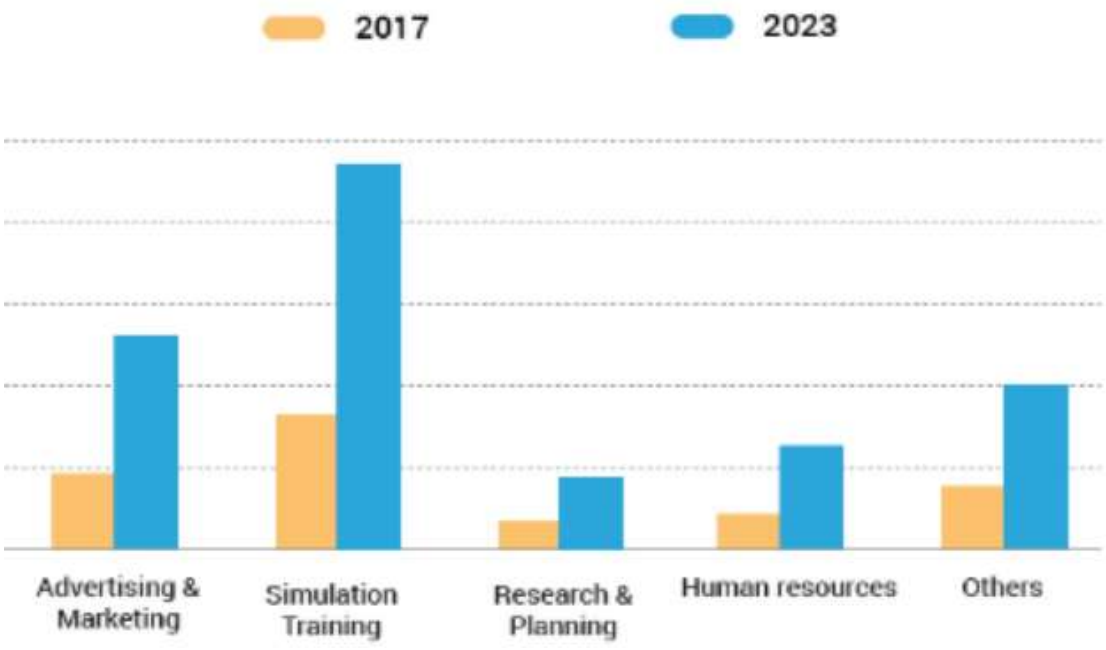
Img 1.5 Sudoku

1.6 Future of Serious Games and its Perspectives

It was estimated in 2016 that the global market of Serious Games was at 2731 million $, and by 2023 it will reach 9167 million $. The main reason for this growth is the increasing rate of mobile applications, the improvement of education and the need for user engagement among companies. Some of the most famous industries in Serious Games development are DIGINEXT, Nintendo Co. and Ltd.



Img 1.6 Serious Games Market Growth (2020 – 2025)



Img 1.6.1 Serious Games market by application

Simulation and Training are estimated to be the most profitable type of application.

The increasing need for learning in the corporate world leads to the augmentation of Serious Games usage in this segment. The immediate application of learning outcomes in the workplace, the problem-solving skills and the acquired experience make Serious Games a valuable tool for skilled and semiskilled workers. (Spoettl et al. 2012)

Although it is expected to have growth in the Serious Games industry, there are still some challenges to overcome. First of all, those types of games are not widely recognized by the public and their acceptance is currently low, especially in the academic contexts. Traditional learning and lecturers are the main obstacles to the expansion of Serious Games in undergraduate courses. To be more specific, accounting courses are the lowest in the usage of Serious Games as a learning tool, at least in the business areas. According to a Delphi study, knowledge and technology are not an issue anymore in the development of Serious Games. The problem remains on the motivation of lecturers to transit and accept games as a new method of teaching. Few games exist for accounting teaching and this is enhanced even more by lecturers who view it only as a technique rather than a part of management and business. Nowadays, with the help of technology and specialized software, even non-professional developers such as teachers can create their own games. With ready templates and assets, educators can design a unique Serious Game catering to the special needs of their subject.

The future of learning lies through mobile devices. In 2019, 33% of all downloaded apps were mobile games and it was estimated that almost one-third of the population worldwide were playing. It is worth mentioning that mobile games come second in time spent while the first place is taken by social media. Thus, it is reasonable that the utilization of games will increase by 2021. It is estimated that people will spend 30 more minutes playing with their smartphones. According to statistics (2020), the global market revenue by the device was: smartphone games coming in the first place with 63.6 billion dollars, in the second place were console games and pc with 33.9 billion U.S. dollars, tablet games took the third place with 13.7 billion and in the final place browser pc games had a value of 3 million $.

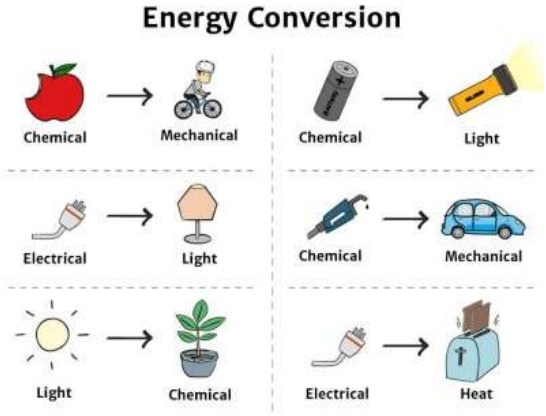
Governments have understood the potential and lucrative market of the gaming industry and they are making their own investments. They fund gaming businesses and aim to attract people from over the world. Germany has spent 50 million euros (2019) in the creation and funding of games. Sweden has helped students to develop their own games using government funding and linking them with startups and investors.

The increasing investment and interest in the gaming industry bring massive revenue, further evolution of gaming technology and a greater engagement in different geographic and demographic populations. Serious Games and traditional entertainment games have proven their value to society and they will be further embraced in the upcoming years.

Chapter 2: Energy

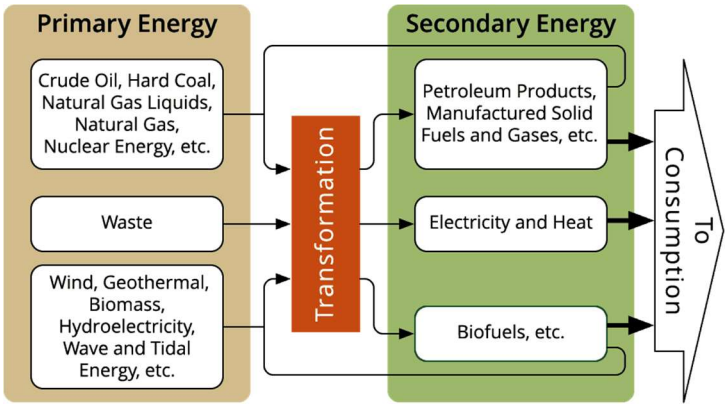
2.1 Definition of Energy

As physicists have cited, energy is the ability to achieve work. The term work is meant to show the transportation of energy to an object. In other words, work can be defined as the applied force over a distance (W = F x d). There are many forms of energy. Some of them are: 1) heat, 2) light, 3) motion, 4) electrical, 5) chemical, 6) gravitational, 7) mechanical and 8) nuclear. People managed to change the forms of energy from one to another. Such an example is rubbing the hands together in order to get warm when the environment's temperature is low. Here the energy is transformed from kinetic (motion) to thermal (heat). Another everyday example is the use of batteries to power a torchlight. The chemical energy of the battery is transformed into electrical energy. The knowledge of energy and its transformations has assisted in the evolution of the current modern civilization.



Img 2.1 Example of Energy Transformations

According to the first law of thermodynamics, energy cannot be created neither destroyed but only convert from one form to another. In the International System of Units (S.I), energy's unit is Joules. The types of energy mentioned above can be grouped into stored energy and working energy. There is a variety of energy sources that exist. They can be renewable, easy to replenish, or non-renewable, hard to replenish. The different sources of energy can be used as primary energy or secondary energy. The term primary refers to the direct extraction of natural resources, the original, unconverted energy. While secondary energy refers to converted or stored energy.



Img 2.1.1 A Diagram of Primary and Secondary Energy

2.2 The Evolution of Energy Usage

Humanity has relied on energy since the beginning of its time. Archeologists have found in Israel burned woods, flints and hearths dating back about 800,000 years. This indicates that fire was used for the first time for warmth and cooking. Fire remnants were also found across Europe, Africa, Asia and the Middle East. Experts believe that humans have been using fire much more earlier. This belief stems from the fact that Homo Erectus gut begun shrinking, meaning that digestion was easier.

At around 500 BC, ancient Greeks used solar energy for heat and light. They built their houses and roads in such a way that all were facing the sun. Ancient Romans (100 BC - 500 AD) followed in Greek footsteps to create their own solar system and access laws. According to the Justinian Code, people were not allowed to block their neighbor's sunlight. There was even a judge who decided how much someone can enjoy the sun or how much were allowed to block the sunlight from their neighbors.

The first coal mining began in China (200 BC). The regions with the most coal were Shanxi and Inner Mongolia, where it was abundant and near the earth's surface, making their extraction easy. Records show that coal was used for copper smelting, manufacturing of steel and iron and for the creation of fires in villages. According to Bronson (1999), coal was also used in blast furnaces. Back in Europe, this mineral was ignored and Marco Polo after his journey from China suggested to Europeans to use coal as a fuel and energy source.

The first windmill was found in Iran and it is dated back to 644 AD. The utilization of wind power in Europe was at around 1,100. In 1700, the Maori tribe wielded geothermal power from hot springs in order to cook and warm themselves. In 1690, coal started to replace wood in Europe due to its depletion. Coal was mostly used for powering up tools and machines. While in New Zealand, coal was discovered in 1848. The discovery of electricity by Benjamin Franklin (1752) started the industrial revolution.

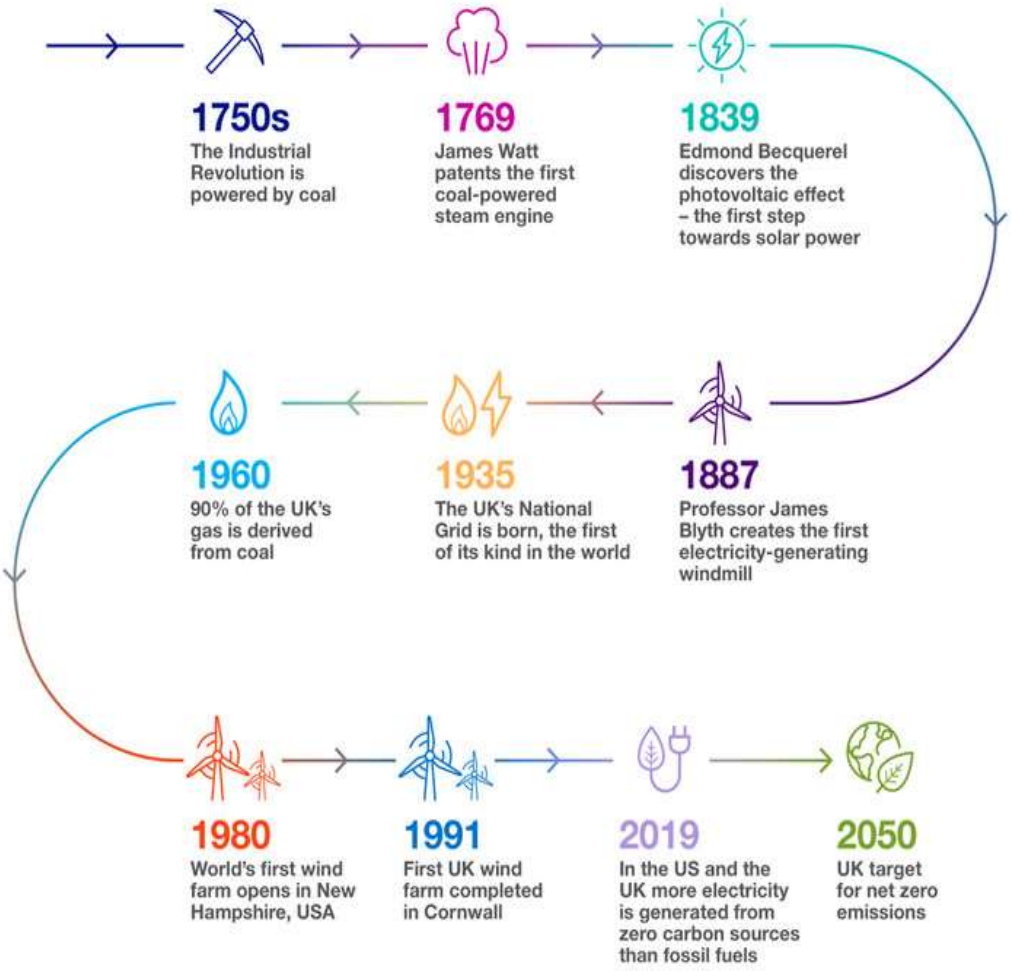
Britain was the first country in the world that used gas as an energy source in 1812. The gas was distributed through underground pipes and provided people with light, heat and energy. The streets of London were illuminated by gas-powered lamps. Some of these lamps still exist today. In 1859 America drilled the first oil well, while the first solar power plant was built in Algeria (1868). Carl Benz created the first car powered by petroleum in 1885 and, in 1892 the hydroelectric power was started to use as an alternative energy source. In the early 20th century, electricity was the main power that sustained cities, countries and assisted the further development of electrical devices such as television.

Img 2.2 An Ancient Roman Sundial. A clock that used sunlight to determine time and solstice.

Img 2.2.1 Gas-powered lamp in London

A German chemist named Otto Hahn discovers nuclear power in 1939, but the first electrical power produced by this type of energy was in 1951, USA. In 1974, the first photovoltaic cell was developed in order to harness solar power. It is worth to mention that the world's first national grid system opened in the UK (1935). Only seven grid areas were used to power the whole country with energy, in contrast with the previous model of energy production, which used multiple power stations. The national grid made energy cheaper and more stable.

Coming to the current century, the 21st, the global energy sector strives to return again to renewable sources, as humanity did in ancient times, and gradually abandon fossil fuels. The emerging of new technologies such as biotechnology used for biomass, and the evolution of cleaner techniques to protect the environment from pollution and extraction of minerals, and the usage of hydrogen as a new energy source, start a new era, a new revolution in the energy sector.

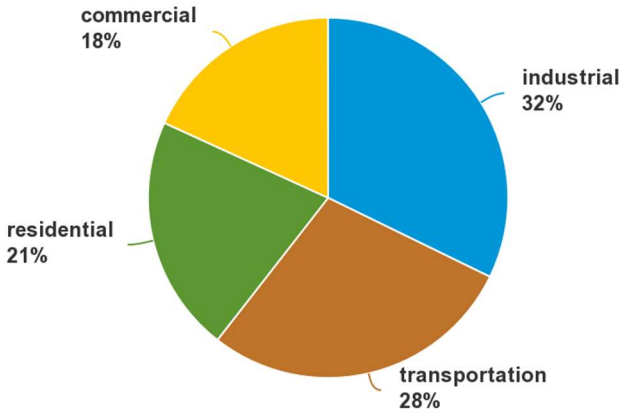


Img 2.2.2 A summary of energy timeline

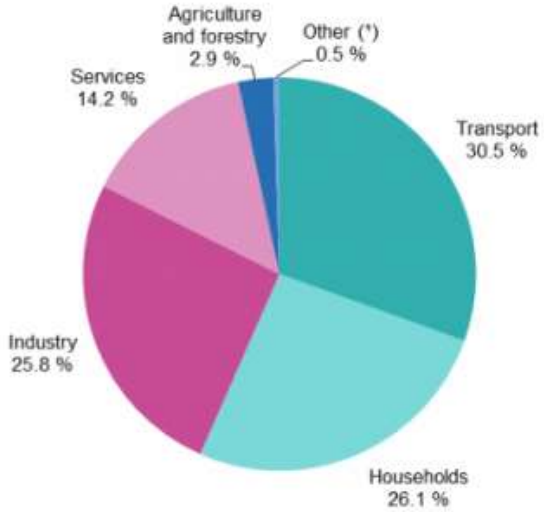
2.3 Energy Uses and Consumption

Energy nowadays is used in many sectors. The main sectors are: 1) residential, 2) industrial, 3) transportation, 4) services or commercial, and 5) agriculture and forestry.

The term residential has to do with homes and apartments. The industry sector includes manufacturing, construction, mining, equipment, and everything that has to do with it. Transportation refers to the way that citizens commute. Means of transportation are cars, busses, ships, airplanes, trains, and motorcycles. The commercial or services field covers workplaces, supermarkets, schools, hospitals, ministries, shops, and many other public places. The last sector, agriculture and forestry, has to do with farming, growing crops, feeding animals, planting and maintaining forests.



Img 2.3 Energy Consumption by Sectors in USA (2019)



Img 2.3.1 Energy Consumption by Sectors in Europe (2018)

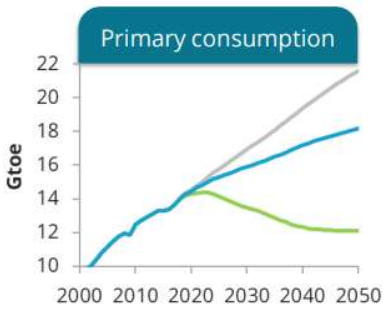
According to statistics, the U.S. world's energy consumption is 17% while its population amounts to 5% globally. Europe with a 7% global population uses 11% energy. It's worth to mention that China alone consumes 24% of the world's energy with a global population of 18%.

IEA (International Energy Agency) has predicted that by 2040 the global population will reach over 9 billion. This results in increased energy demands, specifically by 19%. Enerdata, a research and consulting firm, analyses the global energy markets. Enerdata specialists have made three scenarios about international energy policies and how they affect energy consumption, the share of fossil fuels (petroleum, coal, natural gas), and greenhouse gas emissions till the future, 2050.

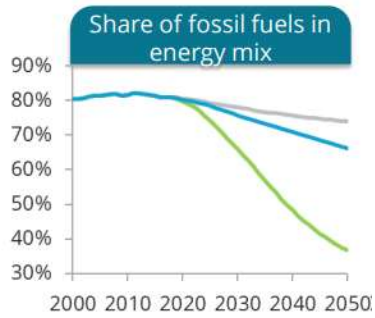
The first scenario is the worst. There are none or little efforts to mitigate greenhouse gas emissions and policies do not target climate change. The energy demand is high and improvements in energy efficiency (reducing the energy required for products and services) are few. Fossil fuels are still the primary energy source and renewable sources (solar, water, wind, etc.) have moderate support. All these result in increased fuel prices due to tense geopolitics and an augmentation on earth's temperature, an estimation of 5 and 6 Celsius.

The second scenario has moderate reinforcement on the reduction of greenhouse gas emissions and climate policies are targeting to decrease fossil fuel usage by slowly increasing the prices. The energy demand is stable due to energy efficiency and renewable sources have a higher share in the global energy market. This outcome leads to a temperature increase between 3 and 4 Celsius (2-3 temperatures lower than the first scenario).

The third and best scenario aims massively to reduce gas emissions, stringent enforcement of climate policies and continuously revising the global energy plan. Energy efficiency is improved and still getting updates to become even better, the global energy demand is stable, limited use of fossil fuels and renewable sources are dominant. The outcome of this scenario is that the temperature of the earth will be limited to a 2 degree Celsius increase.

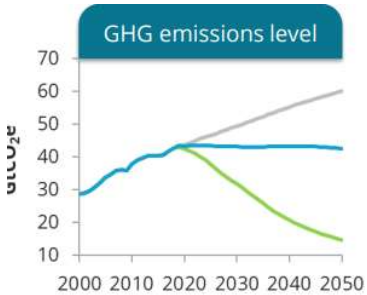


Img 2.3.2 Global Energy Consumption



Img 2.3.3 Percentage of fossil fuels used as an energy source.

The gray line on the diagrams represents the first scenario, the blue line represents the second and the green line is used for the thirds scenario.



Img 2.3.4 Greenhouse Gas Emissions

2.4 Sources of Energy

The energy sources are grouped into two main categories. The first one is named non-renewable and the second category is called renewable sources. The non-renewable category includes 1) petroleum, 2) coal, 3) natural gas, and 4) nuclear power. The renewable sources or green energy as they are called are 1) solar power, 2) wind, 3) water, 4) biomass, 5) geothermal power, and a new type of energy, 6) hydrogen.

2.4.1 Petroleum as a Non-Renewable Energy Source

According to BP Statistical Review (2019), the most used energy source in the world is petroleum, with a percentage of 33.06%. The other sources of energy are listed as follows: 2) coal (27.04%), 3) natural gas (24.23%), 4) hydropower (6.45%), also the most used renewable type of energy, 5) nuclear power (4.27%), 6) wind (2.18%), 7) solar (1.11%), 8) biomass and geothermal power (1%), 9) biofuels (0.68%).

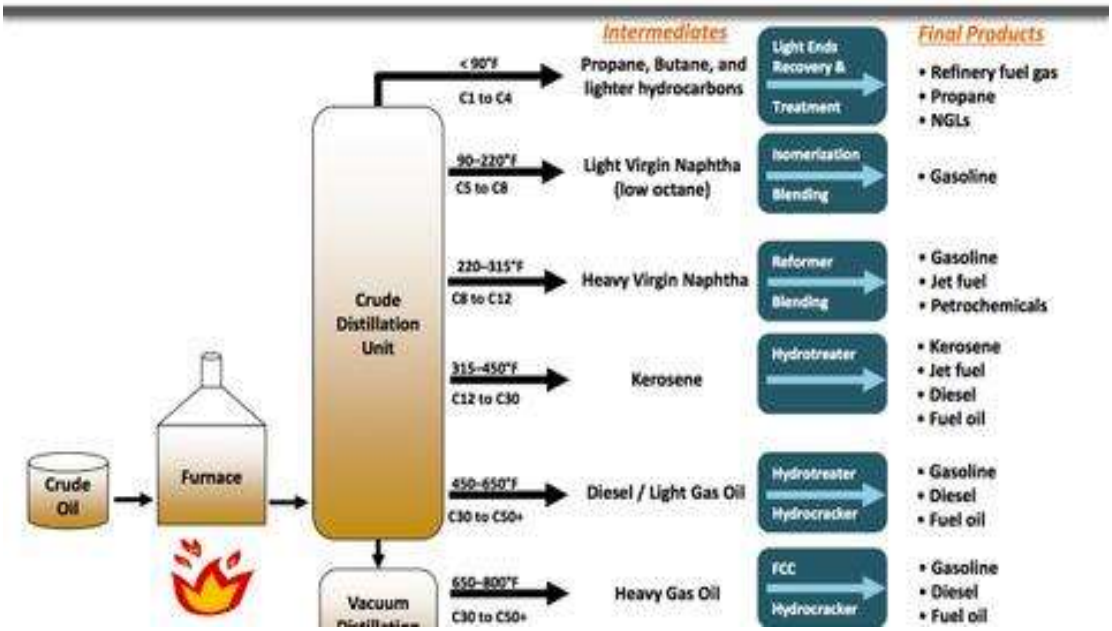
Since petroleum or differently called oil, is the most used source of energy globally, it is worthwhile to know more details about it. Petroleum is a fossil fuel and it was formed from dead organisms, bacteria and plants, pressed under high temperatures and lack of oxygen. Petroleum can be found in the depths of the soil, usually below 1848 m. In 1949, the average depth of oil found was 1108 meters. In 2008 the depth of oil extraction was 1817 m. The oil is a liquid with a natural yellow to black color. Under some circumstances, oil can be found in the form of gas or solid hydrocarbons. Petroleum mostly consists of carbon (83 - 85 %), hydrogen (10 - 14%), nitrogen (0.1 - 2 %), oxygen (0.05 to 1.5%), sulfur (0.05 to 6.0%) and metals with less than 0.1 %. Oil can be light or heavy, or sweet or sour. Depending on the oil's density, it can be classified as light or heavy. Light petroleum takes fewer processes to be refined. Oils with sulfur content greater than 0.5% are considered sour, while the opposite is sweet.

Img 2.4.1 Petroleum

There are four main phases to produce petroleum. The first one is exploration. Different geologists and geophysicists explore the earth's surface and pinpoint the location of underground oil. The second phase is called drilling. A drilling rig makes a hole onto the surface and digs deep into the oil reservoir underground. Then through pipes petroleum is brought to the earth's surface. The third phase is pumping. As the pressure of the well is decreased, the pump will extract the last remaining oil. Finally, when the oil has completely been extracted, the place is filled with cement and a special sign is placed in that zone in order to protect the area. Petroleum, after the extraction from the well, can be transported via ships, trucks, rails, or pipelines.

Img 1.4.2 Oil well

In order to use petroleum and derive its products, it has to be refined. First, the oil is heated into a furnace and then it is introduced into a distillation unit. The distillation unit is separated into fractions according to temperature and oil's weight. The heavier the fraction the lower is placed into the distillation unit. The distillation unit process gives intermediate products like kerosene, which later is further refined and is used as a final product, for example as jet fuel.



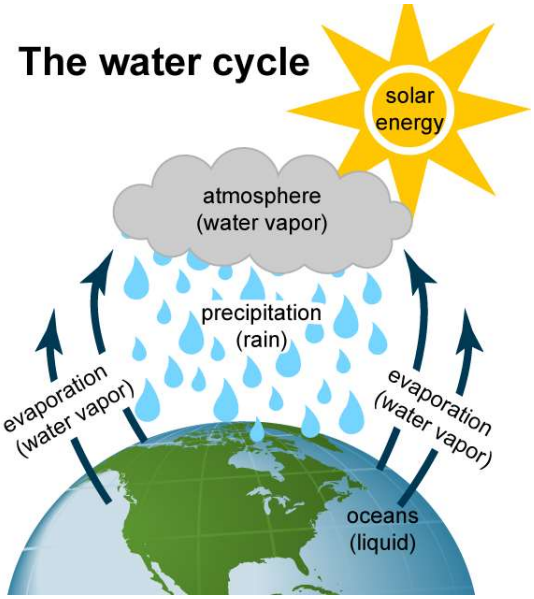
Img 1.4.3 Petroleum Refining Process

Petroleum is used to provide electricity and to power many homes and appliances. Also, it is used as a transportation fuel. Plastic can be made out of oil and produce several products like bicycle tires, dresses, tennis rackets, candles, trash bags, paints, shoes and many more. Furthermore, petroleum is used in many chemicals and in the medical sector like bandages, heart valves and contact lenses.

Although petroleum as an energy source, it is known to pollute and be toxic to the environment and release greenhouse gas emissions, which are part of global warming, there are some advantages of oil usage. First of all, it can be extracted easily at a low cost and be easily transported. Oil has a high density, which means small amounts can produce enough energy. It is suited to power up almost all types of vehicles and make them run longer distances. Also, petroleum is an important component in the creation of a variety of products like medicines and clothes.

2.4.2 Hydropower as a Renewable Source of Energy

Hydropower uses the kinetic energy of the water to power machines and generates electricity. Water evaporates from lakes and oceans, forming clouds and then it comes down as rain or snow. The water cycle is an endless phenomenon, thus making hydropower a renewable source of energy. As it was mentioned before, hydropower is the most used type of green energy in the world. To generate electricity from the water's flow, there is a need to build hydroelectric infrastructures. There are three main types of infrastructures, which are: 1) dams, 2) reservoirs, and 3) power plants.



Img 2.4.4 The Water Cycle

Dams are a barrier across a river to restrict and control the water's flow, forming a reservoir or a lake behind it. Dams come in different sizes, from small ones being used in farms to big infrastructures typically used for water supply and hydropower. Dams are made from concrete or natural materials like rocks and soil. There are four types of dams: 1) Arch Dam, 2) Buttress Dam, 3) Embankment Dam, and 4) Gravity Dam.

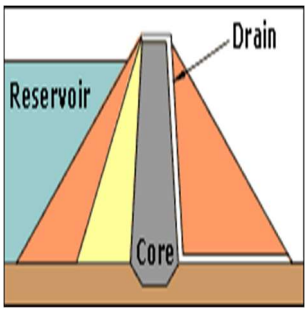
Arch dams, as the name suggests, are curved and form an arch shape. This shape is strong enough to resist the water's force pushing the dam, which is why they are usually built in narrow and steep valleys. Arch dams are constructed from cement. Buttress dams are made from stones or concrete and they have triangular-shaped walls that are spaced at intervals. Those types of dams are suited in both narrow and wide valleys, resisting the force of the water's flow. Embankment dams are usually made from soil or rocks and are shaped like hills, which have a central part that stops the water from penetrating the dam. They are usually used in wide valleys, on both hard and soft soil, because they do not exert pressure on their base. Gravity dams are called this way because gravity holds them down, stopping the water's pressure. They are made from cement or stones or sometimes both. They have a roughly triangular shape and are used on both wide and narrow valleys with the condition that the ground is stable.

Reservoirs are water storage facilities that depend on water level and volume stored. Reservoirs are artificial lakes and can be grouped into three main categories. The valley-dammed reservoirs are constructed in valleys between mountains, and a dam is built to hold

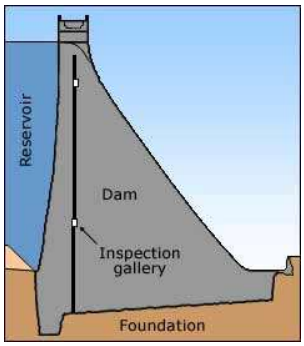
the water. Bank-side reservoirs divert water from existing rivers or streams into a single place. Lastly, service reservoirs do not use natural elements, which mean they are man-made. Water is stored in basins above or below the ground.

Img 2.4.5 Arch Dam

Img 2.4.6 Buttress Dam



Img 2.4.7 Embankment Dam

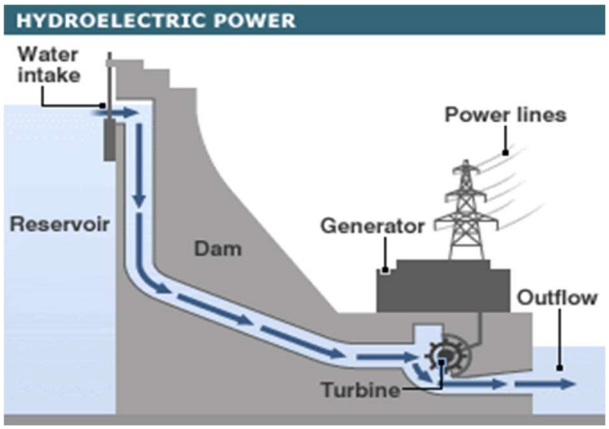


Img 2.4.8 Gravity Dam

Img 2.4.9 Valley-Dammed Reservoir

Img 2.4.10 Bank-side Reservoir

Img 2.4.11 Service Reservoir



Img 2.4.12 Hydroelectric Power Plant

Power plants are the infrastructures that contain generators producing electricity. There are two important variables in power plants, which are the draft and the flow rate. Hydropower plants transfer water at different heights, converting the difference of water into electric power. The process to generate hydroelectric power is as follows:

1) The dam built across the river blocks the water flow and forms a reservoir.

2) Water behind the dam passes through filtering grilles and flows down to a pipe.

3) The potential energy of the water that flows through the pipe at different heights is transformed into kinetic energy.

4) The water reaches the machine room, which converts kinetic energy into a mechanical rotation through spinning turbine blades.

5) The turbine shaft is connected with the electricity generator, which transforms the mechanical rotation energy into electricity. Then electricity is transferred via power lines.

6) The water flows through a channel and it is spilled again into the river.

The hydropower power, which is measured in Watts or Kilowatts, depends on the "head" and "flow" at the site. Head is the difference of height in the entrance of the dam and at the end of the power plant, where the water leaves. Flow is the amount of water that passes through the turbines in the machine room. Two separate hydropower plants with different heads and flows can generate the same amount of power. For instance, a hydropower plant with a head of 2.25 meters and a flow of 3000 liters per second, and the other plant with a head of 45 meters and a flow of 150 liters per second, can both generate 49.7 kW. A hydropower plant that can generate 2 kW power, can support two average homes with electricity. A greater scale of a power plant, 200 MW, can supply 200,000 homes.

The benefits of hydropower energy are many. Some of them are:

1) Efficiency. Hydropower plants can convert 90% of energy into electricity, while fossil fuels lose half the energy due to waste heat and gases released by the process.

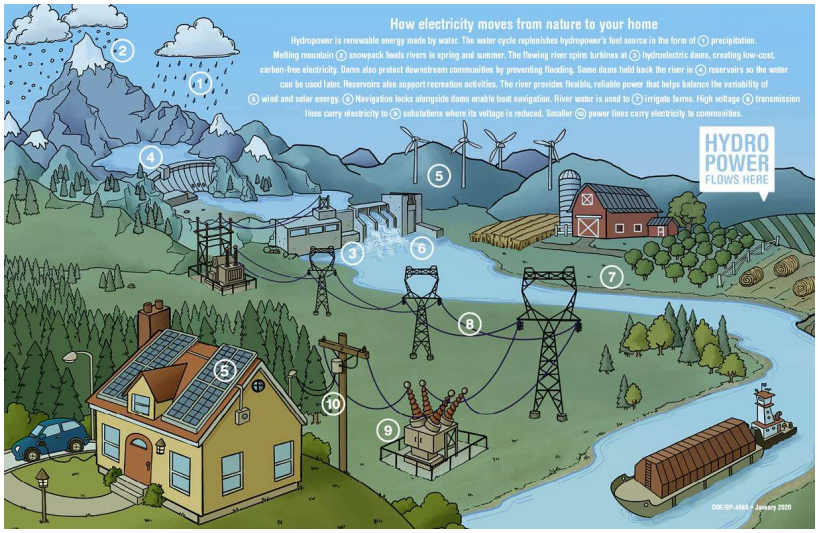
2) Clean energy. No gas emissions are polluting the environment.

3) Abundance. Rain and snow replenish the water supplies. That's why hydropower is a renewable energy source.

4) Affordability. Water is free, and this ensures the low-cost operation of hydropower plants, making electricity cheap.

5) Flexibility. The amount of water can be adjusted, meeting the high or lower demands of energy.

6) Works as a back-up for other renewable sources, such as wind or solar power.

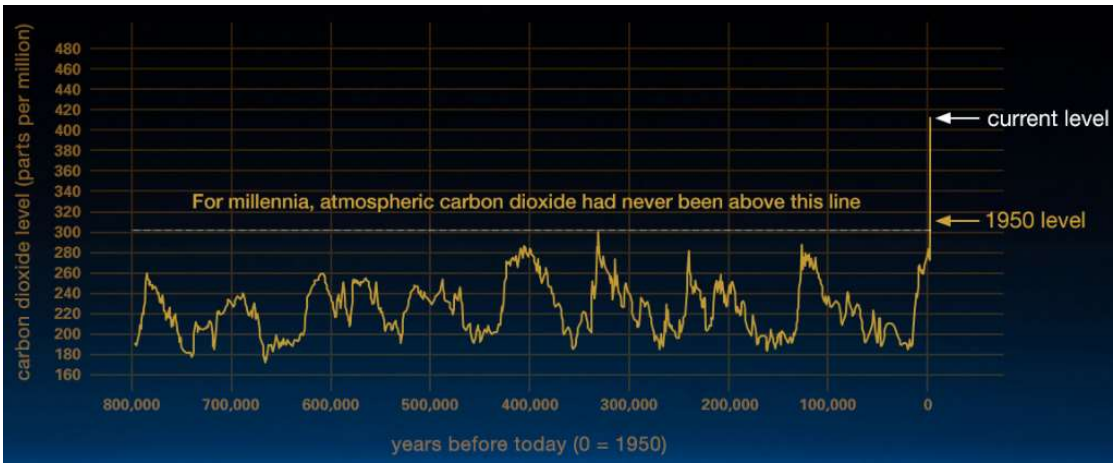


Img 2.4.13 Hydropower activity

Chapter 3: Environment and Climate Change

3.1 Evidence of Climate Change

Earth's climate has never been stable. It has changed throughout history due to small differences in the earth's orbit and the received amount of sunlight. This is natural and not a threat to living beings. However, human activities have damaged and polluted the environment, causing global warming.



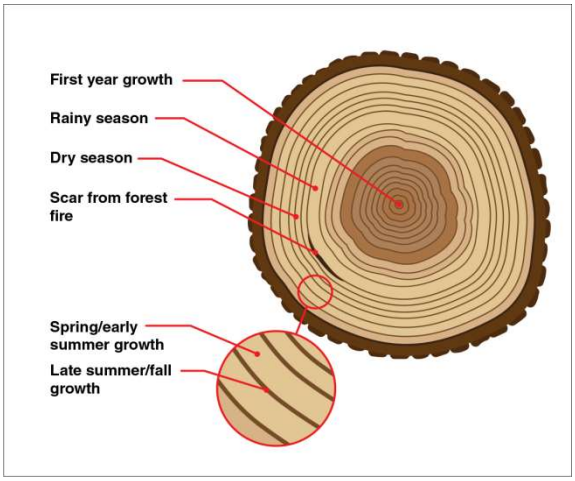
Img 3.1 Carbon Dioxide Levels in the Atmosphere.

Before 1950, these levels have never been above the line shown in the diagram. Carbon dioxide and other gasses do not let sunlight escape from the earth's atmosphere. They are trapping sun's heat, causing the known greenhouse effect. The result of this is the rising of the earth's temperature above the normal levels. Scientists have found evidence on the changing climate with the help of advanced technology and satellites collecting data. Other pieces of evidence can be found in oceans, glaciers, tree rings, coral reefs and rocks.

How can nature provide scientists with that kind of information? It is known that tree rings tell their age but also provide evidence on the climate that the tree grew. The width of the rings records the tree's growth year-to-year. In wetter climates, the width of the tree ring is wide, whereas in hot and dry climates the ring is narrow. An example of this is the data that scientists took for the American climate in the 1200s. Tree rings records show that has been a severe drought from 1276 to 1289 in New Mexico, Arizona, Colorado and Utah of the USA. This might explain why people abandoned their houses at Mesa Verde cliffs.

Fossils such as the remains of plants, bacteria and animals reveal the conditions in which those organisms lived. For example, if oysters lived in a favorable climate, not too warm or too cold, they had enough nutrition and could grow faster and bigger. The width of the oyster's rings reveals climate change. Thin rings indicate an unstable environment.

Oceans are a significant indicator of climate change. They can absorb carbon dioxide and stabilize the climate, but excessive greenhouse gas emissions change the chemistry of seawater and turn acidic. The changes in pH levels of the oceans affect their ecosystem and make the survival of corals and fish difficult. As was mentioned before, carbon dioxide and other gasses trap more solar energy, resulting in increased earth's temperature. This makes oceans warmer, altering sea levels and causing flooding.

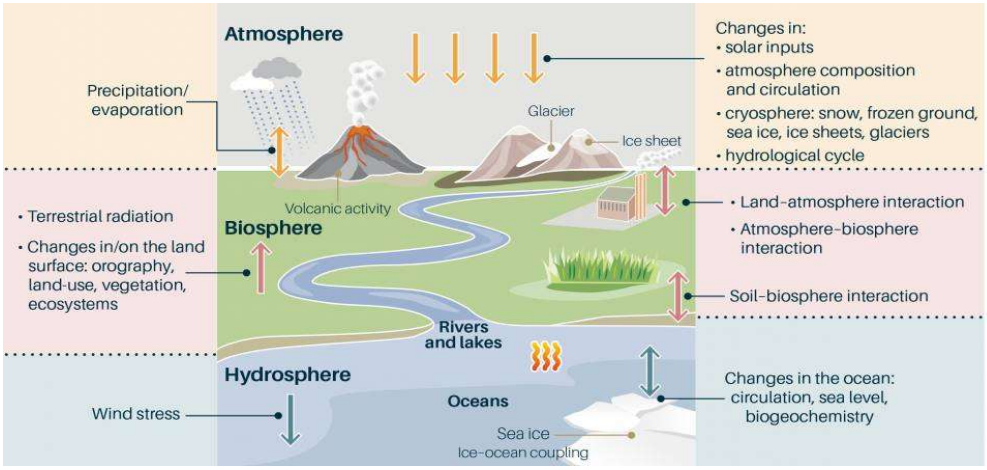


Img 3.1.1 Tree Rings

Img 3.1.2 Fossil Oyster

Glacial ice can also reveal the climate's instability. Scientists analyze ice cores, which are crystallized ice with trapped air bubbles. Those bubbles preserve information about the earth's atmosphere, and this is how scientists know about Ice Ages and so on. Since the Industrial Revolution, the glaciers started to retreat, and with increased usage of fossil fuels, scientists are afraid that some of the glaciers and ice shelves will entirely melt in the upcoming decades if measures for climate change are not taken. Ice shelves are floating ice in the Antarctic's ocean and have become thinner and thinner due to warmer waters. They begin to collapse and change the lines of the grounded glaciers. Many glaciers have retreated around the world.

Img 3.1.3 Retreated Glacier through the years

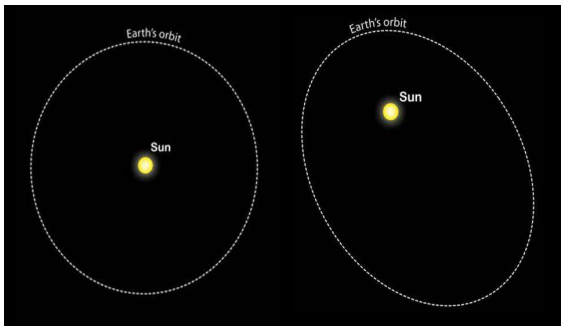


Img 3.1.4 The Climate System. Every change affects each sphere. Atmospheric carbon dioxide has increased 250 times faster using non-renewable energy sources (petroleum, coal, natural gas).

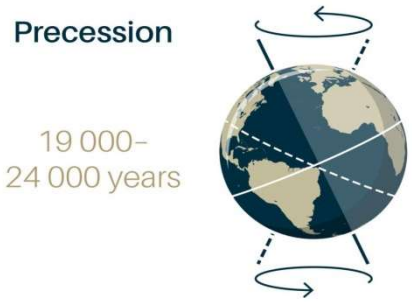
3.2 Causes of Climate Change

Earth's climate has never been stable over the centuries. Many natural factors have affected the climate. Some of them are: 1) Sun's strength, 2) Earth's orbit, 3) Tectonic plates and volcanoes, and 4) Meteorite impacts.

Sun is a crucial factor in the changing climate. Sunlight hits the earth's atmosphere and part of it reaches its surface, while the rest reflects back into space. Changes in solar input and heat do not only affect climate but also change the cloud forming process. The energy from the sun fluctuates from day to day. The short wavelength radiation influences the ozone layer, modifying the temperatures and the clouds' formation. Cosmic rays, highly energetic particles, are also believed to play a role in the earth's temperature and cloud formation, by creating more ions in the atmosphere. Three factors alter the earth's orbit around the sun, eccentricity, axial tilt, and precession. Milankovitch's theory suggests that these three variables affect the amount of solar energy reaching the earth, and therefore changing the climate. The shape of the earth's orbit is elliptical but sometimes becomes almost circular. The changes in the orbit's shape are called eccentricity. The earth's axial tilt affects temperatures as well. The angle moves from 22.1 degrees to 24.5 degrees and back again. Bigger angle means warmer summers and colder winters. The precession is the earth swaying on its axis due to the gravitational forces of the moon and sun, impacting seasons and timing between hemispheres.



Img 3.2.1 The shape of the earth's orbit.



Img 3.2.2 Earth swaying on its axis

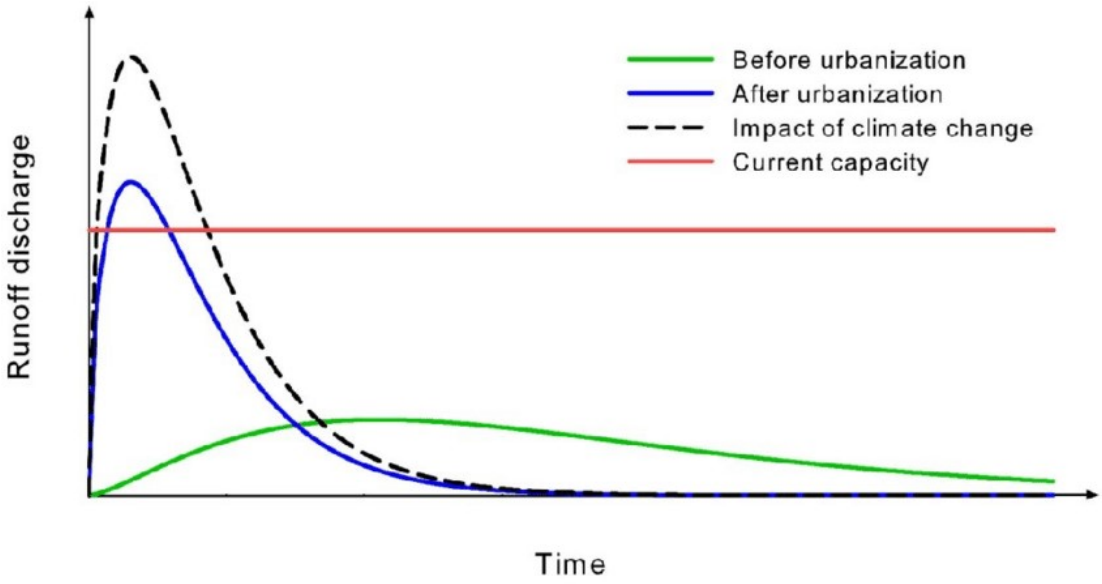
Tectonic plates are known to move continents to different positions. Also, their movements form mountains and volcanoes. Large mountains can influence the air and, subsequently, the earth's climate. Warm air masses become cooler in regions with mountains. Volcanic eruptions can cause global warming or cooling, depending on the released gasses. Carbon dioxide warms the atmosphere, whereas sulfur dioxide cools it. Volcanoes affect the earth's climate by only 1%. Meteorite impacts have contributed to the alterations of the climate. Large meteorite impacts eject dust and aerosols into the air, blocking the sunlight from reaching the earth's surface and lowering the temperatures. Once the dust and aerosols fall back to the ground, the climate becomes warmer.

Although natural factors affect climate change, none of them are significant enough. Human activities are the main cause to be blamed. The burning of fossil fuels releases carbon dioxide and nitrous oxide, gases that stay in the atmosphere for a long time, contributing to the greenhouse effect. In the Industrial Revolution era, the atmosphere had 278 parts of carbon dioxide (CO2) per million. Today the levels have skyrocketed in 414 parts per million. Another human activity that has altered climate is deforestation for land and agriculture. Trees and plants are important in balancing the earth's climate by absorbing greenhouse gasses. When they are cut down, they release into the atmosphere all the carbon that they have

captured. It is estimated that deforestation has caused 10% of global gas emissions. The rise of the population has led more businesses to clear forests and plant crops. Agriculture makes up to 80% of tropical deforestation. Farms gas emissions are methane, coming from cattle, and nitrous oxide from fertilizers. Farms make 13% of global emissions (2011).

The increasing population has also increased urbanization, making people going from rural to urban areas. Overcrowding, pollution, and poor sanitation damage the environment. Urban areas have a higher demand for energy and food consumption, causing more deforestation and gas emissions. According to UN-Habitat, cities produce 70% of global greenhouse gas emissions. Careful urban planning and strict policies can make cities less responsible for climate change. Identifying the issues, developing clear objects, and monitoring the process, drive urban areas into the needed adaptation, reducing emissions.

Img 3.2.3 Deforestation



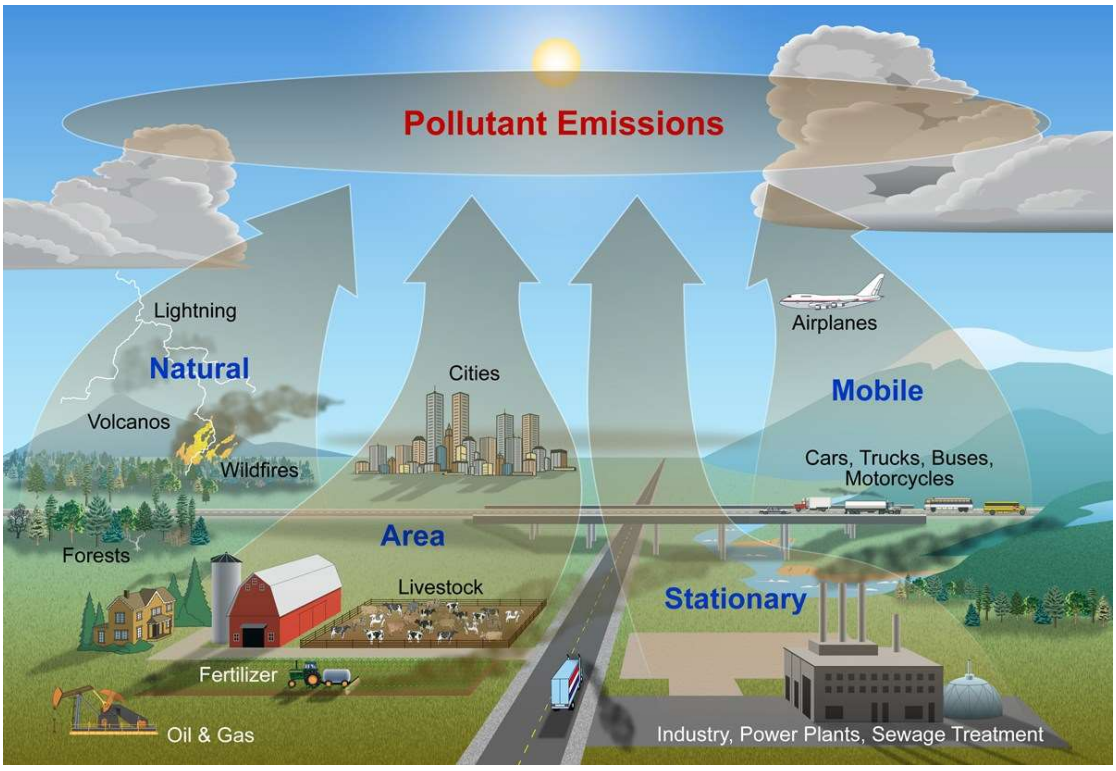
Img 3.2.4 Urbanization and the impact on climate change

3.3 Environmental Pollution

Human activities not only cause global warming and unstable climate but also pollute the environment. There are seven types of pollution. These are 1) air, 2) water, 3) land, 4) radioactive, 5) light, 6) thermal, and 7) sound pollution.

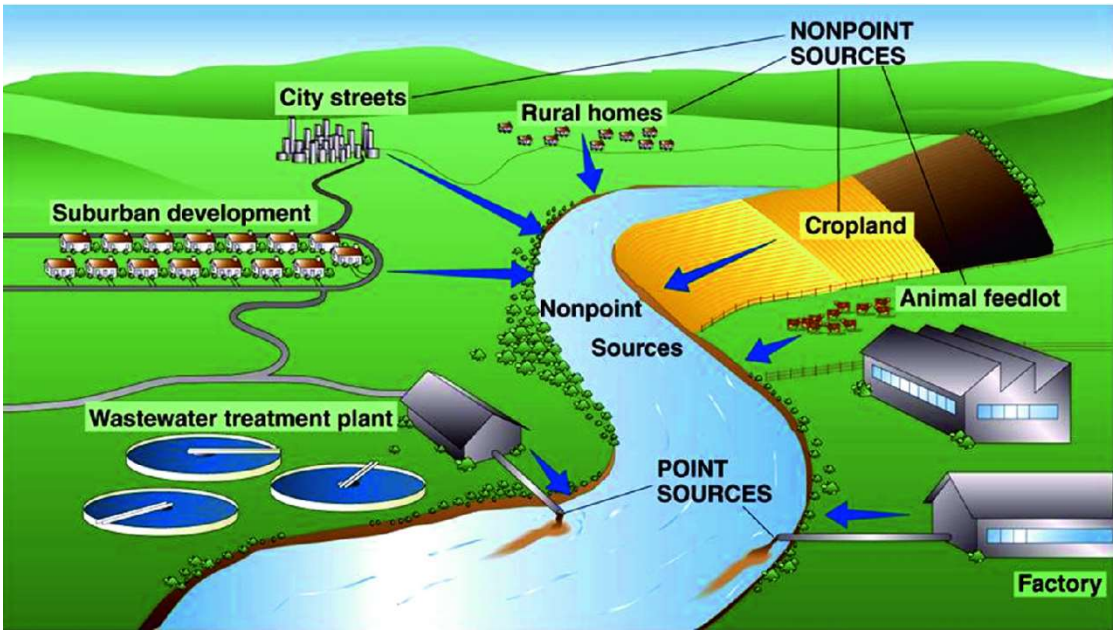
Air pollution comes in many forms. Using fossil fuels for electricity, transportation and industrial activities releases carbon dioxide, sulfur dioxide, carbon monoxide and other dangerous gasses into the atmosphere. In 2000, global chemical production had increased by 400 times more since 1930. They travel in huge distances through the air and can be absorbed by animals and humans via the skin, contaminated food, or water. There are four types of air pollution. Those are a) particulate matter, b) nitrogen dioxide, c) ozone and d) sulphur dioxide. These are the most common and harmful outdoor pollutants.

Particulate matter or PM, is a mix of carbon, organic chemicals, mineral dust, nitrates and sulphates. Particulate matter varies in size and some of them can be seen with the naked eye, whereas others are smaller than the diameter of human hair. The most dangerous are the smaller PM. These particles are a byproduct of industrial processes, diesel and petrol engines. Nitrogen dioxide (NO2) is a gas coming from vehicles, power stations and heating. It is mostly found in urban areas, especially when road traffic is high. Ozone is a 3-atom oxygen gas that is found in the earth's atmosphere and protects it from harmful radiation. Chemical reactions between sun rays and gases coming from cars and industries produce ozone near the ground. The ozone gas is higher during spring and summer. Sulphur dioxide (SO2) is another gas emitted by the vehicles, burning of coal and petroleum, and other industrial processes. It is colorless and can travel great distances.



Img 3.3.1 Air Pollution

Water pollution is chemical, radioactive, waste, or heat released in the oceans, rivers and lakes. There are different types of water pollutants. Some of them are domestic sewage, toxic waste, sediment, thermal pollution and petroleum pollution. Domestic sewage is pollution caused by harmful microorganisms, such as those found in feces coming from city sewage. Organisms metabolizing waste release methane and hydrogen sulfide, gases harmful to the water and air. Toxic waste can be poisonous, carcinogenic, radioactive, or mutagenic. Mercury and chromium are toxic waste disposed of by energy plants. Pesticides used for agriculture such as chlordane, are poisonous. Sediment is the pollution that comes from soil erosion and can be transferred into waters damaging the ecosystem. Heat is a pollutant because decreases the dissolved oxygen in water, lowering its quality. Power plants discharge warm water into the seas that can be 15 °C above the natural temperature of the seas. Oil pollution is caused by accidents from spilled tankers or from roads that were carried into water bodies.



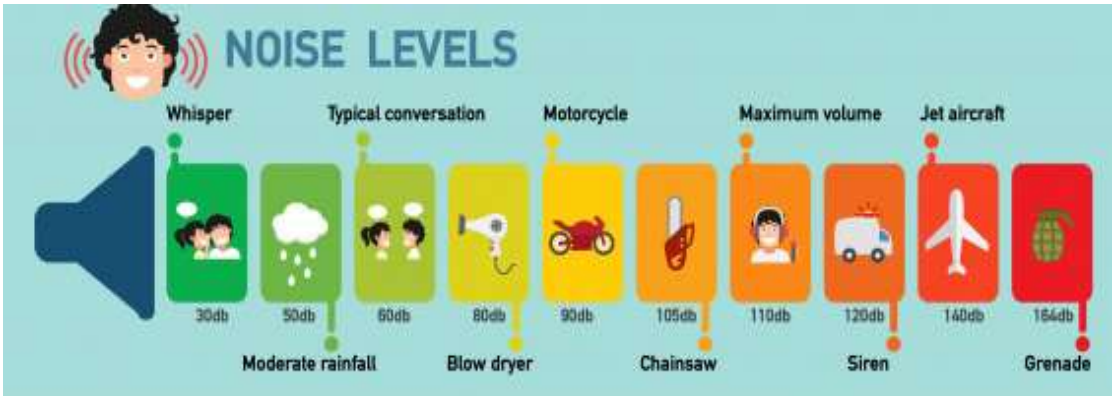
Img 3.3.2 Water Pollution

Soil contamination refers to the deterioration of the land surfaces and underground by waste and harmful substances. The main causes of land pollution are littering, mining, construction and urbanization, and agriculture. It has been estimated that 76% of litter comes from pedestrians and motorists. All litter release chemicals when they get degraded. Mining, the extraction of minerals such as coal, depletes the earth from its resources, causing damage and pollution. Construction can result in large amounts of waste such as metals, bricks and plastic, polluting the area. Raising livestock and growing food crops, if not managed properly, lead to agricultural pollution.

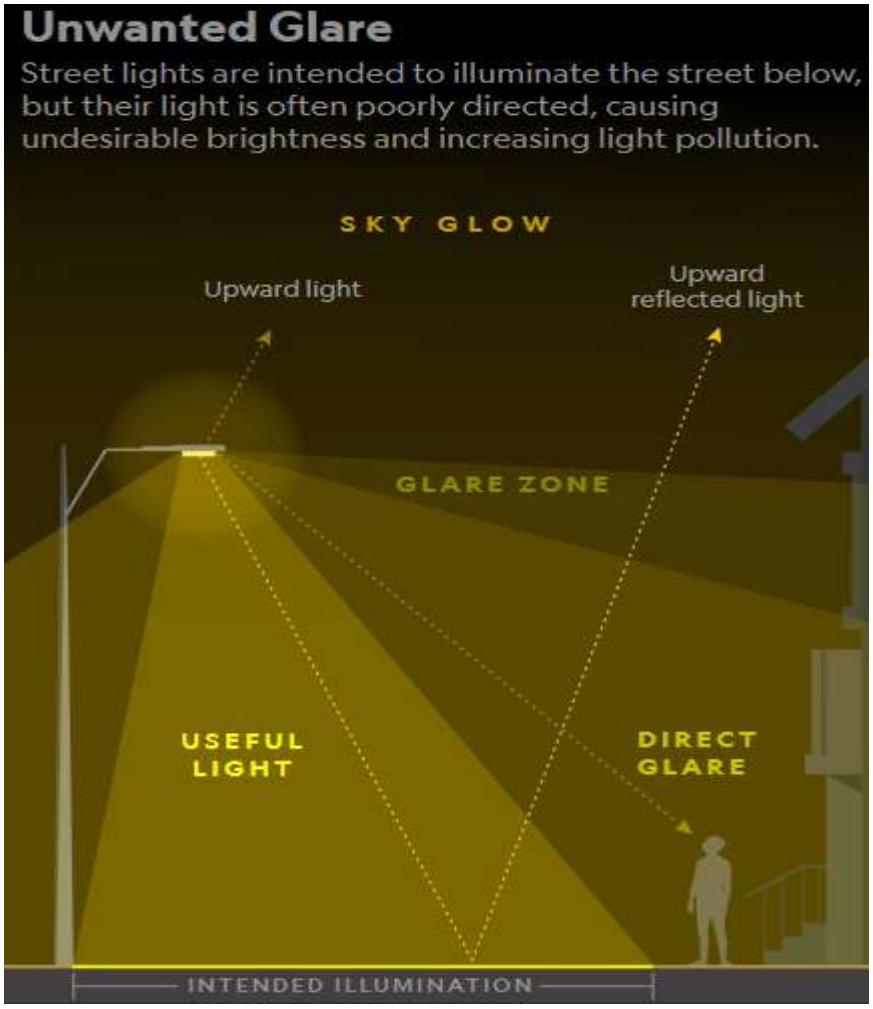
Noise pollution is the high level of sound that can damage humans and other living beings. According to WHO, sound levels of 70 dB and lower do not cause harm even if they are consistent. Noise pollution comes from road traffics from vehicles, construction like drilling, airports/airplanes, industrial sounds like generators, train stations, office sounds, loud music, people arguing, screaming, and many more.

Light pollution is excessive exposure to artificial lights such as bulbs, LEDs and traffic lights. It has been concluded that 83% of the world's population lives under light-polluted skies. Singapore and Kuwait are so light-polluted that citizens cannot see 99% of the stars, whereas Chad and Madagascar are the least affected by light pollution. People there can clearly observe the Milky Way. Light pollution alters the biochemical rhythms of humans and disturbs the life cycle of animals living in the dark.

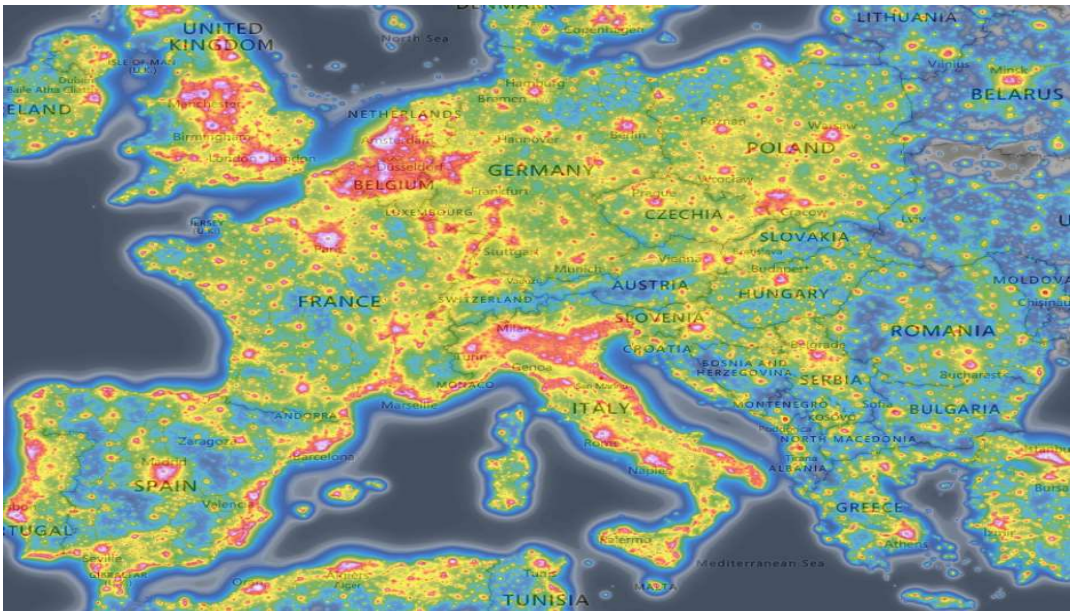
Img 3.3.3 Different sources of land pollution



Img 3.3.4 Levels of noise pollution



Img 3.3.5 Unwanted Light



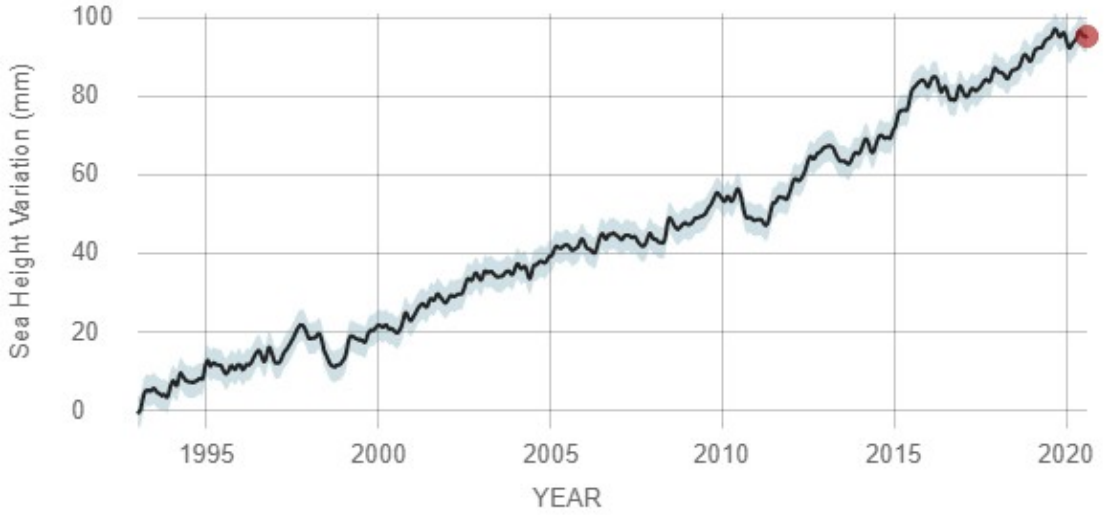
Img 3.3.6 Map of Light Pollution in Europe (2015)

3.4 Effects of Climate Change and Pollution

Climate change and pollution of the environment affect humans and other living beings on many levels. These are major problems that should not be neglected because they are a threat to the ecosystems, health, economy, and overall the planet earth.

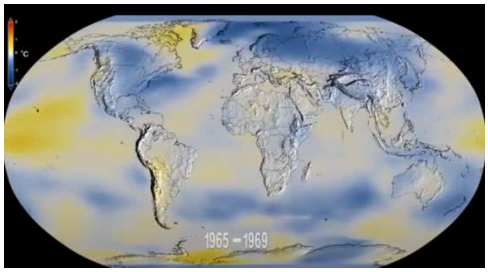
3.4.1 Impacts on the Planet Earth

Scientists have already observed the effects of climate change and global warming on the environment. Glaciers melt faster, sea levels have raised, land losses due to flooding, intense heat waves, and many more. There are two reasons why sea levels have increased. The first was mentioned before (ice melting), and the expansion of seawater as temperatures rise.

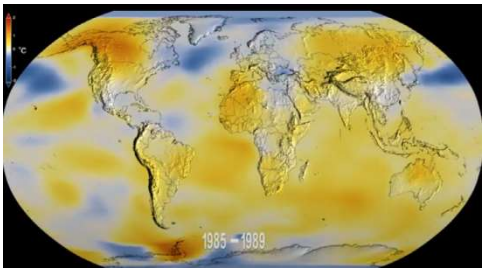


Img 3.4.1 Sea levels rising year-to-year.

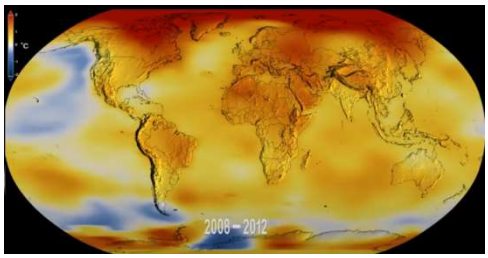
Temperatures will rise even more. According to NASA, in 2019, the earth's temperature hit a high record since 1880. The years 2014-2019 have been the warmest of the last 140 years.



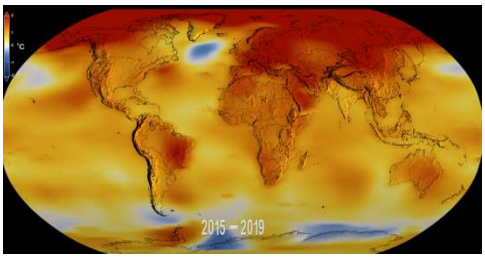
Img 3.4.2 Global Temperatures (1955-1969)



Img 3.4.3 Global Temperatures (1985-1989)



Img 3.4.4 Global Temperatures (2008-2012)

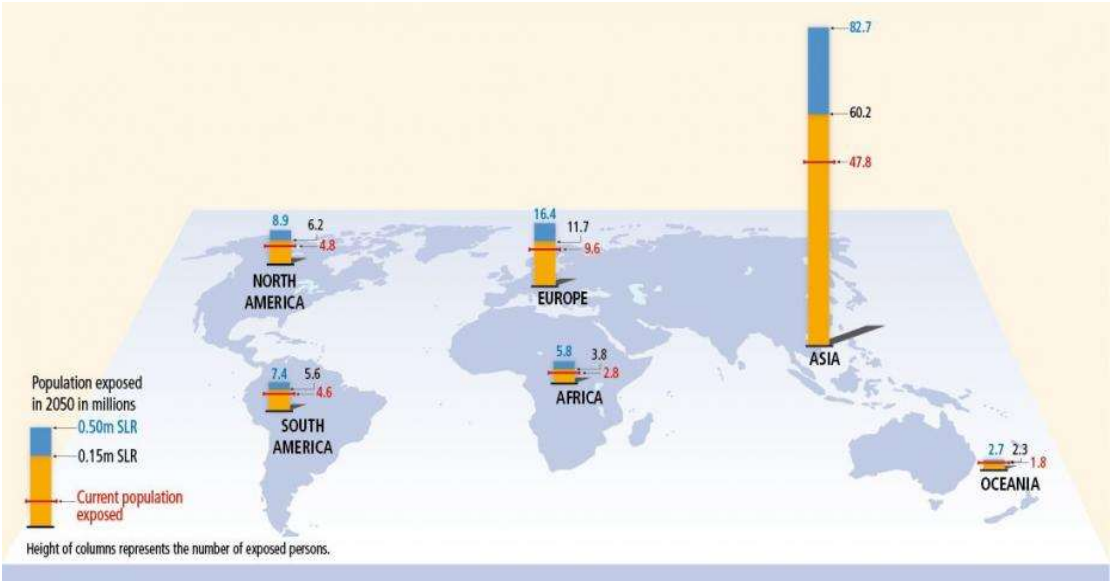


Img 3.4.5 Global Temperatures (2014-2019)

Greenhouse gas emissions are blamed for the length of the frost-free season (FFS). FFS is the period between the last spring frost and the first fall frost. This period determines what types of crops can be grown and for how much. Rainfalls have increased since 1900 in some areas whereas in others have decreased. It is estimated that the north part of the US has more rainfalls than the south, which has much less, in comparison with the last century. Droughts and heatwaves have become more intense everywhere and they last for weeks. The soil has lost a lot of moisture. Warmer waters and temperatures increase the chance of the formation of stronger hurricanes. Small changes in the global temperatures, even 2 degrees more than the average, can greatly affect the whole planet earth. For example, Pakistan and India will experience more often deadly heatwaves like those which happened in 2015. Water is becoming scarcer, especially in the Middle and Near East.

Many countries and regions, such as Greece, are affected by climate change. It has been observed in Greece that the air temperatures from 1990 and onwards, have been rising by 0.4 - 0.6 °C per decade. The frequency of heatwaves is three times higher than the previous decades and the summer season lasts longer. International Panel of Climate Change has reported that the Aegean sea will rise 1.2 - 2.5 degrees Celsius, causing evaporation, which gives more humidity, and extending the summer period.

Africa is considered to be the most vulnerable continent due to poverty, food insecurity and politics. By the end of the 21st century, the increased sea levels will affect coastal areas like Senegal and Mozambique. Climate change also has an impact on agriculture, causing food shortages. Diseases such as malaria and other health threats like malnutrition become worse. Freshwater availability in central and Southeast Asia has decreased, and by 2050 this will affect more than a billion people. Sickness will increase due to disturbances of the hydrological cycle. Biodiversity in Australia and New Zealand will be at great risk in 2050. Fires and drought have become an annual phenomenon, endangering humans, animals and forests. Heat waves will be responsible for many deaths and electrical blackouts. Northern Europe is at risk of frequent floods and increased ground instability. Central and Eastern Europe will experience less rainfall. South's European hydropower potential, agriculture, health and tourism will decline.



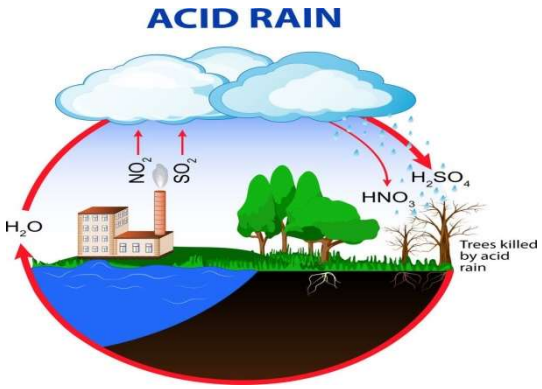
Img 3.4.6 Exposure in flooding

3.4.2 Impacts on the Ecosystems

According to NASA, 1.5 degrees Celsius above the average temperatures can reduce the geographic range of many species such as insects, vertebrates, even plants. At 2 degrees warming, this reduction is tripled. Deforestation and wildfires will increase, reducing the forest biomass. Marine life is also affected by global warming. Oxygen levels in the oceans are depleting, leading to lower quality, which makes the survival of the fish and coral reefs harder. UN in 2019 claimed that many animals and plants will get extinct within decades.

Except for climate change, pollution is also a significant factor in the reduction of the ecosystems' quality. It has been observed that harmful algal blooms have escalated a lot due to human activities, especially in agriculture. High levels of nitrogen and phosphorus contribute to the uncontrolled growth of phytoplankton and algae, which produce harmful toxins. They can affect marine life, people, birds, and subsequently, pollute the water. They are known to cause respiratory irritations and kill animals.

Img 3.4.7 Algal blooms

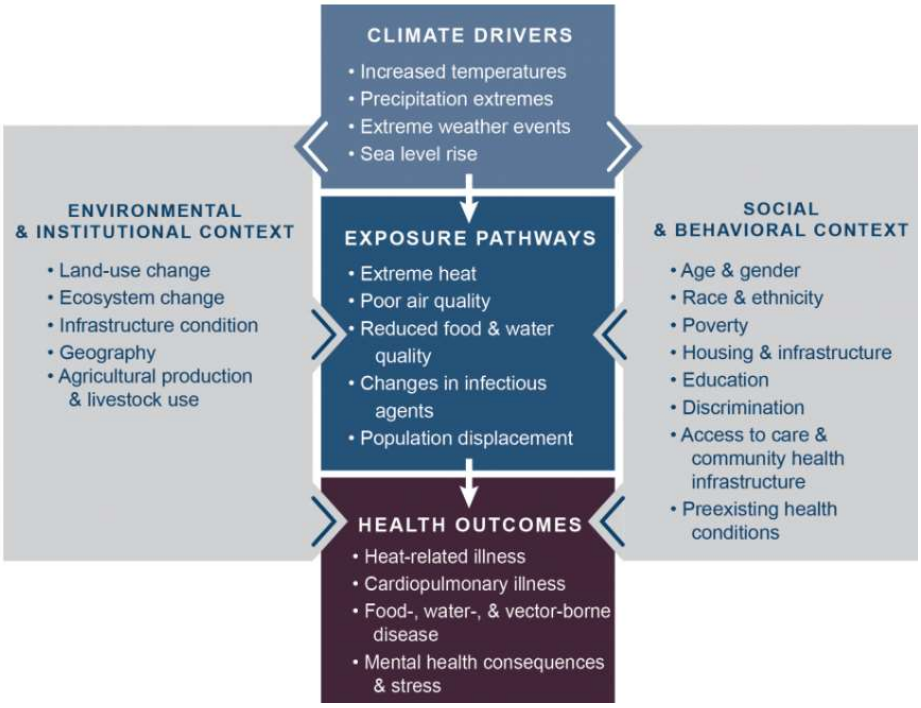


Img 3.4.8 Acid Rain

Sulphur dioxide and carbon dioxide are the main culprits for the formation of acid rain. In conjunction with the sun's rays, they convert into nitrates and sulfates, which are accumulated in the clouds. When rainfall happens, it is 500 times more acid than normal. Unfortunately, acid rain destroys the nutrition in soils such as magnesium and calcium, resulting in the devastation of trees. In Germany, this phenomenon has greatly been observed in lower mountain ranges. In winter, the situation is worse because acid snow is accumulated onto the trees. Acid rain is also responsible for the deterioration of buildings, especially historical ones made out of marble. Rivers and lakes become acidic and destroy marine life.

Another type of pollution that was not mentioned before is electronic pollution (e-waste). Used electronic devices such as pc, phones, and CPUs are being disposed of in wastelands. They are made out of lead, beryllium and cadmium, components toxic to the environment. They pollute the earth's surface, lakes and air. When they are burned they release cancer-producing dioxins affecting the health of humans and animals. Food becomes contaminated due to the soil which has absorbed the electronic waste toxins. It has been found that these toxins can cause birth defects, liver, heart, brain, and kidney damage. 70% of toxic waste comes from electronics.

3.4.3 Impacts on Humans

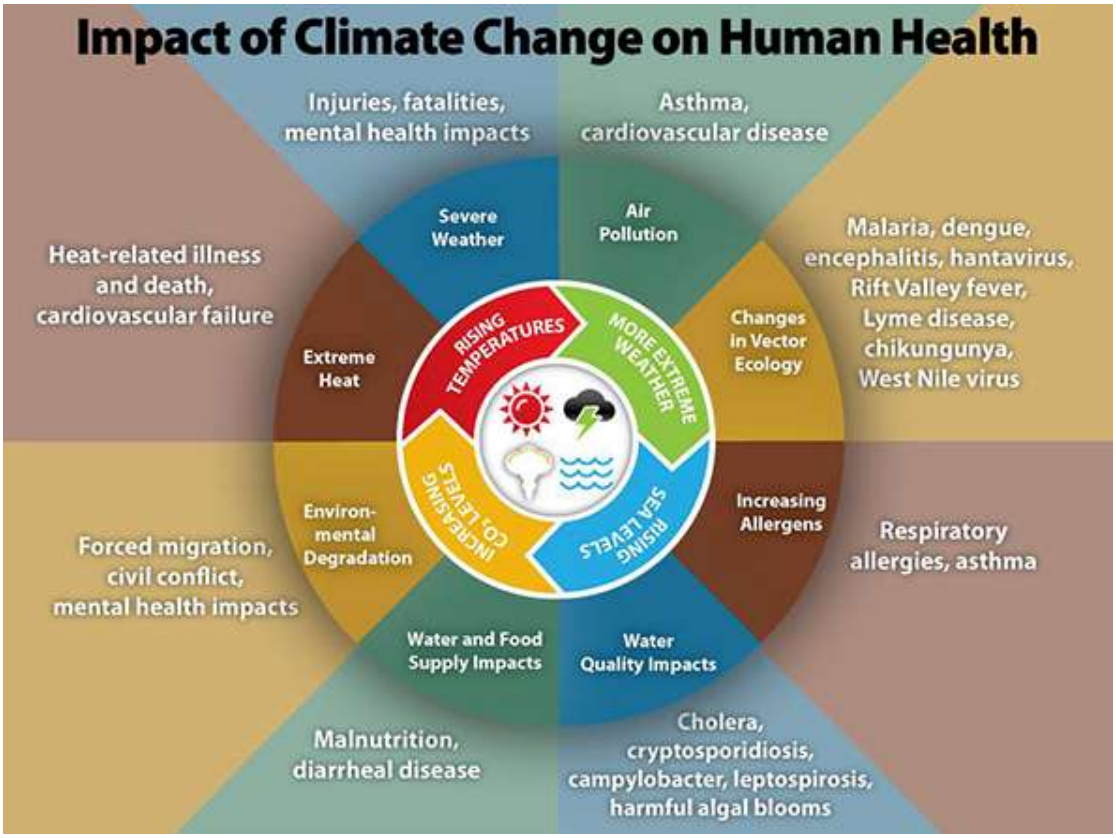


Img 3.4.9 Climate Change and Human Health

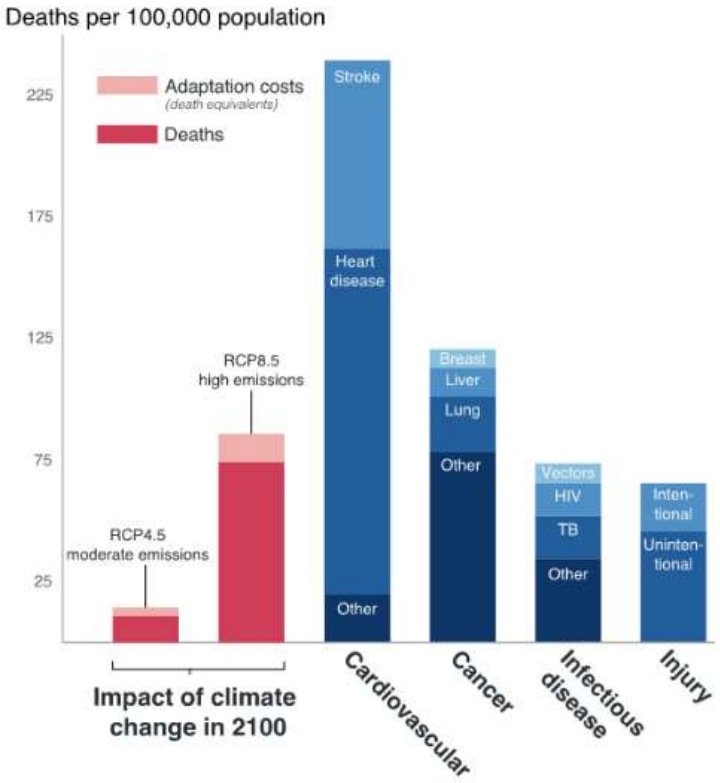
Climate change can affect human health in two ways. The first one is the frequency of health problems that are already affected by weather, and the second way is by causing problems in places when there was not. For example, increased temperatures raise the risk of diabetic people and those with cardiovascular diseases, to heat sensitivity. Mental illnesses may impair due to extreme weather, and people with asthma get worse due to the polluted air affected by human activities and climate change. Also, there is an increase in water-borne diseases and those transmitted through insects. Malaria, which is transmitted by mosquitoes, kills more than 400,000 people every year. Another example is the snail-borne disease named schistosomiasis, which will occur more often as the climate alters.

Air pollution is one of the biggest global problems as it causes many health problems and premature deaths. Chances of cardiovascular diseases, respiratory infections and asthma, are higher in the big cities. Sulphur dioxide (SO2) causes headaches, stress and cardiovascular diseases. Nitrogen dioxide (NO2) affects the blood, liver, reduces lung function, causes irritation on the eyes, throat and nose. Ozone (O3) is responsible for breathing problems and heart-related diseases. Particulate Matter (PM), can cause lung cancer, chronic pulmonary illnesses, affect the reproductive and nervous system. According to Air World Quality, Delhi in India has an index of 482 in pollution, which means it is hazardous. The main pollutant is Particulate Matter (PM). It is recommended for people to wear masks when outside, avoid outdoor activities, close windows at their houses and run an air purifier. Beijing in China has an index of 155 in pollution, which is classified as unhealthy. Tirana in Albania also has an unhealthy air quality, 147, but mostly affects sensitive groups. Athens air quality is considered moderate with an index of 84. Berlin has an index of 6 in air quality, meaning it is very good, and outdoor activities are encouraged.

The above air quality measurements were taken on 23 December 2020.



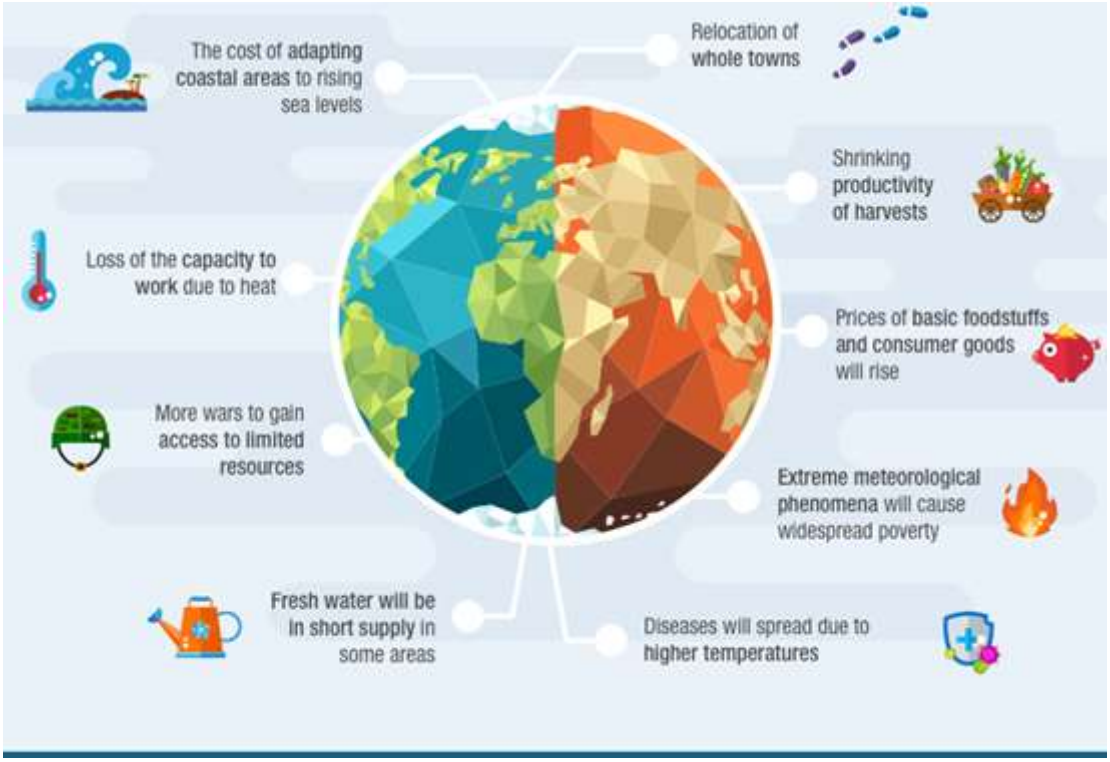
Img 3.4.10 Summary of impacts of climate change on humans



Img 3.4.11 Estimated deaths in 2100 by climate change in comparison to the most common reasons for death

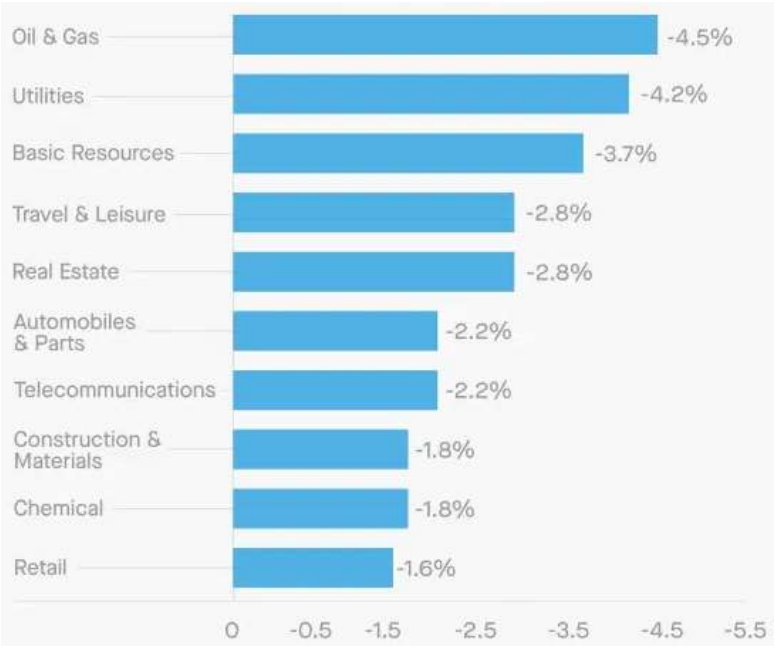
3.4.4 Impacts on the Global Economy

Climate change affects the global economy. Some countries are more vulnerable like Egypt, India and China, and others like Canada, Germany and the USA are less affected. The economic crisis varies on different global earth's temperature. It is estimated that a temperature of +1.5 Celsius more than the average, will drop the global GDP by 8%. This number might go to 13% with a temperature of just 0.5 Celsius more. Global warming will be responsible for property damage, damage losses from flooding due to increased sea level, security threats and mass migration. Approximately, 10.2 to 11.7 million dollars will be lost annually due to damages. Extreme weather, such as hurricanes, is an example of property loss and economic damage. Less capital stock will be available, leading to falling global production. Global warming will reduce the supply, raise the demand and eventually have higher prices. Agriculture is sensitive to weather conditions and frequent droughts reduce crop yields and land availability. This results in higher food prices, uninhabitable areas and mass migration.

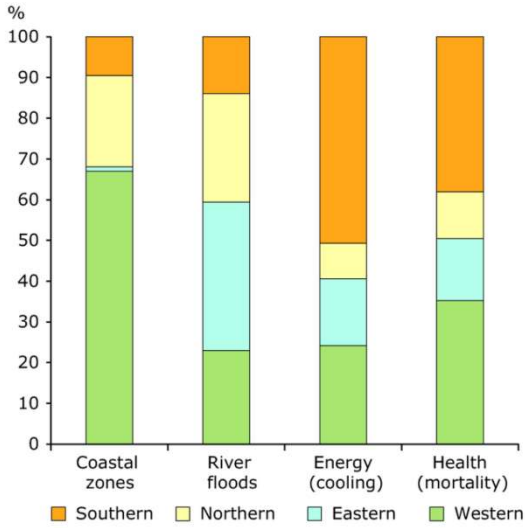


Img 3.4.12 Socioeconomic impacts of climate change

Climate change does not only affect agriculture. It has an impact on manufacturing industries. Alterations in temperature, wind and precipitation are significant variables for construction and engineering. A rainy winter or a windy spring can delay the construction process, which adds the cost to the contractor. Also, coastal erosions and soil instability force construction sites to do more research on geological factors, thus augmenting the cost and end up with high prices estates. On the other hand, dressing, consumption and other ways of lifestyles have a direct link with the state of the environment. For instance, wool production will decrease due to rising global temperatures. Services such as hotels, restaurants, tourism are subjected to high costs for the included industries.



Img 3.4.13 Most affected industries by climate change



Img 3.4.14 Economic cost of climate change in European regions

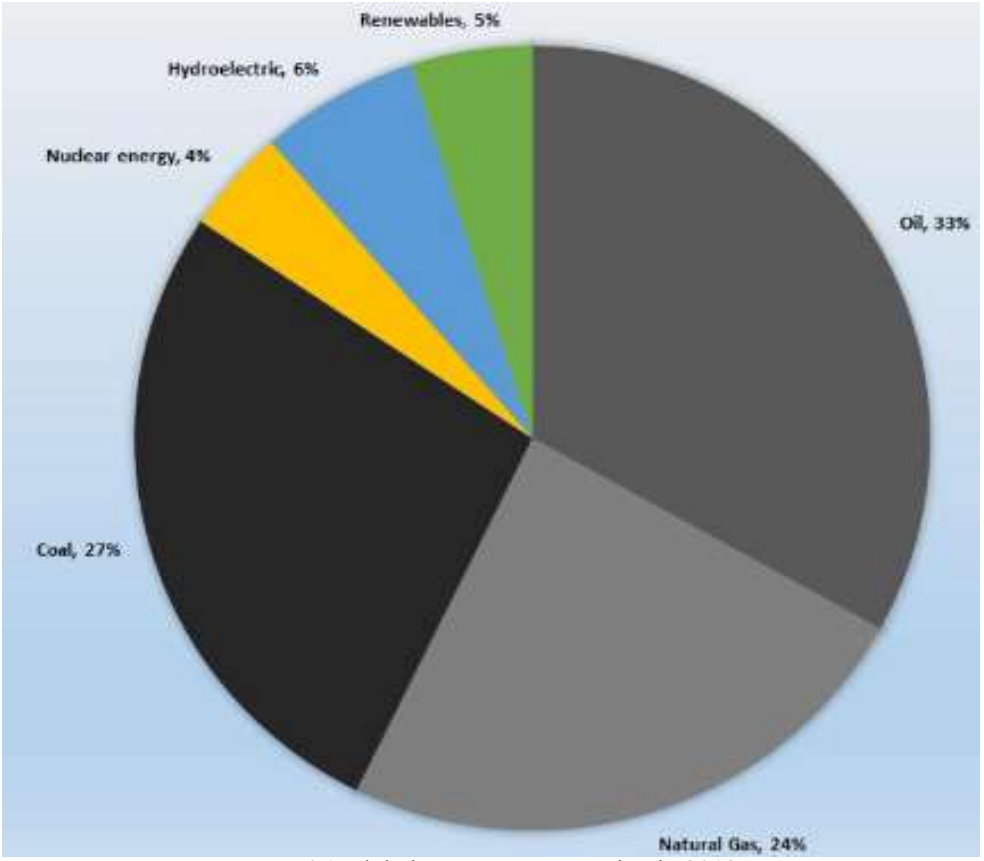
Poor countries are more vulnerable to climate change and the economic damage is higher. It is estimated that by 2030, they will need to spend 140 to 300 billion dollars per year to take defensive measures to protect themselves from extreme weather and overall climate change.

In 2006, Nicholas Stern, a World Bank economist, concluded that in order to mitigate the consequences of climate change, nations need to invest 2% of global GDP. According to an American economist, William Nordhaus suggested the input of high prices in industries that use fossil fuels because this will act as an impediment and will boost the search for renewable sources.

Chapter 4: Energy Transition

4.1 Definition of Energy Transition, Statistics and Plan

Energy transition is the global shift from non-renewable energy sources such as oil, coal and gas, to renewable sources like wind, solar and water. Improvements in energy storage, energy efficiency, energy systems, management and distribution of energy are part of the transition. Also, technological advancements in transportation such as electric vehicles are part of the greener and more sustainable future. The global EV (Electric Vehicles) adoption rate might reach 10-12.5 % by 2025. Industries, governments and society are striving for decarbonization, which means lowering greenhouse gas emissions as much as possible.

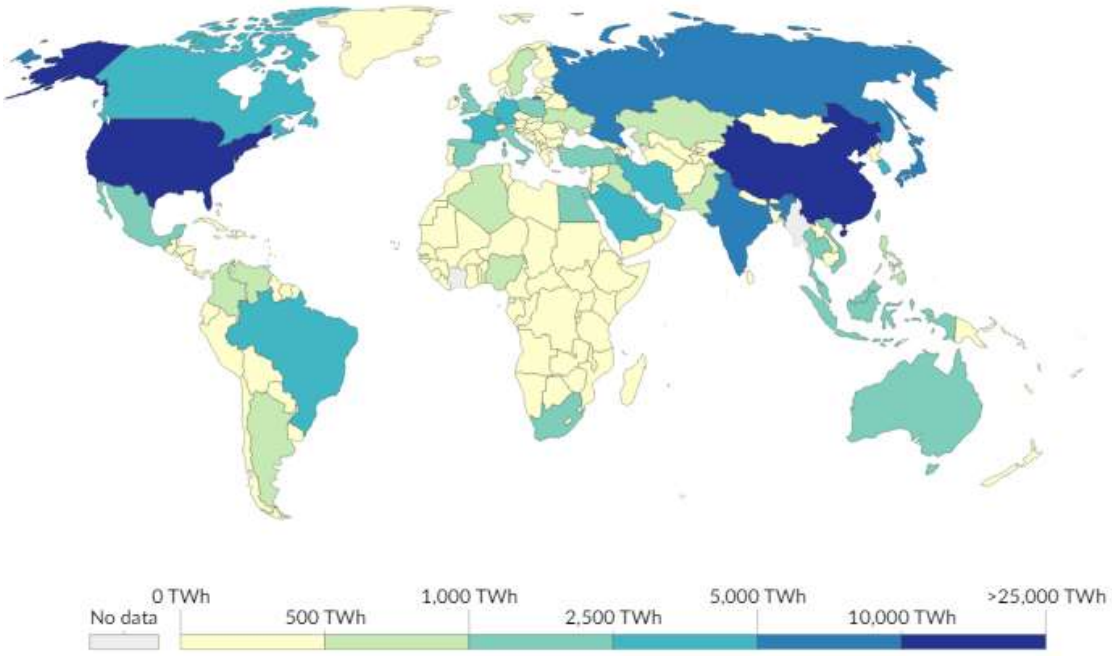


Img 4.1 Global Energy Consumption in 2019

As the above chart shows, fossil fuels still supply 84% of world energy. According to the Statistical Review of World Energy 2020, energy consumption grew by 1.3% in comparison to the previous year (2019). This is the tenth consecutive year with high energy demands. China is responsible for the majority of the world's energy consumption, followed by USA and India. Greenhouse gas emissions vary by each country and the International Energy Agency has estimated carbon dioxide emissions from fossil fuels globally. China, the USA and India are in the top three countries that emitted the most carbon dioxide in 2018.

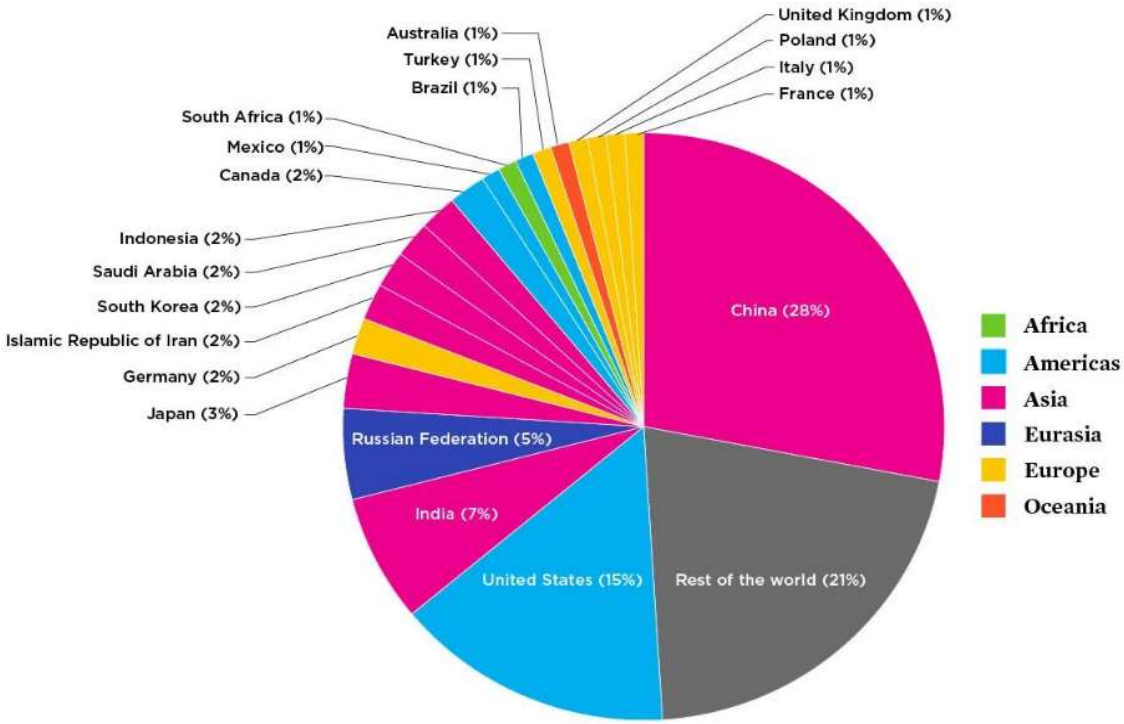
On the other hand, countries with the most renewable energy sources are 1) Iceland, 2) Norway, 3) Kenya, 4) Uruguay, 5) Sweden, 6) Germany, 7) China, 8) the UK and 10) the USA. Iceland generates nearly 100% of energy power from renewable sources due to its landscape. Hydropower and geothermal energy are the primary sources that produce 95% of the country's heating. Iceland is the world's largest electricity generator with 55,000 kWh per

person. The primary source of energy in Norway is hydropower, wind and thermal. They produce 98% of the energy that the country needs. Kenya generates 70% of energy coming from renewable sources. The main energy is bioenergy. In the last years, Uruguay managed to reduce carbon dioxide emissions and the government encouraged investments in the renewable energy sector. The primary source of energy in Uruguay is bioenergy or biomass. Sweden is the third country in Europe and one of the top countries in the world that is counting on renewable energy such as wind and solar power. Germany produces almost 50% of energy coming from renewable sources. Wind power is the main source (23.6%), followed by solar (8.9%) and then biomass (7.8%). Although China produces 25% of renewable energy it is still the country with the most fossil fuel usage and greenhouse gas emissions. England's most used source is wind and they have managed to produce more energy from wind farms than coal. In 2020, the USA invested 700 million dollars in greener forms of energy, amounting to 18% of renewable energy usage. Biomass and wind are the top two sources for the US.

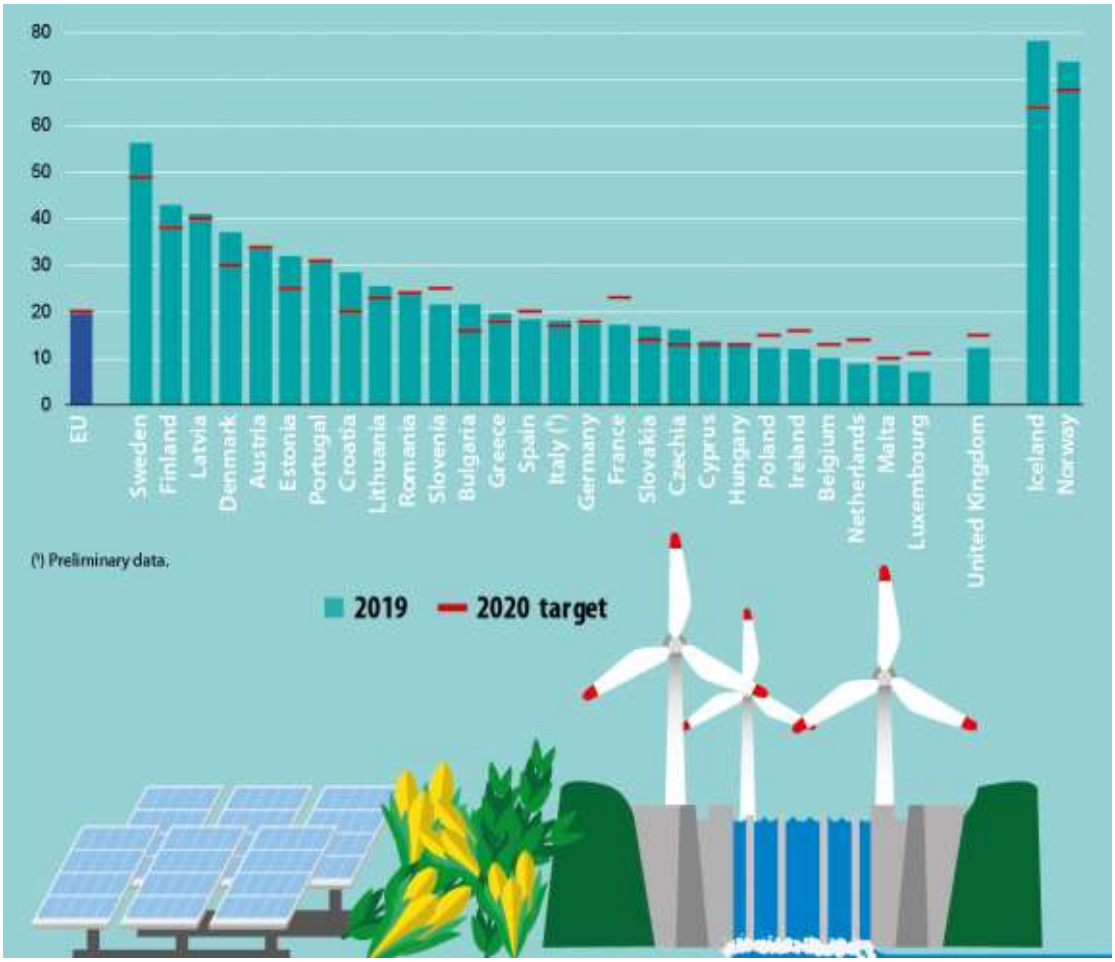


Img 4.1.1 Global Energy Consumption in 2019

Although more countries are adapting and invest in greener energy sources, there is still a lot to do to make the energy transition. The Paris Climate Agreement, an international treaty on climate change, was adopted in December 2015 by 196 countries. The primary goal is to limit global warming below 2 degrees Celsius. To achieve this, countries aim by 2050 to become climate-neutral, reducing greenhouse gas emissions as much as possible. Every five years, countries have to submit their climate action plans known as nationally determined contributions (NDCs). NDCs are actions to reduce emissions and strategies to adapt to climate change and weather conditions. Paris Climate Agreement provides economic, technological and infrastructural building support to the countries. Developed countries should support financially poorer countries in order to adapt and mitigate the climate crisis. Contributions from other nations are greatly supported.

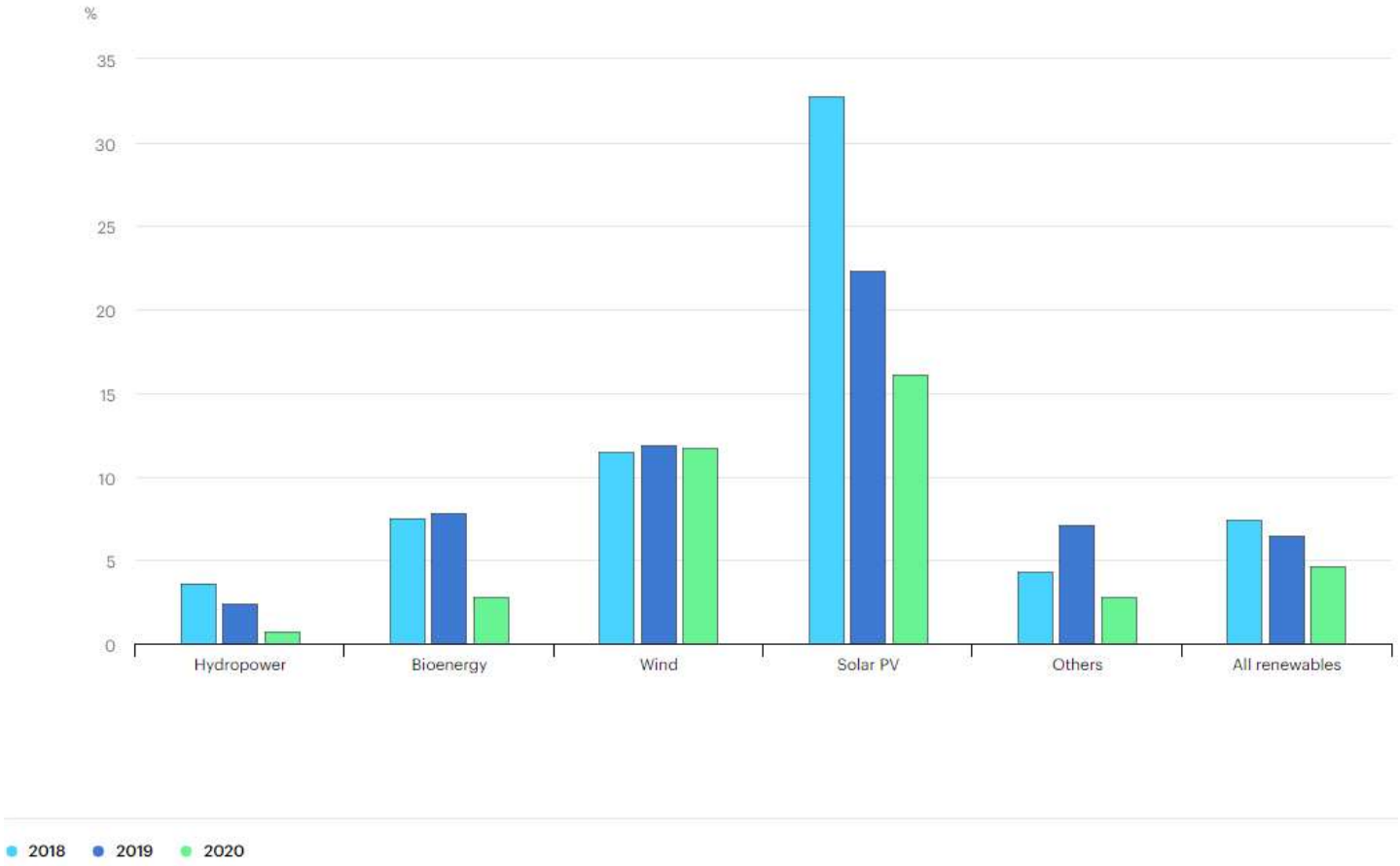


Img 4.1.2 Global Carbon Dioxide Emissions in 2018



Img 4.1.3 Energy Consumption from renewable sources in Europe (%)

Paris Climate Agreement has created an enhanced transparency framework (ETF), starting in 2024, meaning that the countries have to report their work that has been done to mitigate climate change and the overall progress. So far, all these actions have developed new markets, technology and low-carbon solutions. Power and transport sectors are the most flourishing businesses, creating new opportunities.



Img 4.1.4 Renewable electricity generation growth by source (2018-2020)

Wind power is expected to be the first in absolute generation terms compared to other renewable sources. Windy weather in many regions gave a boost to wind power in 2020. Electricity generated by biomass is expected to slow down due to supply chain interruptions, organization and planning problems. Power plants in Europe use wood pellets as fuel, which mostly come from North America. Electricity generated by renewable sources such as wind and solar power depends on weather conditions, which together with hydropower are accounting for 90% of the electricity production.

4.2 The Pillars of Energy Transition

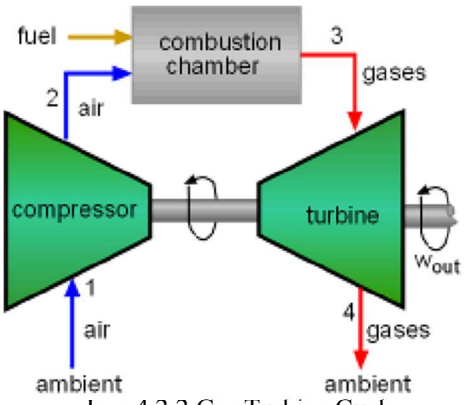
Energy transition is a challenge, but it can be achieved through research and advancements in technology. The first thing that is required to do is to change the way energy is generated. The generation points should be decentralized, which means implementing a Distributed Generation (DG) model. This model refers to the generation of electricity near the place it will be used. The distributed generation system applies to homes, businesses, industries, military bases and many other places. The advantages of such a supply are reduction of electricity losses along with the network and support clean and reliable power. Common systems in the residential sector that are used in the DG model are solar photovoltaic panels, small wind turbines and emergency backup generators fueled by gasoline or diesel. Commercial and industrial sectors use a combination of heat and power systems, solar photovoltaic panels, hydropower, biomass, wind, waste incineration and backup generators.

Img 4.2 The evolution of electric power grid

The USA produces 12% of its electricity from hydropower, wind and solar. Wind turbines, dams and photovoltaic panels are used. Energy storage is important for the distributed generation system. Batteries, compressed air, thermal and pumped hydroelectricity support the energy generation and distribution. There is also mechanical energy storage that exists and this is the flywheel. The flywheel is a rotating device that stores rotational energy assisted by gravitational and kinetic forces. Its input is electricity stored in the form of kinetic energy. The flywheel is connected to a generator that interacts with the rest of the power grid. When the power in the network fluctuates, the inertia allows the rotor of the flywheel to spin, converting the kinetic energy into electricity.

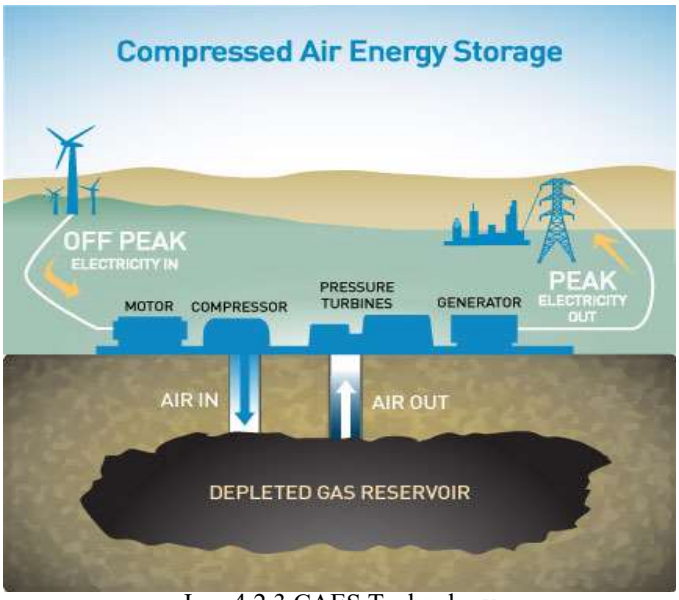
Img 4.2.1 Flywheel

Compressed air energy storage (CAES) is based on the gas turbine cycle. Air at atmospheric temperature and pressure enters the turbine's engine and the compressor compresses the air into high pressure. Through the combustor the air's temperature increases.



Img 4.2.2 Gas Turbine Cycle

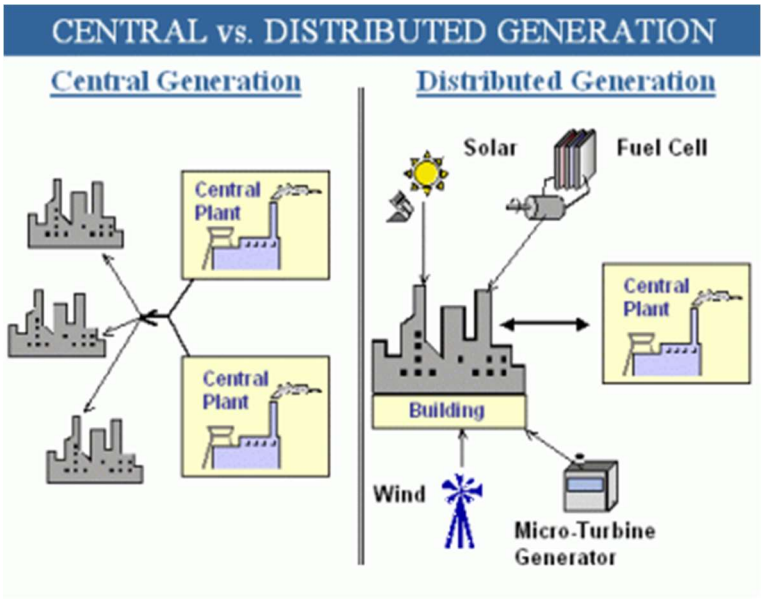
The gas generated from the gas turbine is stored in an underground cavity. When power is needed, the underground gas passes through air turbines, generating electricity. CAES has large power storage capacities and long life compared to other storage energy technologies.



Img 4.2.3 CAES Technology

The current electric grid still uses fossil fuels. The USA generates 85% of electricity from non-renewable sources. When electricity is produced from power plants, it travels through a network consisted of high voltage transmission lines. After that, the electric power goes to the substations, where high voltage is converted to low voltage power. Through low voltage transmission lines, electricity is distributed to the customers. The customers or end-users are industries, homes, hospitals and other buildings. In the US, 26% of electricity goes to agriculture, construction, mining and industrial facilities, whereas 36% is used for commercial and government buildings. Combined heat and power or cogeneration is the production of electricity and heat from a single source, used directly to the end-users. Finally, electric vehicles, which are a part of the end-users, can store energy. When the power from the rest of the electric grid is low, such as at night, electric vehicles can supply the grid with energy.

The electric grid described above is a hybrid model, which means it uses both distributed and central generation. The centralized system involves only the power plants generating energy, and through the network is being distributed to the customers.



Img 4.2.4 The difference between Central and Distributed Generation system

Distributed generation (DG) has many advantages. It is adaptable, which means it can use alternative and renewable energy sources. Second, reduces the dependence on power plants and transmission lines, lowering the cost, transmission congestion and power loss. Third, reduces price instability in energy markets. Forth, it is ecology friendly because the DG model is based upon renewable energy sources and low carb emission technologies. Also, it is reliable due to back up energy generation systems. Furthermore, it is flexible and does not rely on complex large systems.

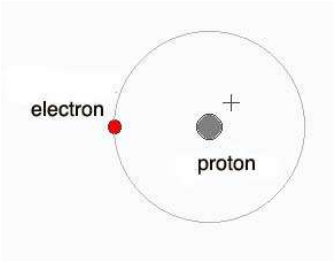
It was previously mentioned that the first pillar for the energy transition is changing from a centralized system to that of a distributed generation system. The other pillars are: 1) Electrification, 2) Power system flexibility, 3) Renewable sources, 4) Innovation, and 5) Green Hydrogen.

Electrification refers to the end-users increasing the power demand, met by renewable energy sources. The growth of electric vehicles is part of end-user electrification. The generated power cost will be lower than the power from non-renewable energy sources. When power systems are flexible, they can easily integrate new technologies and increase renewable energy usage. Grid expansion and operational measures assist in the adaptability of power systems. Decarbonization is an important part of the energy transition. Advances in biofuels, new materials, economy and technology will help reduce greenhouse gas emissions. Innovation in challenging sectors will make the energy transition feasible. Hydrogen is a new alternative form of energy used instead of fossil fuels.

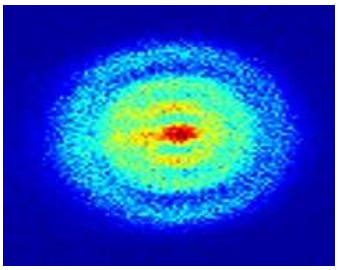
IRENA (International Renewable Energy Agency), the transformation of the energy system will boost the global GDP by 98 trillion USD by 2050. New occupations are expected to increase globally to 42 million by 2050.

4.3 Hydrogen as a New Energy Source

Hydrogen (H) is the most common element found in the universe. It exists in all forms of atoms up to 90%. From the living beings to stars, hydrogen is a part of the formation. The structure of the hydrogen atom is simple. It has only one electron and one proton.



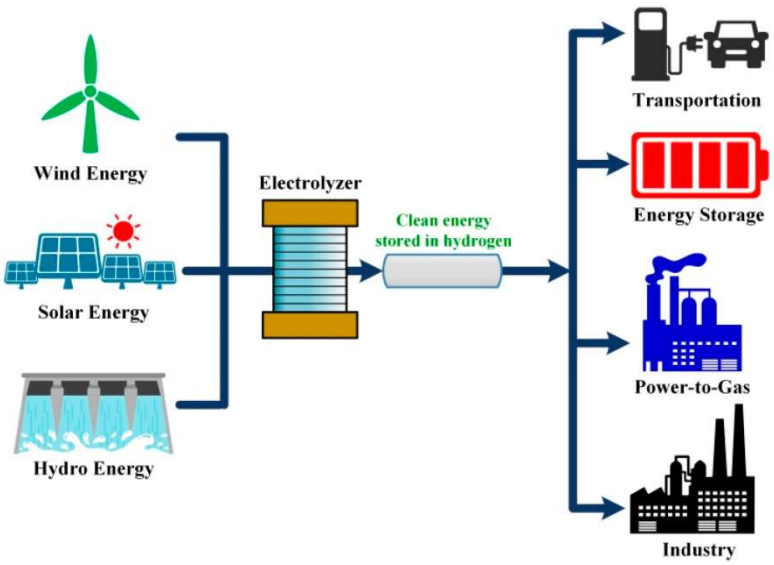
Img 4.3 Hydrogen Atom Diagram



Img 4.3.1 Hydrogen Atom seen by a quantum microscope

Hydrogen in its pure form is rarely found on the earth. Mostly it is combined with oxygen or other elements. Henry Cavendish was the first person who discovered this abundant element in 1766. Scientists have studied hydrogen for years due to its potential as an alternative source of energy. When hydrogen is burned, it produces only water, making it a clean fuel without pollution. Hydrogen can be produced from many and different sources. Those are natural gas, wind, solar, geothermal, biomass, nuclear, coal and petroleum. There are many ways to produce hydrogen and use it as fuel. Some processes are through electrolysis, steam methane reforming, direct solar water splitting and biological processes.

Electrolysis is a form of production that comes from renewable sources. Electricity is used to split water into hydrogen and oxygen inside the electrolyzer. A DC source and two electrodes are included in the electrolyzer. The electrolysis can be done either at low temperature or high. The amount of electricity and the method used for the electrolysis determine the efficiency of it.



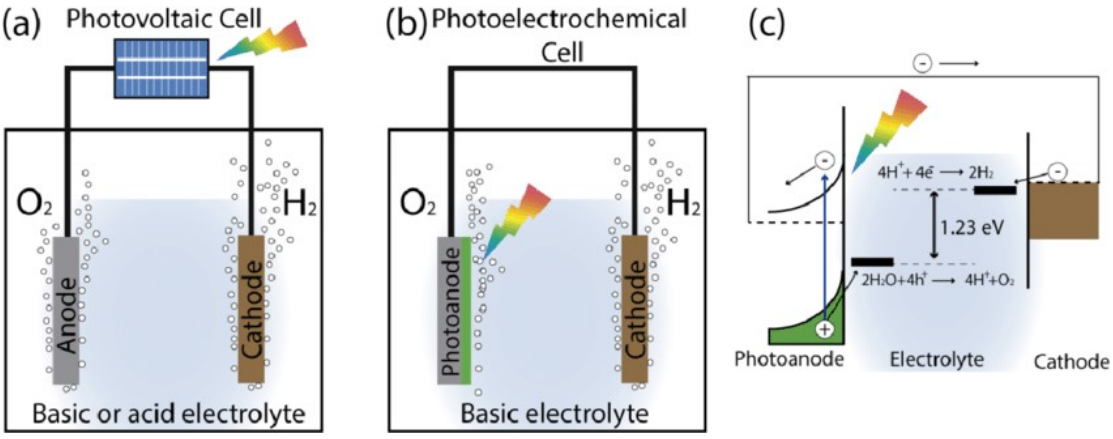
Img 4.3.2 Hydrogen as an energy source

Img 4.3.3 Electrolyzer

Researches are done to improve the efficiency of the electrolyzer system, operating life, reduce material costs and enhance power.

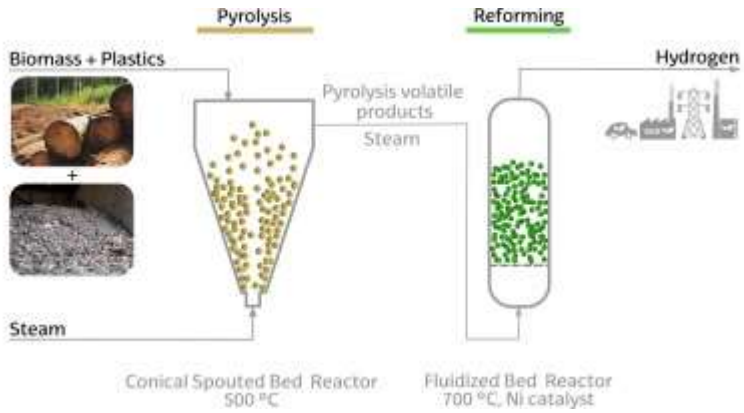
Direct solar water splitting is another method for the production of hydrogen. This process uses solar power to produce hydrogen from water without using electrolysis. Some methods used for this splitting include: photoelectrochemical water splitting, photobiological, high-temperature thermochemical cycles and biomass gasification.

Photoelectrochemical water-splitting uses electrodes in photoelectrochemical cells (PEC) that can separate water into hydrogen and oxygen using solar power. Dissolved metals can be also used instead of the semiconducting electrodes. Unfortunately, PEC is low in stability and efficiency, at least for now. There is an ongoing research to increase the performance and make it available for the market.

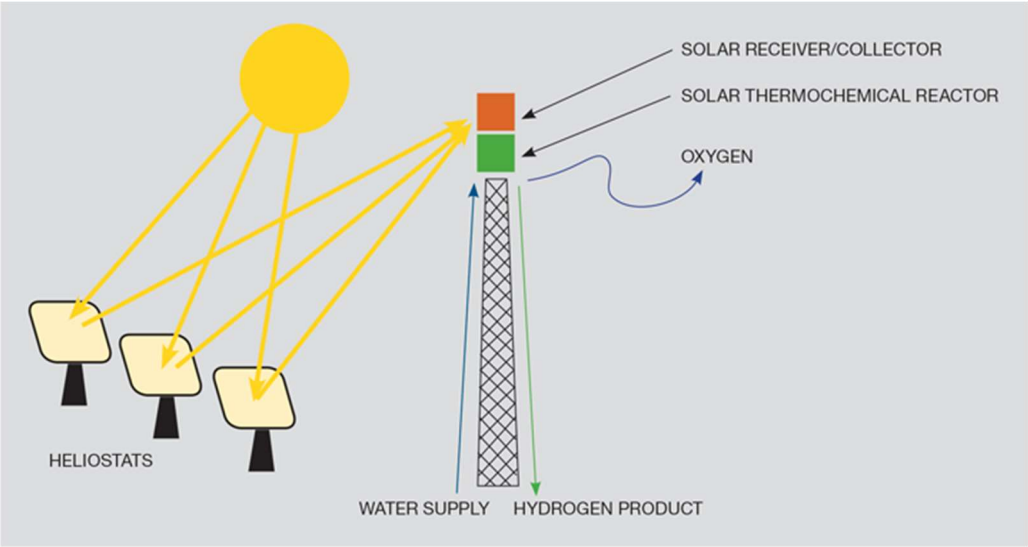


Img 4.3.4 Electrochemical water-splitting using the solar power

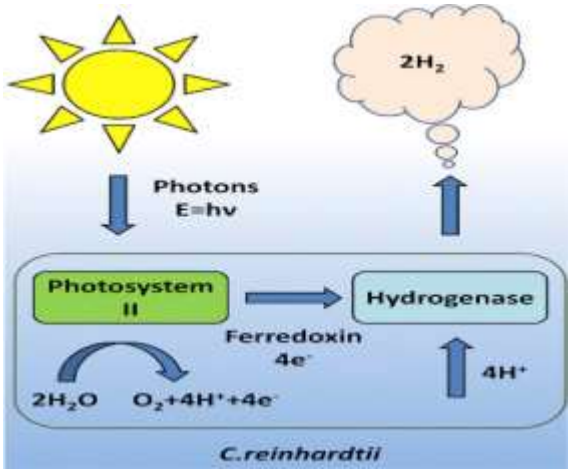
Photobiological hydrogen production uses specific types of algae or bacteria that under certain conditions, they produce hydrogen. They absorb solar energy, and cell enzymes split water into hydrogen and oxygen. High-temperature thermochemical cycles use concentrated solar energy to split hydrogen and oxygen from water. In order to make this reaction, high temperatures, between 500-2000 Celsius, are used to generate a series of chemical reactions. Each cycle of the process reuses the chemicals. Biomass gasification uses high temperatures in order to alter biomass such as wood, agricultural waste and grasses into a synthetic rich-hydrogen gas.



Img 4.3.5 Hydrogen production with the use of biomass

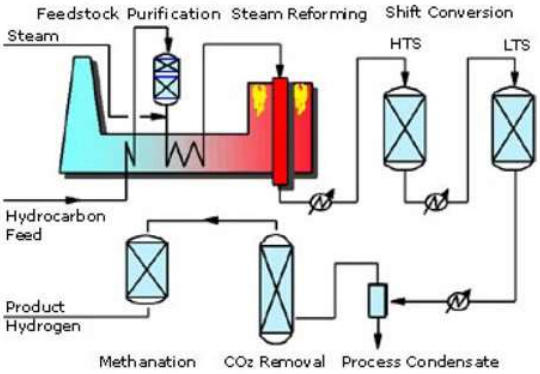


Img 4.3.6 Thermochemical cycles for the hydrogen production



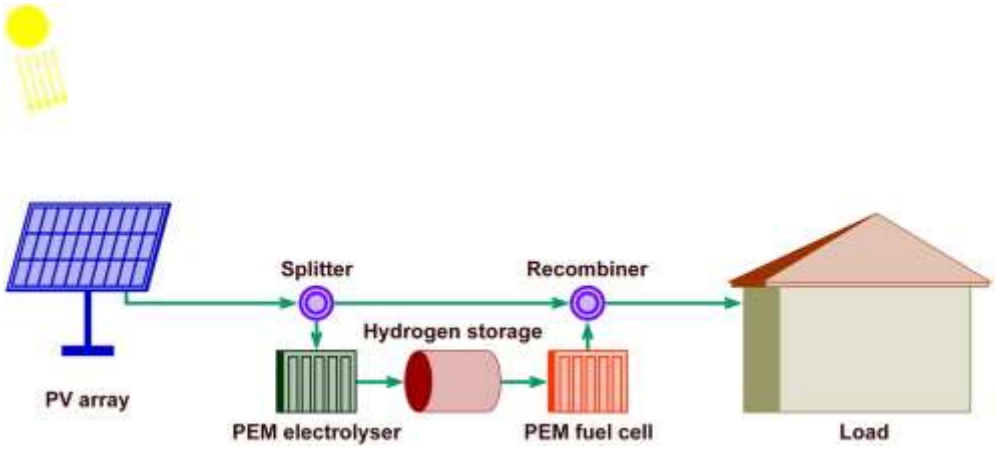
Img 4.3.7 Photobiological hydrogen production

The steam methane reforming process uses natural gas, petroleum, or naphtha to produce hydrogen. The first step is to desulfurize the mentioned resources. Then they are heated and mixed with steam. Afterward, they pass a catalyst in a top-fired steam reformer to produce hydrogen and other carbon gases. The hydrogen is separated with the use of a pressure swing adsorption.

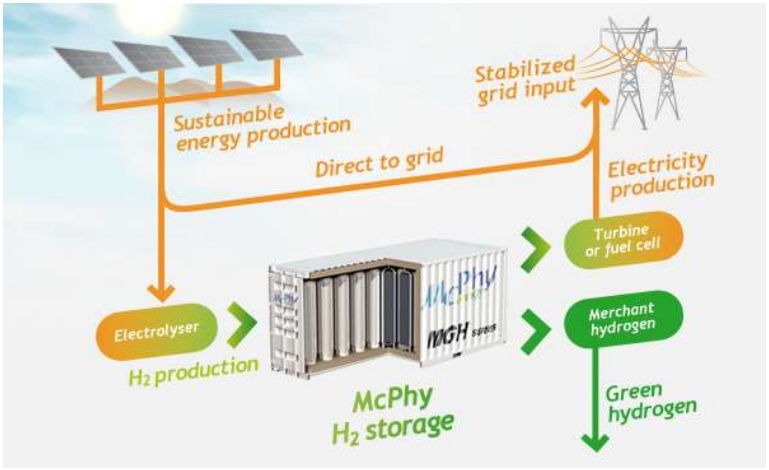


Img 4.3.8 Steam Methane Reforming Process

Hydrogen is used a lot in the space industry, mainly as a rocket fuel. It can also be used in electric vehicles providing them with electricity stored in cells. Furthermore, it can be used to power houses, buildings, supply with electricity remoted regions, and used as a back-up in the energy systems in case of a power fluctuation in the electric grid, without emitting harmful gases. Hydrogen can be stored in a liquid form, as a compressed gas, or in cold/cryo compressed form in high-pressure tanks. It is worth to mention that hydrogen as a fuel has lot of energy. 1kg has three times more energy than 1 kg gasoline.



Img 4.3.9 Stored Hydrogen for off-grid power supply

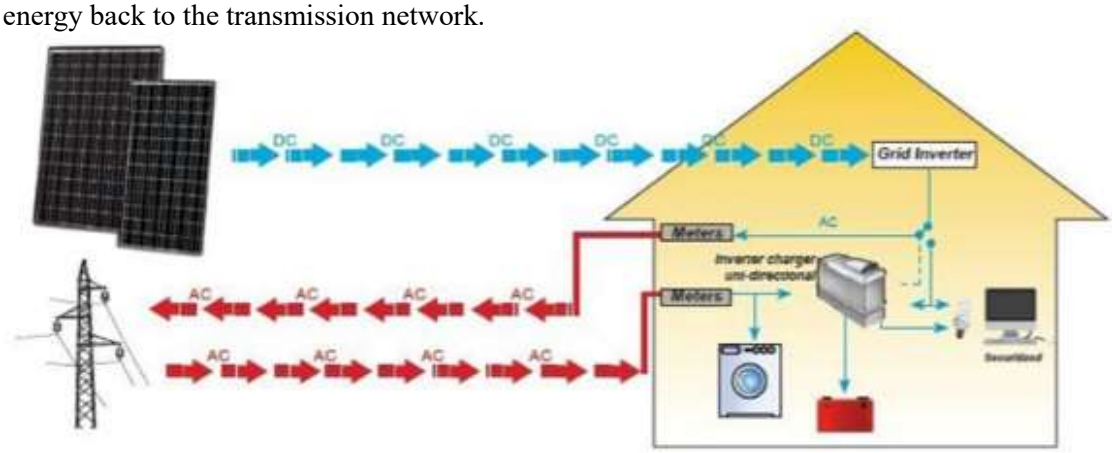


Img 4.3.10 Stored Hydrogen for grid usage

The advantages of hydrogen are: 1) high efficiency, 2) no carbon emissions, 3) suitable for distributed generation systems, hence no power loss, 4) high ratio of electricity to heat in comparison with the conventional power plants that use fossil fuels, and 5) can be combined with other renewable sources. The disadvantages are: 1) high cost due to expensive materials used to harness the energy, 2) safety issues because the hydrogen gas is flammable, 3) the lifetime of fuel cells (that store the energy), needs to be longer, and 4) infrastructures are still under development. Nevertheless, hydrogen offers a promising future for the energy transition. The advancements of technology and science will make adequate use of this alternative energy source and bring a new way of living.

4.4 Smart Grid

A smart grid is an electrical network with a two-way flow of electricity. In the past, power plants were the only generators of energy supplying the town, which means the power flow has only one direction (e.g., from the power plant to the house). The bi-directional flow of electricity allows the end-users (houses, industries, hospitals, etc.) to send the surplus of energy back to the transmission network.



Img 4.4 Bi-directional flow of electricity

Smart grids are considered such because they use data and telecommunication technologies to detect and react to fluctuations in the power network and troubleshoot other issues. Also, they have self-healing capabilities. Self-healing means that a system can detect malfunctions and solve the problem with the required settings in order to operate normally. An electrical grid to have a self-healing ability has to detect fast the network disturbances, distribute the resources properly, continue its work under any conditions, even in bad weather and minimize the restoration time when there is a problem. To monitor the transmission lines, the electric grid uses circuit breakers, transformers, advanced sensors, signal processors and communication networks. Sensors provide useful data such as overhead conductors, temperatures, pinpoint the location of the faulty lines, detect tower failures, etc.

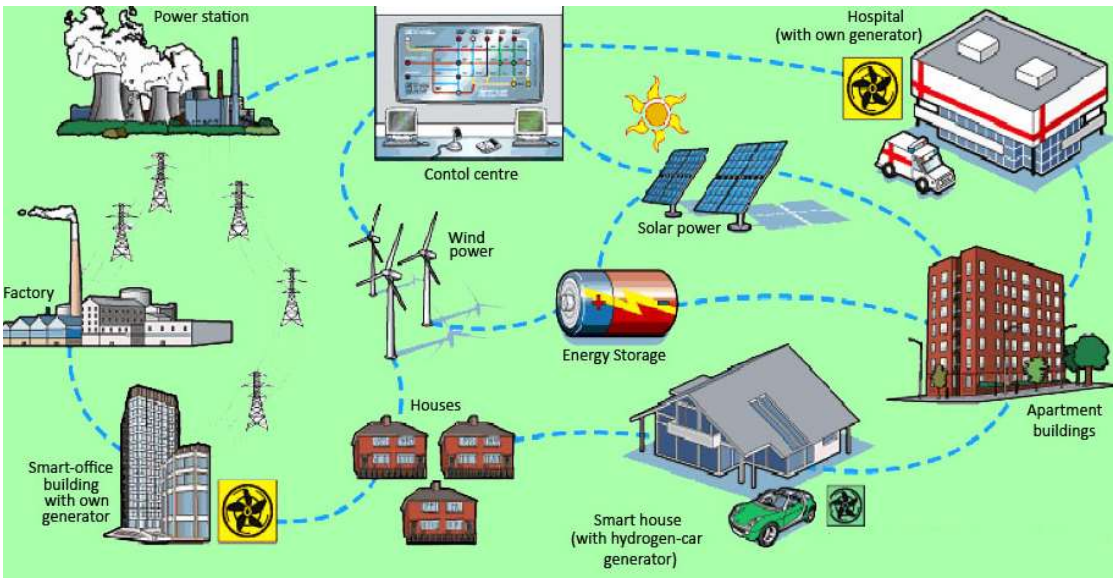
A smart grid uses software agents for control, management, synchronization and data transportation between electrical devices and power stations. Those software programs can be grouped as: 1) Grid Component Agent: controls the performance of transformers, circuit breakers and protective relays. 2) Distributed Resource Agent: controls the power flow of the grid. 3) End-User Agent: monitors and estimates the power consumption of the consumers. Also, communicates with the distributed resource agent to maintain energy availability. 4) Failure Control Agent: monitors the device's state. If it is going to fail, the failure control agent reports to the supervisor agents in order to prevent the damage. 5) Data Analyze Agent: reports to the supervisor agents about the whole system/ grid performance. The performance is estimated by the devices' state, generated power amount and load demand. If there is a malfunction to the grid, the supervisor agents determine the best method to solve the problem and restore the grid's state to normal. 6) Graphical Visualization Agent: provides a graphical interface of the system's performance.

Smart meters are seen as an essential component of the smart electrical grid. The traditional meters display the energy consumption of the end-users. The bills are generated according to the consumption done at a specific time. The architecture of the conventional meter is: consumer premises -> electronic meter -> manual collection of data -> manual billing.

On the other hand, smart meters are an upgraded version of the conventional electromechanical meter. They serve as an interface between end-users and power plants. They record power consumption, collect data and inform the utility centers. The smart meter architecture goes as follows: consumer premises -> smart meter -> communication protocol -> data management systems -> utility center. The tasks carried by the smart meter can be summarized as 1) data collection, 2) bi-directional communication, 3) data analysis and 4) decision support.

The advantages of the smart meter are many. For the utility centers, some of them are reduction of the required personnel due to advanced monitoring technologies, increased ability for load management, uses the grid resources efficiently and offers the latest tariff for the electricity market. The advantages for the end-users are accurate electrical billing, allows the scheduling of the electrical usage, allows consumers to plan and manage their electrical equipment reducing costs during peak load times, and allows the switching between conventional and renewable resources of energy.

It is estimated that by 2023, 65% of electrical companies will have invested in advanced technologies to support smart grids and upgrade the load potential of the networks up to 35%. The benefits of the smart grid are high efficiency, integration of renewable sources and reduction of carbon emissions, offering reliability, allowing customers to manage electricity consumption, and finally support the development of electric vehicles.

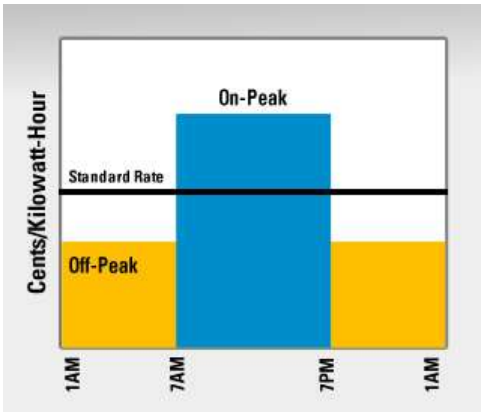


Img 4.4.1 The Smart Grid Idea

As it was mentioned before, consumers can actively participate in the energy system. Through the smart grid, the end-users can save energy and money. Some utility centers offer customers a way to save money by controlling remotely electrical devices and turn them off during times of peak power demand. However, smart grids allow more sophisticated programs, resulting in greater energy and money savings for both customers and companies. Such programs are time-off use pricing, compensation programs for electrical devices and net metering.

The time-of-use programs depend on the off-peak and on-peak times of demand in energy. An off-peak time is considered the early morning, nights, weekends and holidays. The on-

peak time is weekdays on a chosen period. This period could be between 7 a.m. to 7 p.m., 8 a.m. to 8 p.m., 9 a.m. to 9 p.m., or 10 a.m. to 10 p.m., depending on the customer's choice.



Img 4.4.2 Electric bill depending on the time

During peak energy demands, power plants struggle more to supply all the customers, so they have to use less efficient ways such as reducing the voltage. The cost of those hours is higher. The solution to this problem is provided by the time-of-use programs, aiming for even distribution of power. The utility centers offer low energy prices to the end-users when they consume electricity during off-peak times. Energy management systems will assist customers to monitor the period of time which has high prices, turn off devices that are not used and see what appliances consume more energy. All these can happen with the help of smartphones or computers.

Net metering allows end-users to sell their surplus of energy that they generate either with the use of solar power or other renewable sources. The energy that end-users do not need goes back to the grid. Customers are charged only with the energy that they consumed. Net metering has economic benefits not only for the customers but can also create jobs and encourages investment. With the use of net metering, solar power will have more demand, thus offering jobs for manufacturers, electricians, and installers of photovoltaic panels.

Homes can have power stations to charge electric cars, making them a storage of energy. When a customer gets power from the car's battery pack instead of from the grid, utility centers make a discount on the electric bills. This happens due to the decrease in the lifespan of the car's battery, thus offering a compensation program. A department of water and power in the US named Pasadena, offers a 200$ discount for residents having a standard electrical charger, whereas those who have a Wi-Fi electric vehicle (EV) charger get a 600$ discount.

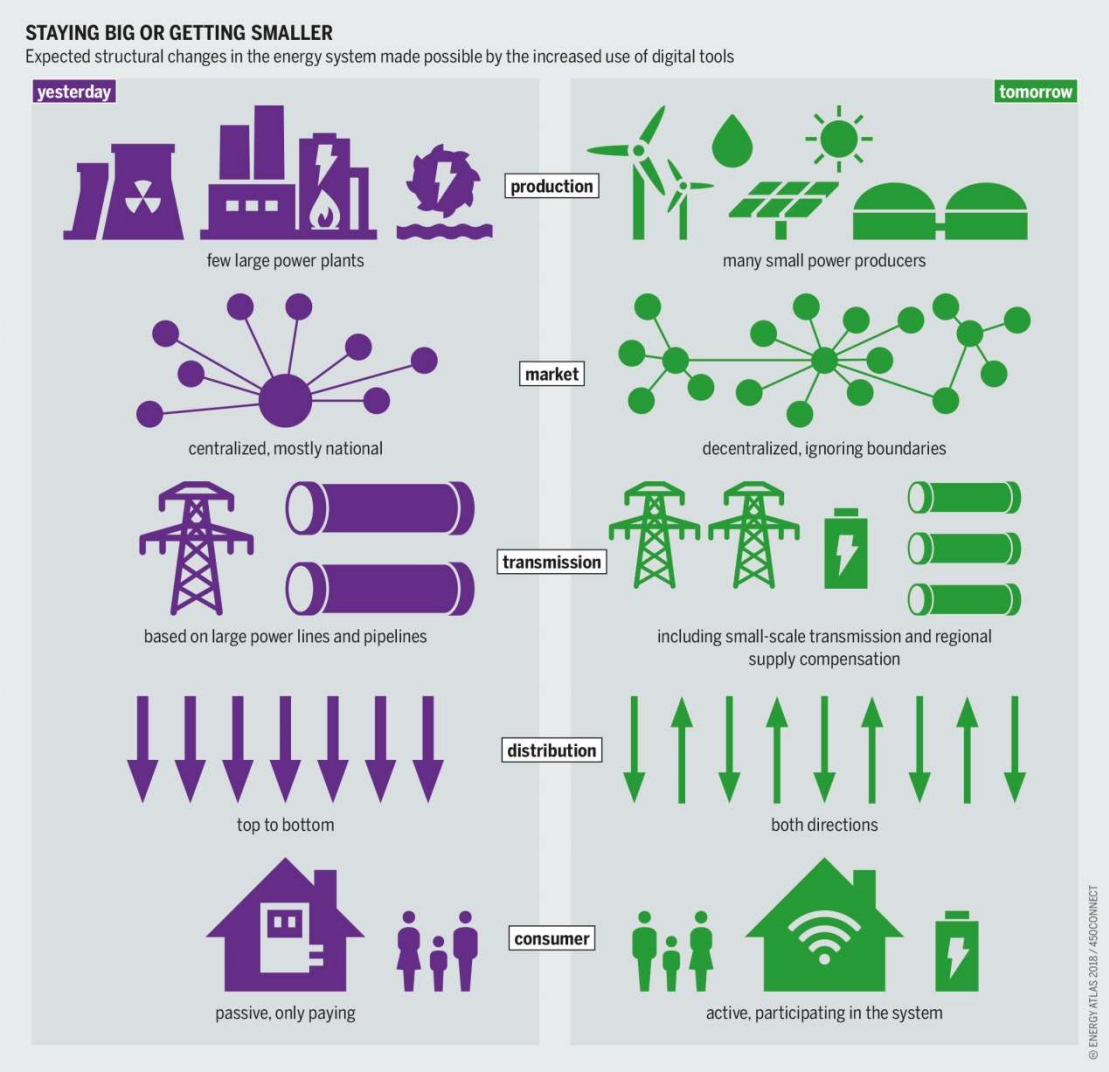
Smart grid overall has benefits and offers opportunities, but there are still challenges ahead till the total implementation of it. One challenge is the supply change. Renewables are still not predictable and reliable enough to be the main source of power. Wind and solar power rely on the weather. If it is not blowing or shinning, neither wind turbines nor solar panels will be able to generate electricity. This inconsistency does not make renewable energy suited for high demand times of energy. Furthermore, some renewable sources cannot be integrated into the high voltage transmission lines.

Another issue is the technical challenges. The current electrical grid has a high number of distributed nodes that operate together in real-time. In order for a grid to be smart, there is a need to embed smart devices and data centers into the system. Figuring out where intelligence

needs to be is a complex task. In addition, there is a need to manage the new equipment with a lower lifespan together with the old transmission lines and network. Each device connected to the smart grid is both an electronic device and an intelligent node that collects data and manages situations. This raises the security concern. Some of the privacy concerns are: determining personal behavior and specific appliances used, monitoring in real-time activities through gathered data and targeted home invasions.

Another challenge is worldwide standards and interoperability. There is a need for devices and other pieces of equipment to work together at every level of the system. Utilities should not have problems buying a piece of equipment from different vendors, which have other standards and working process. There should be a focus on key interfaces at a global level, in order to achieve efficiency and interoperability.

Nonetheless, the smart grid will contribute to better energy and system management, provide customers a chance to organize and take part in the system and offer new jobs, expand the market and increase investments.



Img 4.4.3 The main differences between conventional and smart grid

4.5 Electric Vehicles (EV)

Electric vehicles, shortly EV, are vehicles that are either partially powered with electricity or fully powered. There are two types of EVs; hybrids and fully electric. Hybrid vehicles can be categorized as mild hybrids, full hybrids and plug-in hybrids. Overall a hybrid car combines two different sources of energy. The first is the stored electric energy in the batteries and the second power is the energy coming from petrol or diesel.

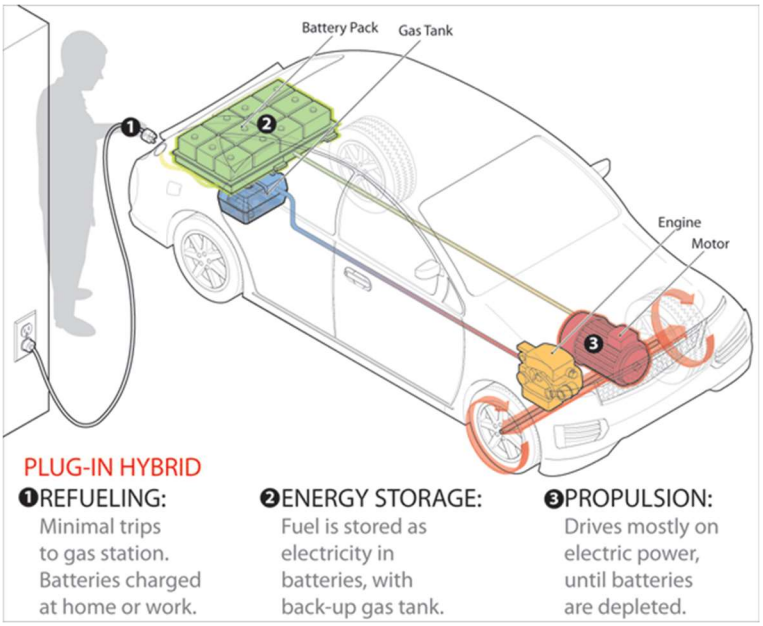
Img 4.5 Honda Insight, a hybrid car

Img 4.5.1 Tesla Model S, a fully electric car

A fully hybrid car uses a combustion engine in conjunction with electric motors. They work either independently or simultaneously. Usually, full hybrid cars have small amount of electricity, which is being used as a provider of extra power, improving fuel costs. However, this type of car can also run with only electric power, but for limited distances and at low speed. The car batteries are small but can be charged quickly. It is worth to mention that the batteries are charged with electricity from the engine that burns its fuel. Some examples of fully hybrid cars are Toyota Corolla and Lexus. Mild hybrid vehicles also use two sources of power, with the exception that the combustion engine and the electric motors cannot work independently. The electric motor is solely used as extra power for the car's engine. Examples of mild hybrid cars are Suzuki Ignis and Swift supermini. Plug-in hybrids are vehicles that work as full hybrids, with the difference of having larger batteries to store electric energy. The term plug-in means that the car or other type of vehicle can be charged on power stations.

When the car's battery is emptied, the combustion engine turns on, which makes the vehicle work as a conventional car operating with diesel. Plug-in hybrids are charged from the power grid. As it was earlier mentioned, they can be used as energy storage for the end-users. Usually, an energy storage system for the plug-in vehicles (also for the full-electric) is batteries. There are four types of batteries; lithium-ion batteries, nickel-metal hydride batteries, lead-acid batteries, and ultracapacitors.

Lithium-ion batteries are the most used batteries in plug-in hybrids and in fully-electric vehicles. They are the most efficient batteries due to their high energy per unit mass, good temperature performance and low self-discharge. The main challenge with these types of batteries is the high cost of the materials. There is ongoing research to reduce the cost and extend their lifespan. Nickel-metal hydride batteries are mainly used in hybrid vehicles. They have specific energy and power capabilities. Unfortunately, they have a short lifespan, high self-discharge, high cost and overheating issues. Lead-acid batteries are safe and inexpensive and are mostly used in electric vehicles. However, their short life cycle and poor performance in colder temperatures make them harder to use extensively. Ultracapacitors provide electric vehicles with extra power and can be used as secondary energy storage. The energy is stored in a polarized liquid between an electrode and an electrolyte. The bigger the liquid's surface, the better is the energy storage capacity.



Img 4.5.2 Plug-in Vehicle

Plug-in hybrids use 30 to 60 percent less petrol than conventional vehicles, reducing the dependence on fossil fuels. Because of this, they emit fewer greenhouse gasses, making them environmentally friendly. Also, electricity is cheaper than gasoline. Another benefit is fuel efficiency. Advanced techniques such as regenerative braking, save fuel when the driver steps on the brake pedal. The energy is stored for later use. The aerodynamic design of hybrid vehicles assists in fuel conservation.

It is estimated that the hybrid market vehicle will grow about 16.35% during 2020-2025. The main reason for this growth is environmental concern and governments adopting policies on reducing gas emissions. Asia-Pacific is expected to have the fastest-growing market. The Norwegian Road Federation has reported that 31.2% of sold cars were fully-electric in 2018. Research in battery technology will drive the growth of hybrid vehicles.

Electric vehicles, as the name suggests, operate solely with electricity. When the battery gets empty, it can be recharged in power stations just like the plug-in hybrids. They can also be charged with a standard 120V charging cord, plugged-in the garage. The speed of the charging depends on the station's voltage and the size of the battery. Electric vehicles with large batteries charged at 120V can take up to 20 hours to be fully charged, whereas it takes only 4-8 hours if they are charged at 240V. When the batteries reach the end of their lifespan, they can be recycled. The early electric cars (2011-2016) could drive for 100 miles until they need recharging. Current models can travel for 250 miles and cars such as Tesla can run for 350 miles until the recharge. On the other hand, plug-in vehicles can drive for 10-50 miles on electricity, and then change to gasoline for about 300 miles.

A study done in Germany by two technical institutes compared the performance of 49,000 battery-electric cars and 73,000 plug-in hybrid cars in Germany and the USA. They found that plug-in hybrids were driving 30 miles on average as the fully electric cars. That means that hybrids are as effective at reducing greenhouse gas emissions as fully electric cars. The reason for this is that most people cover their needs within 30 miles of driving per day, meaning that in this range, the plug-in hybrid car still uses only electricity before exhausting it and turning on the gasoline.

4.6 Energy Efficiency

Energy efficiency is the elimination of energy waste. In simple terms, it means using the same amount of energy for doing a better task or using less energy to do the same amount of task. An example of this could be an energy-efficient washing machine compared to a conventional one. The efficient machine could last longer or work better while using the same amount of energy as the traditional machine. Another example is an energy-efficient TV that uses less energy to perform the same task as the non-efficient TV. Energy-efficiency does not only apply to devices but also to a wider variety of sectors such as buildings, energy generation and distribution, transportation and industry.

The energy used in buildings (residential and commercial sectors) is part of major energy consumption of a country. It is estimated that Europe spends 40% of the energy on buildings, Brazil spends 42%, and the Philippines uses about 15-20% of the energy used in the residential sector. The level of urbanization, national policies to promote energy efficiency, the number of buildings in an area, and the degree of electrification (electricity from renewable sources), affect the percentage of a country's energy consumption on buildings.

The energy efficiency of a building is measured by energy consumption standards. Air-conditioning, heating, electricity, illumination, and the materials used for the conduction of heat, are some of the values included in those standards. Doors and windows can gain or lose heat, resulting in an increase in energy consumption. Most buildings have a minimum standard for these components. Some benefits coming from energy efficiency in buildings are lower maintenance requirements, reduced need for electric power and energy used for heat or cooling, and an increase in the property value. The measures to increase energy efficiency in buildings can be categorized into specific groups such as reducing heating demand, reducing the energy required for illumination, reducing electricity consumption for devices, good housekeeping, and many more.

Some of the solutions to reduce heating demand are; improving the insulation of the building, limiting the exposed areas by having less complex building shapes, reducing air leaks on wall cracks, installing weather-stripping doors and windows, and many more. To reduce lighting requirements in buildings: maximum use of daylight, installing lamps with high luminosity, and lighting control. For example, when someone leaves a room, automatically lights are switched off. In order to limit electricity consumption, buildings should be equipped with new and energy-efficient appliances. To make this task easier, electric devices have energy labels attached to them. Energy labels help consumers save money and energy. They may save up to 285€ per year and energy efficiency policies will create up to 66 billion euros for companies.

Img 4.6 Energy Labels on electric appliances

Energy generation and distribution can also be energy-efficient through smart grids and combined heat-power generation systems. Those systems capture the extra heat from power plants and use it to supply nearby buildings with heating, cooling and warm water. The energy efficiency with this is increased between 33 to 80 percent. Transportation comes in second place as a producer of greenhouse gas emissions in Europe. Hybrid vehicles and fully electric reduce fuel consumption and gas emissions, making them very energy efficient.

People can implement simple measures in everyday life, especially at home, to save energy. For example, during the winter, it is suggested to keep the thermostat between 18 and 20 degrees, close doors to unused rooms, and install energy-efficient heating systems. Also, turning off appliances that are not used for a long time, switching to LED lights, waiting until the dishwasher becomes full and selecting the shortest washing programs, insulating the roof, and installing solar panels are some ways to save energy and money.

Img 4.6.1 Energy Efficient Benefits on economy and buildings

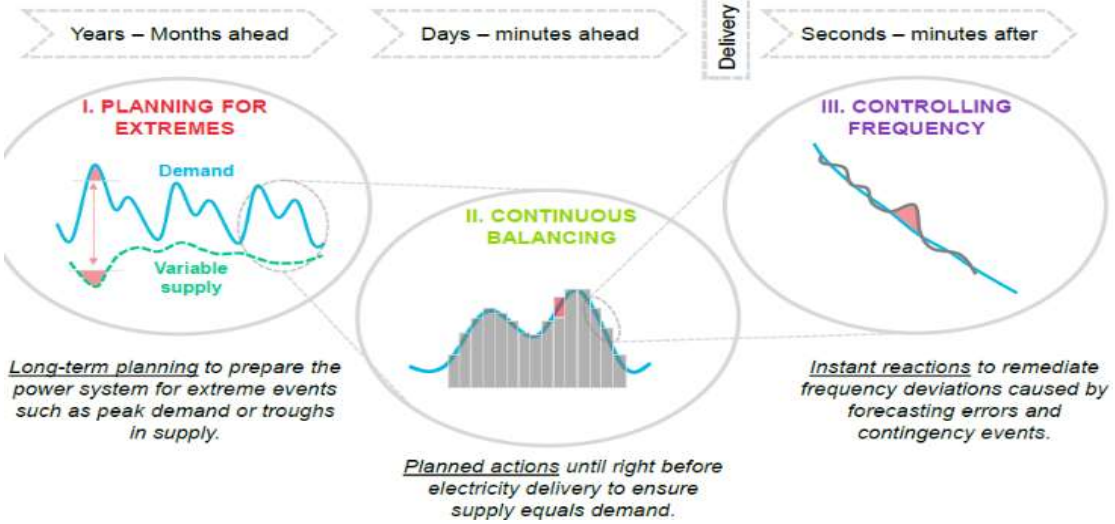
Energy efficiency also has impacts on health. For example, lower heating bills positively impact mental health and improve wellbeing. Better air quality reduces respiratory diseases and chronic pains. Reduced mold decreases cardiovascular diseases, and appropriate room temperatures limit temperature-related illnesses and increase productivity.

4.7 Energy Transition Challenges and Future Perspectives

Every sector has its challenges, including energy transition. The first challenge is the inconsistency in power generation from renewable sources such as wind and solar. They depend heavily on the weather. When the wind is not blowing or the sun shining, they cannot generate electricity 24 hours every day. Therefore they cannot meet the energy peak demands. Additionally, wind power generates electricity according to the wind's intensity. If the intensity is low, then the generated power will also be low. The solution to this is the energy storage of wind power when there is a surplus. Unfortunately, energy storage systems are not yet well developed and they only store energy temporarily.

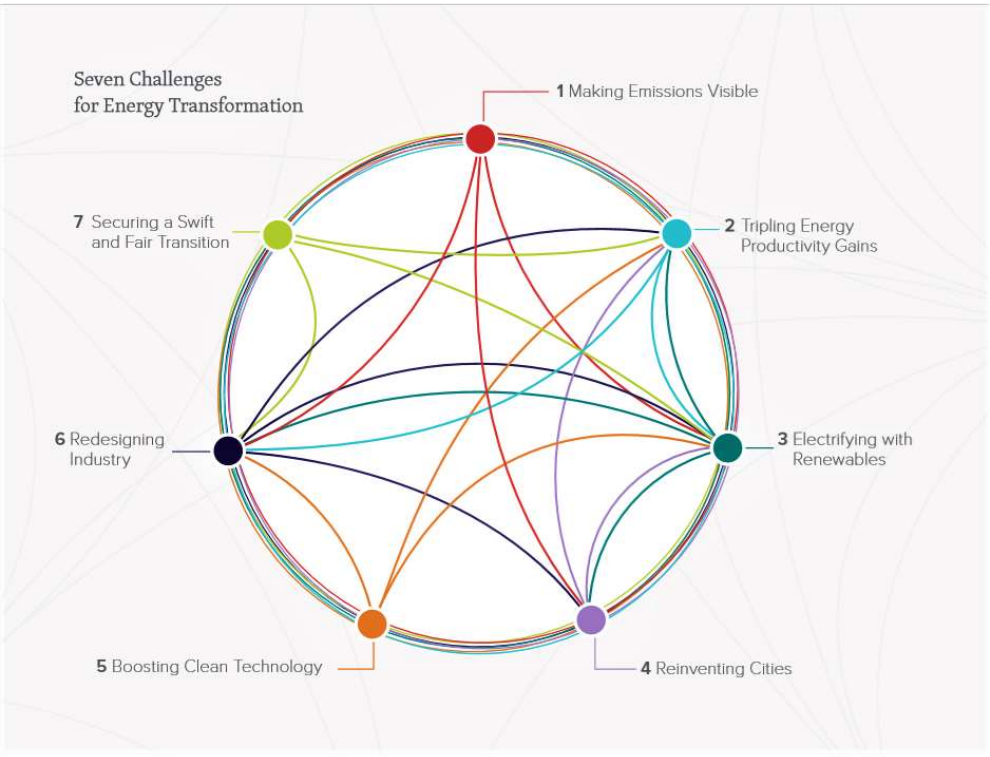
Solar power has the same issue as wind power in energy generation and storage. Another problem with solar power is that in order to manufacture solar panels, the materials used and the process of their construction, emit greenhouse gas emissions such as nitrogen trifluoride and sulfur hexafluoride. Biomass also has its disadvantages. There is a need for a large amount of land for crops to be planted and watered. After they grow, they have to be stored in large spaces before the energy conversion takes place. The rise of the human population makes it even more difficult to use biomass due to the increased need for food and energy. Also, biomass is not entirely a clean energy. It emits greenhouse gasses but much lower than fossil fuels.

Exploiting tidal power, for example, having wind turbines in the ocean or other machines, is still problematic due to their low resistance in saltwater. Hydropower does not emit harmful gases, but the construction of dams, restrict the natural flow of rivers, leading to disrupted animal migration and lowering the water's quality. Hydropower as an energy source is more reliable than solar and wind power. However, still depends to some degree on the weather. Droughts and the amount of water varies from month to month, hence the energy production fluctuates. The construction of dams and hydropower facilities are expensive. Geothermal energy extracts heat from the underground. The hot water reservoirs below the earth's surface are converted by geothermal energy systems into steam, which is directed into a turbine attached to a generator. Some of the disadvantages are high capital costs, probability of releasing harmful gases, geothermal is suited for particular terrains such as Iceland, which has many hot springs. Also, it can cause soil instability due to drilling and the construction of geothermal plants.



Img 4.7 Renewable Energy increases the complexity of power systems

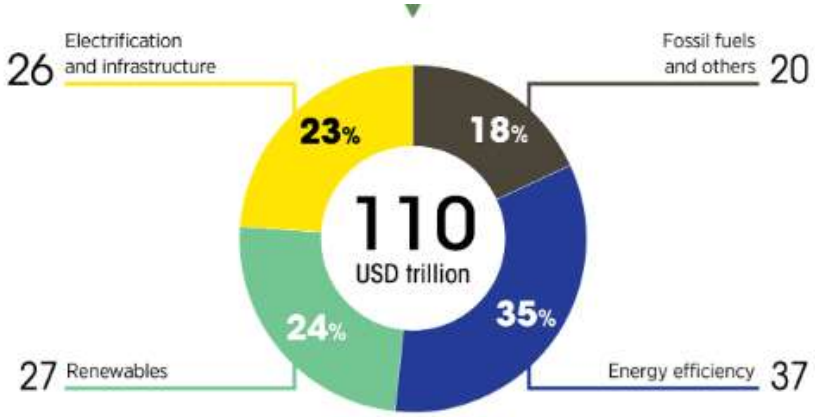
Another challenge is the current electric grid. The aging equipment, maintenance, devices that need more energy to operate, lack of infrastructure investment and increasing costs, make the energy distribution, management, and keeping with energy demands difficult. The digitalization of energy supply chains raises security concerns. For example, cyber-attacks, energy theft, system errors, and tracing consumers' behaviors, such as at what time of the day they use certain appliances, are some cyber problems of the energy transition. Furthermore, national policies, negotiations and contracts can lead to increasing costs for farms that want to use renewable energy.



Img 4.7.1 A summary of energy transition challenges

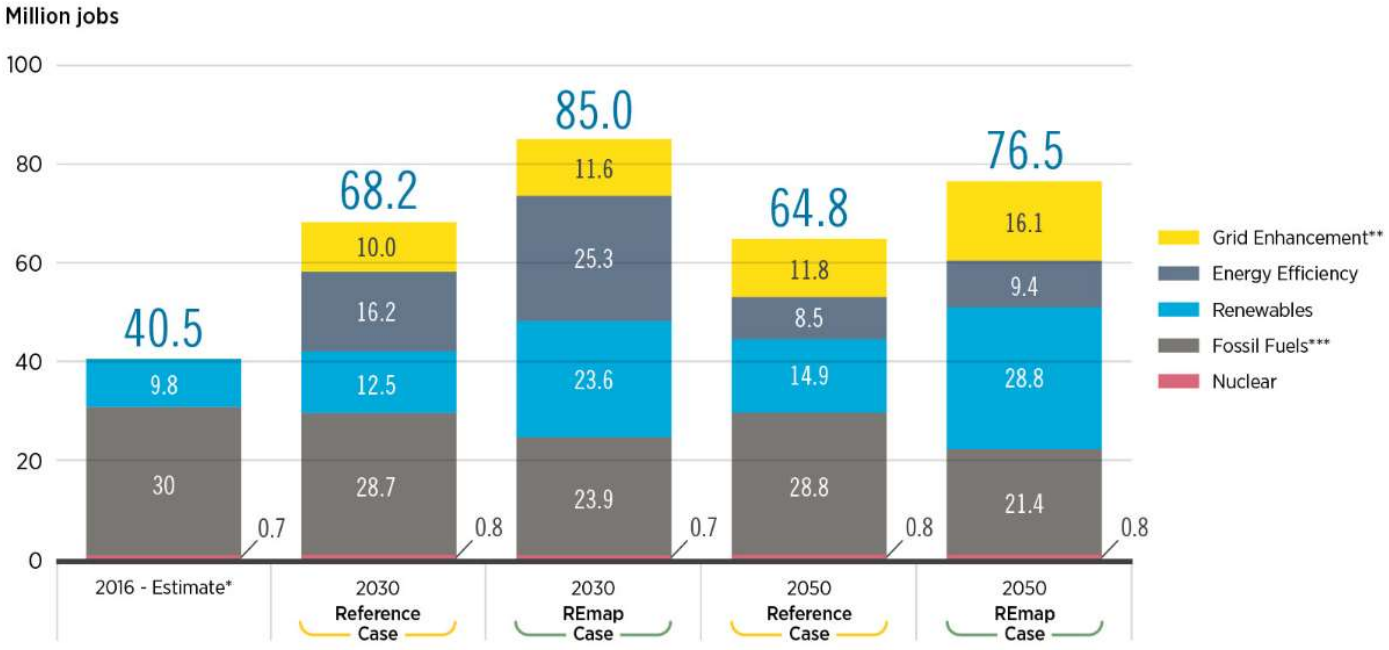
In 2018 the European Union set some future targets on energy transition and climate change till 2030. Greenhouse gas emissions should decline by at least 40% below 1990 levels, increase energy efficiency up to 32.5%, and have affordable, clean energy around Europe. Also, renewable energy supplying the power sector has to reach 57%. Solar and wind power will be the prevailing sources of renewable energy. Gas needs to be cut by 30%, petroleum by 25% and coal by two-thirds.

Oil and gas companies have also set their own strategies for the energy transition. Producers want to transform existing operations, such as drilling and refining, in order to reduce carbon emissions. Examples of operational transformation are increasing efficiency and using electric drilling platforms. Also, producers seek to switch on biofuels and hydrogen coming from natural gas.



Img 4.7.2 Future Investments for Energy Transition (until 2050)

Img 4.7.3 Decarbonization Targets



* Estimates for jobs in energy efficiency and grid enhancement are not available for 2016.

** The jobs in grid enhancement make reference to the jobs for T&D grids and Energy Flexibility, created in the development, operation and maintenance of infrastructure to enable the integration of RES into the grid.

*** Includes all jobs in the fossil fuel industry including in their extraction, processing and consumption.

Img 4.7.4 Estimated future occupations by sector. REmap is the global analysis made by IRENA.

B. METHODOLOGY

Energy Bender is a Serious Game for Android users, made by UNIWA, IDPE Team. It was launched at the end of November 2020 on the Play Store. The game's primary goal was to teach players about the energy transition and its importance. Energy Bender consists of multiple mini-games with educational content. This application does not have a linear structure, which means players get to choose the mini-game they want to play in their preferred order.

Chapter 1: Energy Bender, a Mobile Game

1.1 Application Overview

The first thing that the player notices is the main menu, or differently called, starting menu. The menu's image is intentionally designed to show the difference between a cleaner and greener world using renewable sources and the polluted and disturbed ecosystem created by fossil fuels.

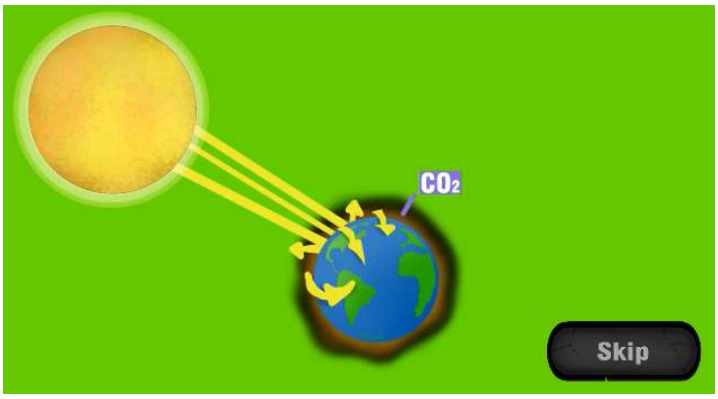
Img 1.1 Starting Menu of the Serious Game Energy Bender

Once the player taps on the "New Game" button, an elderly man will appear, presenting himself. He is a climate change Professor, and his goal is to guide the player throughout the whole game, giving instructions and advice.

Img 1.1.1 Introduction part of the game

The video proceeds with the Professor explaining what energy transition is, why it is important and how greenhouse gases affect the earth's climate.

The skip button is designed so the player can skip the video and continue directly into the game.

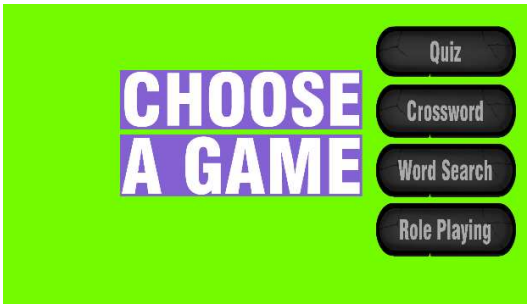


Img 1.1.2 Video on Climate Change and Energy Transition

After the video finishes, the first mandatory game appears. It is called "an introduction game" that covers the types of energy sources. The player has to match the image with the correct word. When the player taps on one icon, a question mark will appear, meaning that it is "waiting" to be paired with the correct word. For example, the icon featuring a dam has to be matched with the word hydropower.

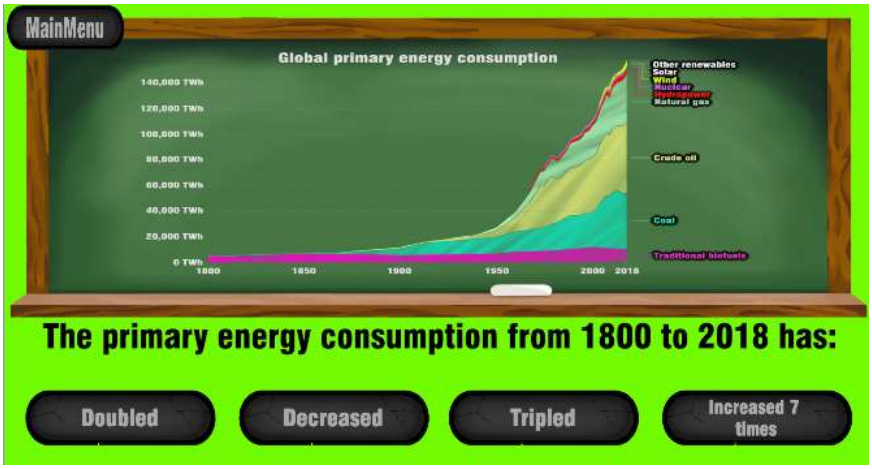
Img 1.1.3 The first game of the Energy Bender. Matching the icons with the right word

When the players match all the icons and words correctly, the Professor will appear congratulating them. After that, another menu emerges on the screen, the so-called "mini-game selection menu." The player has the option to select the game they want to play at the moment. When one of the categories is tapped, the Professor will explain the game before it starts.



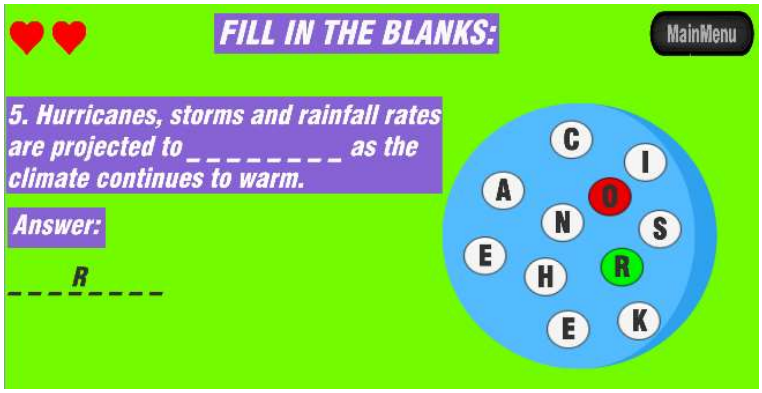
Img 1.1.4 The mini-game selection menu

The first mini-game that appeared on the menu is called Quiz. This is a game about charts and statistics that show the global energy consumption, types of energy being used in different countries, and many more. The player has to answer correctly each question related to the above charts. After the game finishes, the Professor states the amount of correct and wrong answers the player has given.



Img 1.1.5 The Quiz mini-game

In the game Word Search, players have to find the missing word in a sentence by completing it with the correct letters. The given letters are shuffled, and some of them are entirely wrong. When the wrong letter is tapped, a heart erases, which means the player lost a life out of the three given at the beginning of the game. The correct letter appears on the missing word and it is colored green. After the completion of the word, the Professor gives his thumbs-up, and a next button is shown, so the player can continue with the next challenge.



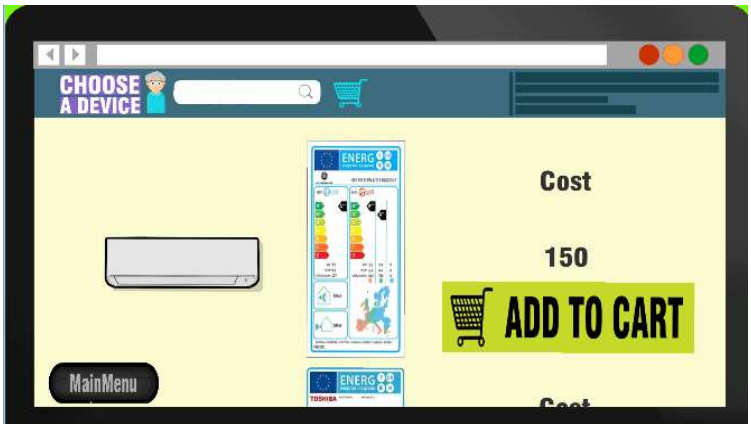
Img 1.1.6 The Word Search mini-game

In the Crossword mini-game, players have to tap on one of the horizontal or diagonal sets of boxes in order to see the question. The player has to find the word that the appeared sentence was "trying to say." In the black box, the player writes the answer and checks if it is correct. If it is, the word appears on the crossword.

The last mini-game of the menu is Role Playing. This game is designed to make the players responsible for the electric appliances they buy, aiming for the most energy-efficient devices. The eventual goal is to save both energy and money.

Notice that in every type of mini-game, there is a "Main Menu" button that enables the player to return back to the selection menu. This can be done whenever they desire, even in the middle of the game.

Img 1.1.7 The Crossword mini-game



Img 1.1.8 The Role Playing mini-game

After the player buys all the necessary devices, a preview of the house appears with each appliance in its own place.

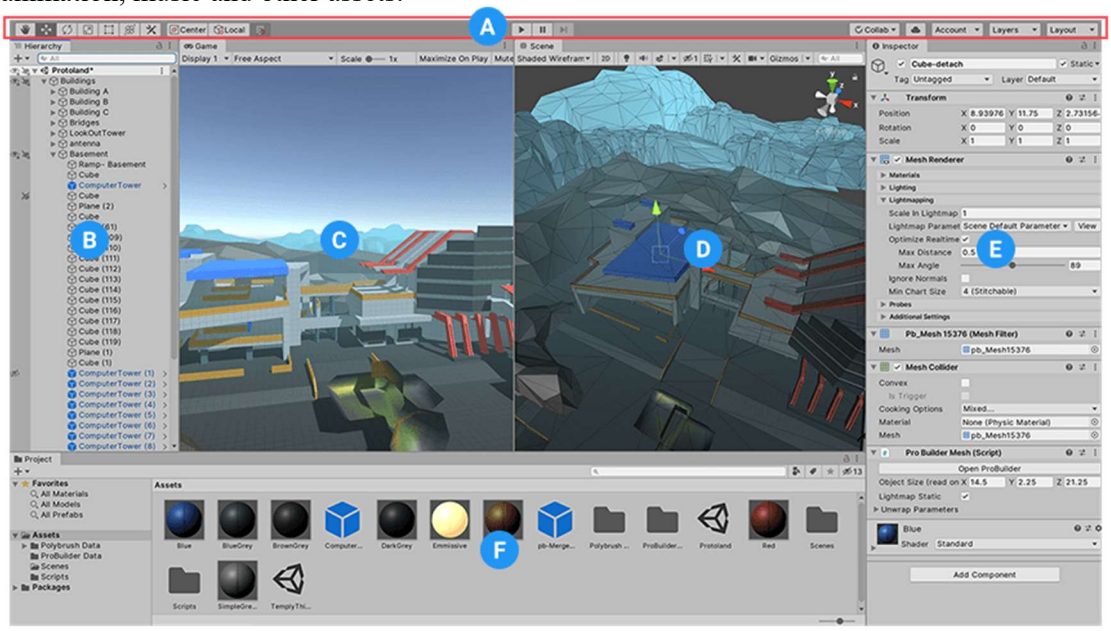
Img 1.1.9 A preview of the kitchen in the Role Playing game

When the players finish all the mini-games, they can replay them again whenever they want.

Chapter 2: Technology and Software Used

2.1 Unity as a Game Engine

Unity is a game engine used for the development of 2D and 3D games. Some famous games made with Unity are Super Mario Run, Deus Ex: The Fall, Angry Birds, Temple Run, and many more. Unity has many features such as collision detection, physics and rendering. There is also an Asset Store where developers can download 3D models for their game, materials, animation, music and other assets.



Img 2.1 Unity's Interface

Unity has a simple interface, divided into six parts for better organization and management. The first part, (A), is called the toolbar. It has a variety of options such as play and pause buttons, resizing objects, exporting files, etc. The second section, (B), is the hierarchy. Here, the developer can see each object that has been inserted in the game. Those objects can be placed in the scene view (C). The developer navigates and builds the desired scene/level of the game. The game view (D) is where the final result can be seen. It is projected as it would look on the phones or pc screens of the users. At the inspector window (E), the developer can edit and view all the properties of the object selected in the Hierarchy window. The last section, project window (F) is where files and all the assets of the game (animations, scripts, music, etc.) are displayed.

Unity uses C# as a coding language. C# is object-oriented, which means it is "targeting" the game objects. A set of data, variables, and instructions are given for each object in the Hierarchy window. The given game object acts according to the instructions written in the script. Attributes describe the game object's size, color, position in the scene, etc. When the developer finishes coding a script, most of the times, it gets attached to a game object in order to execute the program.

The simple and easy interface, C# language, a vast amount of tutorials, and an active forum, make Unity a friendly engine for game development, especially for beginners.

2.2 C# as a Programming Language

C# is a programming language used for a variety of tasks such as developing games, web apps, Windows .NET framework and others. This programming language was created in 2000 by Anders Hejlsberg, a Danish software engineer in Microsoft. It is worthwhile to mention that C# ranked in the fourth place of the most popular languages according to PYPL (Popularity of Programming Language Index).

Img 2.2 C# Logo

```
function A(){
    // This function creates a new scope
    // Let's call it 'Scope A'

    var a = 5;

    function B() {
        // This inner function creates a new scope
        // Let's call it 'Scope B'

        var b = 6;
    }
}
```

Img 2.2.1 A simple example of C# language

Every language has rules and grammar. The basic concepts are variables, data types, operators, if-statements, classes, functions, iterations, and lists. Variables store a value and can be used in calculations, or as a parameter of a function, or as an attribute of an object. For example, if you want to assign a value like someone's age, you have to set a variable named "age" and equate it with a number such as 12 (age = 12). The variable's name can be anything. However, there are some grammatical rules for the name, such as starting with a lowercase letter or avoiding special characters like "?" at the beginning of the name.

Data types are grouped into five main categories; string, char, integer, float, and boolean. A string is an alphanumerical array used to store texts and words. A char is used to store only one letter. Integers are numbers without a fractional part as number 5. On the other hand, floats are used for decimal numbers such as 5.3. Booleans can only store two values; true or false, or 0 or 1. True or 1 means that a statement or a condition is true; therefore the code is executed, whereas False or 0 means the opposite.

Operators are symbolized with: =, != , ==, ||, &&. Their meanings: = is used to store a value in a variable. != means that something is not equal. == is used as an expression to say that a variable equals to a specific value. || means OR. The operand && means AND. If-statements describe a condition. If the statement is true, then the code is executed, whereas if it is false, there is no execution of the code. For example, if (name == "Elida") { Console.WriteLine("True")}; This line of code means that if the variable name equals the string "Elida," then on the screen, the word "True" will be displayed.

Iterations are a block of code that gets repeated over and over again. The keywords to start a loop are: for, while, do while. The while loop executes the code when the given condition is true. For example, while (number < 10) { Console.WriteLine("Loops");} This means that if the number is less than 10, then the word "Loops" will be displayed multiple times as long as the number is less than 10. The for loop is used when there is a specific number of times that the code needs to be executed. For example, for (int i = 1; i <6; i++) { Console.WriteLine(i); } The variable i is an integer and the value that has stored is 1. i less than 6 means that the code will be looped 5 times and i++ means that in every iteration it will add plus 1 in the

value that i has stored. In conclusion, in the first iteration, the code will write the number 1, the second iteration will display the number 2, and so on. Finally, the do while loop is similar to the while loop, except that it tests the condition at the end of the code.

Lists or so-called arrays are variables that store multiple other variables. For example, string [] colors = {"red", "blue", "yellow"}; The list colors has 3 string values stored in it, and it can be accessed with the use of indexes like Console.WriteLine(colors[0]); This line of code will display the first value stored in the list, which is "red."

A function or method is a code that will be executed only when it is called. For example, void myExample() { Console.WriteLine("Hi!");} Void means that this function does not return a value. The name of the function is myExample. When this method is called, the screen displays the word Hi! To call the method it must be used inside the Main function of the program. The Main function is simply the point where a program begins.

The keyword class is used to construct objects such as variables and functions. Classes save a lot of time for the developer because they can be used many times within the program, creating multiple objects. For example,

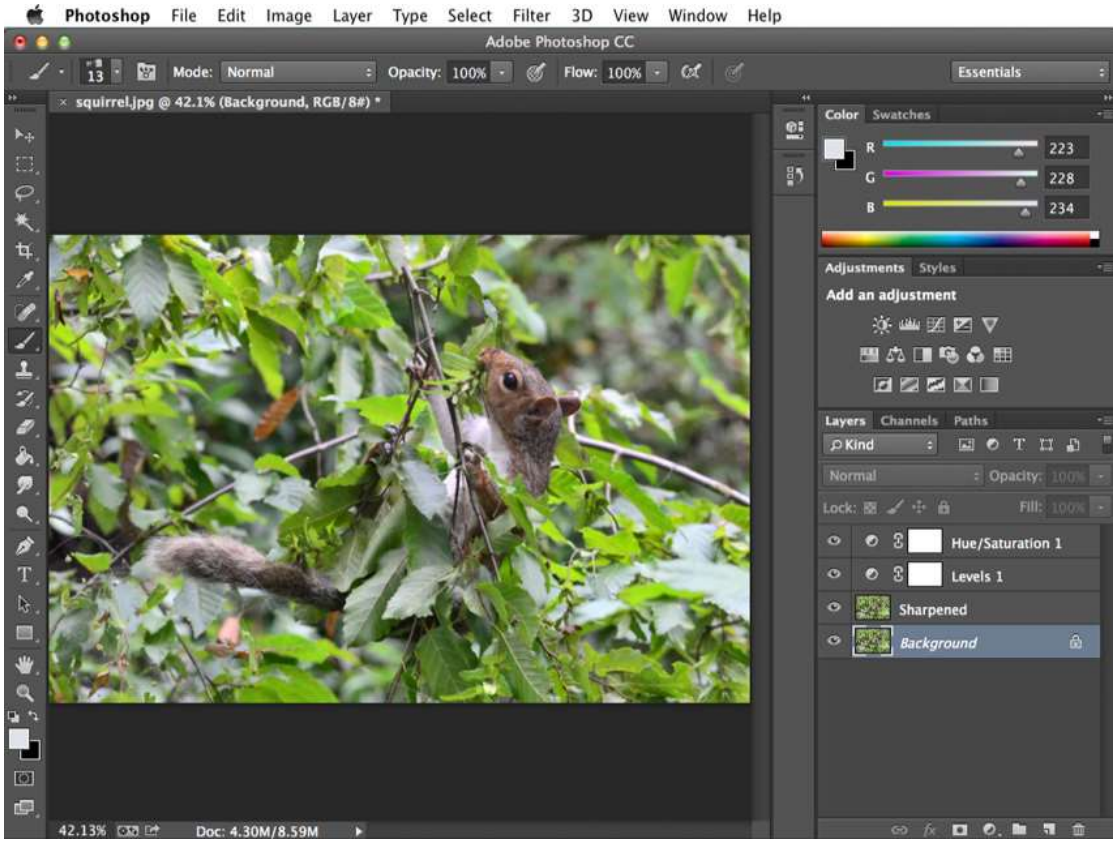
```
class Flower
{
    string color = "white";
    static void Main(string[] args)
    {
        Flower myObj = new Flower();
        Console.WriteLine(myObj.color);
    }
}
```

Thus far, a class named Flower has been created. Classes always start with a capital letter. A string variable named color has been added inside the Flower class and it stores the value "white." In the Main function, the object of the Flower class has been named myObj, and used the keyword new in order to create the object. Then the WriteLine displays the value of the myObj object, which in this case is the color white.

Last but not least, in the C# language, some special keywords are used in front of the classes. Some of them are public, private and static. The keyword public means that the class is visible and accessible to other classes of the program, whereas the private means exactly the opposite. The keyword static in front of a variable or function or class means that they belong to them and not an instance of them. The value of a static variable does not change from instance to instance but is a constant value throughout the program.

2.3 Photoshop

Photoshop is a professional software used for image editing, artwork creation, illustrations and animation. It is the most famous program for image manipulation and editing. There are many versions of Photoshop such as Adobe Photoshop, Photoshop CC, Photoshop Express, and others.



Img 2.3 Photoshop Interface

Photoshop interface consists of 10 main sectors. Those are the Menu Bar, the Control Panel, the Document Window, the Tools Panel, the Selection Tools, the Drawing Tools, the Type Tool, the Shape Tool, the Color Picker Tool, and the Layers Panel.

The Menu Bar has different types of commands. For example, you can save and open files. The Control Panel is used for the customization of tools. For example, changing the pen's size. The Document Window displays the file's name and the zoom level, such as 50%. The Tools Panel contains all the necessary tools for editing or designing. The Selection Tools allow the user to select shapes or parts of an image. The Drawing Tools, as the name suggests, allows users to use brushes or other types of tools for drawing or erasing. The Type Tool is used to enter texts. The Shape Tool is used to insert circles, triangles, and other geometrical shapes. The Color Picker Tool allows users to select the desired color. Last, with the Layers Panel, a user can view the layers of the current document and turn them on and off.

Chapter 3: App Implementation

3.1 Coding Scripts and their Relations with the Unity Environment

Img 3.1 Main Menu Scene

First of all you create a scene by right-clicking in the Assets sector. You choose Create-> Scene. Then you give the desired name, in this case StartingMenu. By default when you open a scene there is a Main Camera object viewed at the Hierarchy sector and a Canvas. On the Canvas the developer designs the game, inserting images, buttons, audio, etc. In order for the Canvas to fit on every screen size, there is a need to change the settings on Canvas Scaler. From there UI Scale Mode -> Scale with Screen Size. Then you type the default resolution, in this case 1920 x 1080. In addition, on the Rect Transform object of the Canvas, there is a need to put Anchors and Pivots. Those can be considered as “pins” that prevent the whole Canvas to move or change its view in different screen sizes. In this way, the Starting Menu scene looks the same way in every screen size.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;

using UnityEngine.SceneManagement;

public class NewGameScript : MonoBehaviour {

        public AudioSource ButtonClick;

        void Awake() {

                ButtonClick.gameObject.SetActive(false);

        }
```

Img 3.1.1 Script for the New Game Button

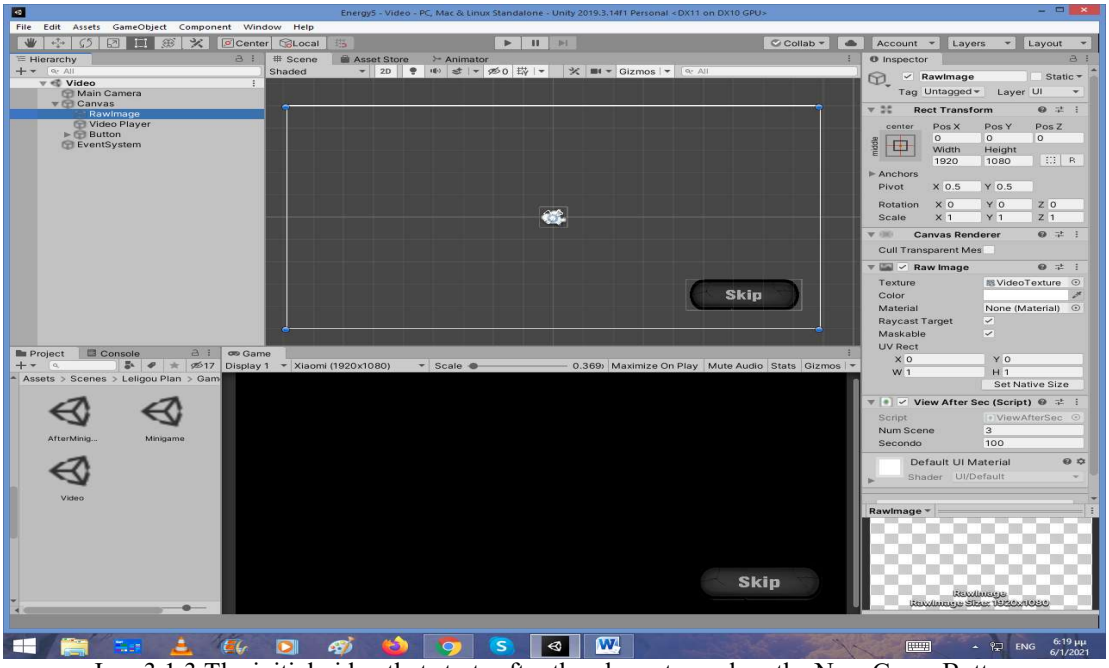
```
        public void gotointro()
        {
                ButtonClick.gameObject.SetActive(false);
                ButtonClick.gameObject.SetActive(true);
                Invoke("NxtScenary", 1);
        }
}
```

Img 3.1.1 Script for the New Game Button (second part)

This script allows the player to start the game when they tap on the New Game Button. When they tap on it a sound generates, so the player can understand that there was an input. The function gotointro() is specifically attached to the New Game Button on the "On Click()" function that every button has. This means that the gotointro() works only when the player taps on the button. The same logic is also applied to the Credits and Exit Button. The difference with the Exit Button is that an extra block of code exists in order for the player to exit the game.

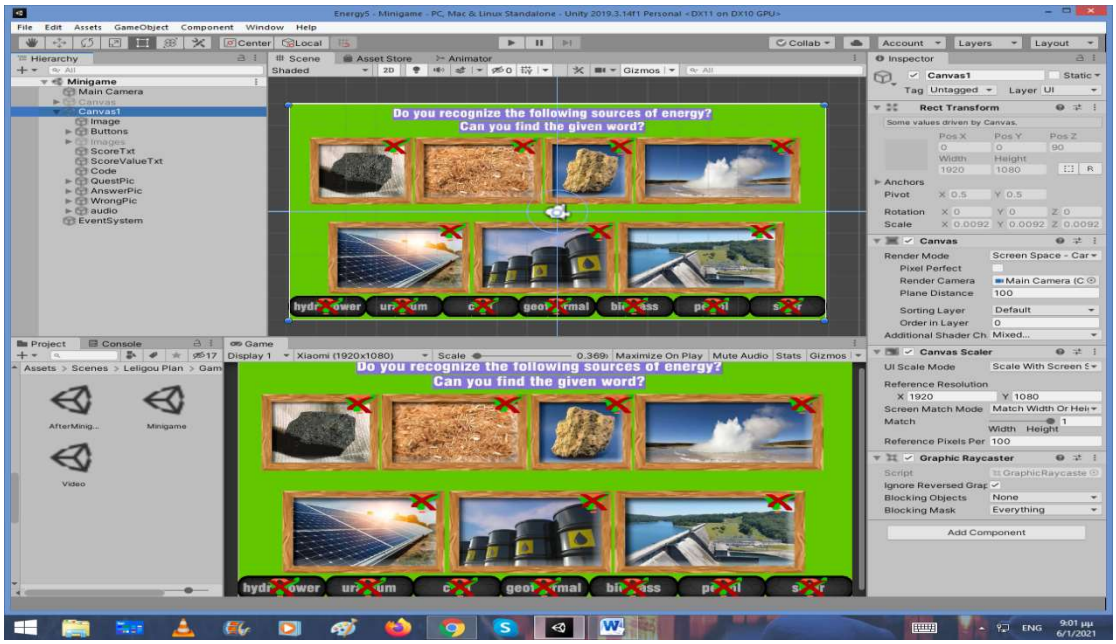
```
public void NxtScenary()
{
    Application.Quit();
}
```

Img 3.1.2 Script for the Exit Button



Img 3.1.3 The initial video that starts after the player tapped on the New Game Button

In this scene, the introduction video which talks about energy transition, the main component of the scene in Unity is the Video Player game object. This is the container for the video clip that we want to play. Also, a Video Texture needs to be added in the Video Player in order for the video clip to play on a target (meaning the texture). A Skip Button is added, enabling the player to skip the video and proceed to the next scene.



Img 3.1.4 The first mini game of the Energy Bender app

This is the mini game that plays after the explanatory video of the energy transition. The player has to match the icons with the given words below. When the player taps on the icon or the word below them (those in the black boxes), a question mark appears. To do this, a question mark icon is added on the top right corner and in each word. When the match is wrong, the question mark disappears and a specific sound activates indicating that the answer was wrong. If the match is correct then the tick icon appears in both the source image and the word inside the black box, accompanied by the "sound of correctness." In addition, a counter exists in the game, which is an integer variable named sceneCounter. Every time the player gets the correct answer, the sceneCounter adds by one. Since there are seven sources that need to be matched, an if-statement exists that says "if the sceneCounter equals 7, then go to the next scene, which goes by the number 4.

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

using UnityEngine.UI;

using UnityEngine.SceneManagement;
```

```
public class TotalMiniGame : MonoBehaviour
{
 public class Icon {
   public string name;
   public Button btn;
   public Image questImg;
   public Image answerImg;
   public Image wrongImg;
   public bool isClicked;
   public AudioSource wordclick;
   public AudioSource correct;
   public AudioSource wrong;
      public Icon(string _name, Button _btn, Image _questImg, Image _answerImg, Image
_wrongImg, bool _isClicked, AudioSource _wordclick,
          AudioSource _correct, AudioSource _wrong)
      {
      name = _name;
      btn = _btn;
      questImg = _questImg;
      answerImg = _answerImg;
      wrongImg = _wrongImg;
      isClicked = _isClicked;
      correct = _correct;
      wrong = _wrong;
      wordclick = _wordclick;
      }
 }
```

Img 3.1.5 The main code of the matching mini game.

```
public int sceneCounter;


 public string nameA;
 public Button btnA;
 public Image questImgA;
 public Image answerImgA;
 public Image wrongImgA;
  public AudioSource wordclickA;
  public AudioSource correctA;
  public AudioSource wrongA;


  public string nameAA;
 public Button btnAA;
 public Image questImgAA;
 public Image answerImgAA;
 public Image wrongImgAA;
  public AudioSource wordclickAA;
  public AudioSource correctAA;
  public AudioSource wrongAA;


  public string nameB;
 public Button btnB;
 public Image questImgB;
 public Image answerImgB;
 public Image wrongImgB;
  public AudioSource wordclickB;
  public AudioSource correctB;
```

Img 3.1.6 The main code of the matching mini game. (part 2)

```
public string nameC;
 public Button btnC;
 public Image questImgC;
 public Image answerImgC;
 public Image wrongImgC;
  public AudioSource wordclickC;
  public AudioSource correctC;
  public AudioSource wrongC;

  public string nameCC;
 public Button btnCC;
 public Image questImgCC;
 public Image answerImgCC;
 public Image wrongImgCC;
  public AudioSource wordclickCC;
  public AudioSource correctCC;
  public AudioSource wrongCC;

  public string nameD;
 public Button btnD;
 public Image questImgD;
 public Image answerImgD;
 public Image wrongImgD;
  public AudioSource wordclickD;
  public AudioSource correctD;
  public AudioSource wrongD;
```

Img 3.1.7 The main code of the matching mini game. (part 3)

```
public string nameE;
  public Button btnE;
  public Image questImgE;
  public Image answerImgE;
  public Image wrongImgE;
    public AudioSource wordclickE;
    public AudioSource correctE;
    public AudioSource wrongE;


    public string nameEE;
  public Button btnEE;
  public Image questImgEE;
  public Image answerImgEE;
  public Image wrongImgEE;
    public AudioSource wordclickEE;
    public AudioSource correctEE;
    public AudioSource wrongEE;


    public string nameF;
  public Button btnF;
  public Image questImgF;
  public Image answerImgF;
  public Image wrongImgF;
    public AudioSource wordclickF;
    public AudioSource correctF;
    public AudioSource wrongF;
```

Img 3.1.8 The main code of the matching mini game. (part 4)

```
public string nameG;
  public Button btnG;
  public Image questImgG;
  public Image answerImgG;
  public Image wrongImgG;
    public AudioSource wordclickG;
    public AudioSource correctG;
    public AudioSource wrongG;


    public string nameGG;
  public Button btnGG;
  public Image questImgGG;
  public Image answerImgGG;
  public Image wrongImgGG;
    public AudioSource wordclickGG;
    public AudioSource correctGG;
    public AudioSource wrongGG;


    //public Icon[] icons;
    public List<Icon> icons = new List<Icon>();


public void Awake(){
  sceneCounter = 0;


    questImgA.enabled = false;
    answerImgA.enabled = false;
    wrongImgA.enabled = false;
```

Img 3.1.9 The main code of the matching mini game. (part 5)

```
questImgAA.enabled = false;
    answerImgAA.enabled = false;
    wrongImgAA.enabled = false;
        wordclickAA.gameObject.SetActive(false);
        correctAA.gameObject.SetActive(false);
        wrongAA.gameObject.SetActive(false);
    questImgB.enabled = false;
    answerImgB.enabled = false;
    wrongImgB.enabled = false;
        wordclickB.gameObject.SetActive(false);
        correctB.gameObject.SetActive(false);
        wrongB.gameObject.SetActive(false);
    questImgBB.enabled = false;
    answerImgBB.enabled = false;
    wrongImgBB.enabled = false;
wordclickBB.gameObject.SetActive(false);
        correctBB.gameObject.SetActive(false);
        wrongBB.gameObject.SetActive(false);
        questImgC.enabled = false;
    answerImgC.enabled = false;
    wrongImgC.enabled = false;
        wordclickC.gameObject.SetActive(false);
        correctC.gameObject.SetActive(false);
        wrongC.gameObject.SetActive(false);
    questImgCC.enabled = false;
    answerImgCC.enabled = false;
    wrongImgCC.enabled = false;
```

Img 3.1.10 The main code of the matching mini game. (part 6)

```
wordclickCC.gameObject.SetActive(false);
        correctCC.gameObject.SetActive(false);
        wrongCC.gameObject.SetActive(false);
        questImgD.enabled = false;
    answerImgD.enabled = false;
    wrongImgD.enabled = false;
        wordclickD.gameObject.SetActive(false);
        correctD.gameObject.SetActive(false);
        wrongD.gameObject.SetActive(false);
    questImgDD.enabled = false;
    answerImgDD.enabled = false;
    wrongImgDD.enabled = false;
        wordclickDD.gameObject.SetActive(false);
        correctDD.gameObject.SetActive(false);
        wrongDD.gameObject.SetActive(false);
        questImgE.enabled = false;
    answerImgE.enabled = false;
    wrongImgE.enabled = false;
        wordclickE.gameObject.SetActive(false);
        correctE.gameObject.SetActive(false);
        wrongE.gameObject.SetActive(false);
    questImgEE.enabled = false;
    answerImgEE.enabled = false;
    wrongImgEE.enabled = false;
        wordclickEE.gameObject.SetActive(false);
        correctEE.gameObject.SetActive(false);
        wrongEE.gameObject.SetActive(false);
```

Img 3.1.11 The main code of the matching mini game. (part 7)

```
questImgF.enabled = false;
    answerImgF.enabled = false;
    wrongImgF.enabled = false;
        wordclickF.gameObject.SetActive(false);
        correctF.gameObject.SetActive(false);
        wrongF.gameObject.SetActive(false);
    questImgFF.enabled = false;
    answerImgFF.enabled = false;
    wrongImgFF.enabled = false;
        wordclickFF.gameObject.SetActive(false);
        correctFF.gameObject.SetActive(false);
        wrongFF.gameObject.SetActive(false);
        questImgG.enabled = false;
    answerImgG.enabled = false;
    wrongImgG.enabled = false;
        wordclickG.gameObject.SetActive(false);
        correctG.gameObject.SetActive(false);
        wrongG.gameObject.SetActive(false);
    questImgGG.enabled = false;
    answerImgGG.enabled = false;
    wrongImgGG.enabled = false;
wordclickGG.gameObject.SetActive(false);
        correctGG.gameObject.SetActive(false);
        wrongGG.gameObject.SetActive(false);
Icon iconA = new Icon(nameA, btnA, questImgA, answerImgA, wrongImgA, false,
wordclickA, correctA, wrongA);
Icon iconAA = new Icon(nameAA, btnAA, questImgAA, answerImgAA, wrongImgAA,
false, wordclickAA, correctAA, wrongAA);
```

Img 3.1.12 The main code of the matching mini game. (part 8)

```
Icon iconB = new Icon(nameB, btnB, questImgB, answerImgB, wrongImgB, false,
wordclickB, correctB, wrongB);

    Icon iconBB = new Icon(nameBB, btnBB, questImgBB, answerImgBB,
wrongImgBB, false, wordclickBB, correctBB, wrongBB);

    Icon iconC = new Icon(nameC, btnC, questImgC, answerImgC, wrongImgC, false,
wordclickC, correctC, wrongC);

    Icon iconCC = new Icon(nameCC, btnCC, questImgCC, answerImgCC,
wrongImgCC, false, wordclickCC, correctCC, wrongCC);

    Icon iconD = new Icon(nameD, btnD, questImgD, answerImgD, wrongImgD,
false, wordclickD, correctD, wrongD);

    Icon iconDD = new Icon(nameDD, btnDD, questImgDD, answerImgDD,
wrongImgDD, false, wordclickDD, correctDD, wrongDD);

    Icon iconE = new Icon(nameE, btnE, questImgE, answerImgE, wrongImgE, false,
wordclickE, correctE, wrongE);

    Icon iconEE = new Icon(nameEE, btnEE, questImgEE, answerImgEE,
wrongImgEE, false, wordclickEE, correctEE, wrongEE);

    Icon iconF = new Icon(nameF, btnF, questImgF, answerImgF, wrongImgF, false,
wordclickF, correctF, wrongF);

    Icon iconFF = new Icon(nameFF, btnFF, questImgFF, answerImgFF,
wrongImgFF, false, wordclickFF, correctFF, wrongFF);

    Icon iconG = new Icon(nameG, btnG, questImgG, answerImgG, wrongImgG,
false, wordclickG, correctG, wrongG);

    Icon iconGG = new Icon(nameGG, btnGG, questImgGG, answerImgGG,
wrongImgGG, false, wordclickGG, correctGG, wrongGG);

    //icons[0] = iconA;

icons.Add(iconA);

  icons.Add(iconAA);

  icons.Add(iconB);

  icons.Add(iconBB);

  icons.Add(iconC);

  icons.Add(iconCC);

  icons.Add(iconD);
```

Img 3.1.13 The main code of the matching mini game. (part 9)

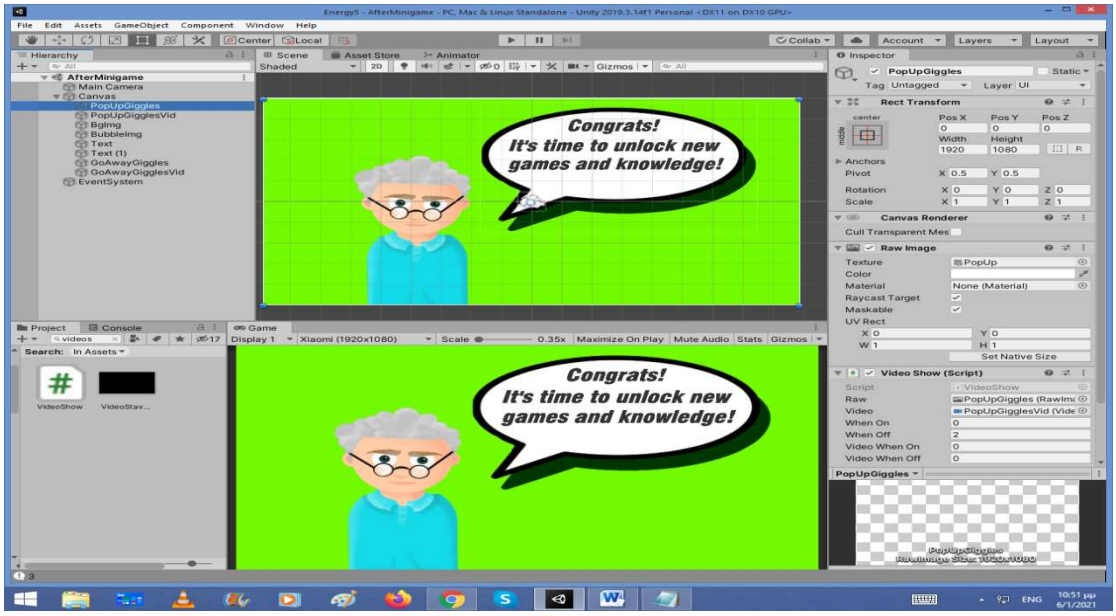
```
icons.Add(iconDD);
    icons.Add(iconE);
    icons.Add(iconEE);
    icons.Add(iconF);
    icons.Add(iconFF);
    icons.Add(iconG);
    icons.Add(iconGG);
    //Icon[] icons = {iconA, iconAA, iconB, iconBB, iconC, iconCC, iconD, iconDD,
iconE, iconEE, iconF, iconFF, iconG, iconGG};
  }

  public void btnPressed(Button btn){
    for(int i = 0; i < icons.Count; i++){
      if(btn == icons[i].btn){
        icons[i].btn.interactable = false;
        icons[i].wrongImg.enabled = false;
        icons[i].questImg.enabled = true;
        icons[i].isClicked = true;
        icons[i].wordclick.gameObject.SetActive(false);
        icons[i].wordclick.gameObject.SetActive(true);
for (int k = 0; k < icons.Count; k++){
          if(icons[k].isClicked == true  && icons[i].name == icons[k].name &&
icons[i].btn != icons[k].btn){
            icons[i].btn.interactable = false;
            icons[k].btn.interactable = false;
            icons[i].answerImg.enabled = true;
     icons[i].questImg.enabled = false;
icons[k].questImg.enabled = false;
```

Img 3.1.14 The main code of the matching mini game. (part 10)

```
icons[k].answerImg.enabled = true;
            icons[i].isClicked = false;
            icons[k].isClicked = false;
                    icons[i].correct.gameObject.SetActive(false);
                    icons[i].correct.gameObject.SetActive(true);
            sceneCounter++;
            if(sceneCounter == 7){
              SceneManager.LoadScene(4);
            }
}else if(icons[k].isClicked == true  && icons[i].name != icons[k].name && icons[i].btn
!= icons[k].btn){
             icons[i].btn.interactable = true;
             icons[k].btn.interactable = true;
             icons[i].questImg.enabled = false;
             icons[k].questImg.enabled = false;
             icons[i].isClicked = false;
             icons[k].isClicked = false;
                    icons[i].wrong.gameObject.SetActive(false);
                    icons[i].wrong.gameObject.SetActive(true);
                  }
       }
       // icons[i].isClicked = true;
     }
   }
  }

}
```

Img 3.1.15 The main code of the matching mini game. (part 11)

First, a class named Icon is made. The class Icon represents the source images and the words in the black boxes. It has attributes such as name, the wrong and right icons that accompany every source image and black box, audio sources that are generated when the match is correct or wrong, etc. In addition, a boolean variable is added named isClicked. This indicates if one of the black boxes or source images are tapped by the player. If they are not, the isClicked is false, else it is true. The icon constructor is made for later use. The blocks of code that immediately follow, are used to declare the game objects of this scene. Then a list named icons is made, which has all the source images and black boxes variables in it. At the start of the game, everything is set at false. This means that no correct or wrong icons appear, no sounds are generated and the counter is set to zero. The main function, which is used for the immediate execution of the player's action is named btnPressed. With a for loop, the program loops over and over again the icon list and checks if anything is tapped. If the player has tapped on a box or source image the boolean variable isClicked turns true, the tick icons appear and the "correct sound" is being heard. In this case, the counter that was mentioned before adds plus one in its stored value. Else, if the match was wrong, the tick icon does not appear, "the wrong sound" generates and the counter's value does not change. Eventually, when the player finds all the correct matches, the counter becomes 7 and the function SceneManager() loads the next scene by its index.



Img 3.1.16 The scene after the player completes successfully the matching icons mini game

In this scene the Professor congratulates the player. To do this a Video Player is added with a "Pop up video clip," where the Professor makes his abrupt entrance. A script named VideoShow is made in order to calculate the time when the Professor appears and when he disappears.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.Video;
using UnityEngine.UI;

public class VideoShow : MonoBehaviour
{
    // Start is called before the first frame update
    public RawImage raw;
    public VideoPlayer video;
    public float whenOn, whenOff, videoWhenOn, videoWhenOff;

    void Start()
    {
        raw.enabled = false;
        video.playOnAwake = false;
        video.isLooping = false;

        Invoke("videoReveal", videoWhenOn);
        Invoke("Reveal", whenOn);
        Invoke("Hide", whenOff);
    }

    public void videoReveal()
    {
        video.Play();
    }
```

Img 3.1.17 The script is attached on the Video Clip object located at the hierarchy

```
public void Reveal()
    {
        raw.enabled = true;
    }

    public void Hide()
    {
        raw.enabled = false;
    }
}
```

Img 3.1.18 The script is attached on the Video Clip object located at the hierarchy (part 2)

When the video ends, the image of the Professor remains and another independent image appears, which is a bubble icon. The bubbles represent the place where the text appears (the Professor's words). Similar to the previous script, there is also another script for these bubbles to appear.

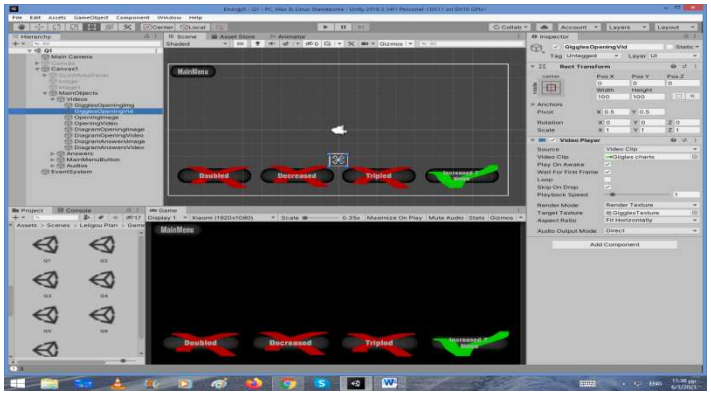
```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;

public class ImageShow : MonoBehaviour
{
      public Image img;
      public float whenOn,whenOff;

// Start is called before the first frame update
```

Img 3.1.19 This script is attached on the bubble images.

```
void Start()
{
        img.enabled = false;
        Invoke("Reveal",whenOn);
        Invoke("Hide",whenOff);
}

public void Reveal()
{
        img.enabled = true;
}

public void Hide()
{
        img.enabled = false;
}
}
```

Img 3.1.20 This script is attached on the bubble images. (part 2)

The variable img represents the bubble object, which is shown in the hierarchy. It is public because enables the developer to associate with ease the bubble game object with the img variable. The float variables whenOn, whenOff, are used for the time when the bubble appears. In the beginning the bubble does not appear, hence it is set to false, but when the variable whenOn starts, in this case at the 2 seconds, the img is set to true and the bubble appears.



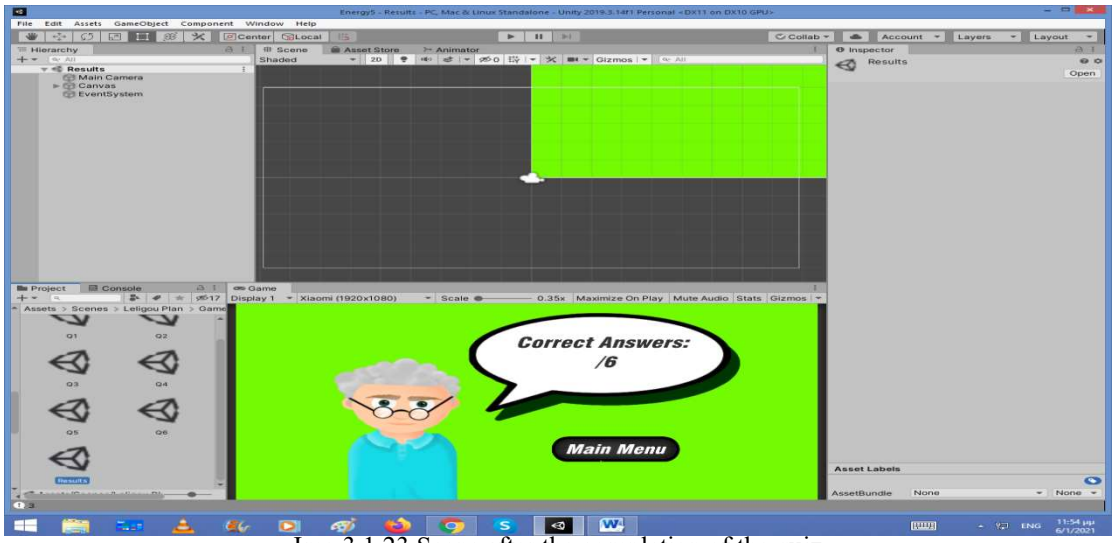
Img 3.1.21 The quiz mini game scene

This scene follows the same logic as the previous scenes, both in video clips and tick or x icons appearance. When the player taps on the wrong answer, the x icon is shown, whereas when the player taps on the correct answer, the tick icon appears. No matter the player's choice, the below script is activated.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;


public class ViewAfterSec : MonoBehaviour {
	public int numScene;
	public float secondo;


	public void NxtScenary()
	{
		SceneManager.LoadScene (numScene);
	}


	public void FewSecondsLater()
	{
		Invoke ("NxtScenary", secondo);
	}


	void Start()
	{
		FewSecondsLater();
	}
}
```

Img 3.1.22 This script is attached to every button, which are the options that the player has to choose

With the help of this script, the player proceeds to the next question of the quiz after some seconds. In this way, the player has enough time to see whether the chosen answer was correct or wrong. In addition, at the correct buttons, a counter variable is attached. Initially, this is set at zero, but when the button is clicked, the counter's value becomes one. This counter variable is labeled as static. This means that the counter's stored value is unique at every scene (when the player goes to the next question the scene changes). In other words, there are not multiple instances of this counter variable, thus its value is preserved through the scenes.



Img 3.1.23 Scene after the completion of the quiz

This is the Results scene, where the player views how many correct answers had. To show the correct answers of the player, it is necessary to reveal the previously mentioned static variable named counter.

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

using UnityEngine.UI;


public class Resultz : ShowResults

{

    string right;

    public Text txt;


 // Start is called before the first frame update
```

Img 3.1.24 Script attached to a Text game object, where this object represents the player's score

```
void Start()
    {
        right = corrects.ToString();
        txt.text = right;
    }
}
```

Img 3.1.25 Script attached to a Text game object (part 2)

In order to show a result, a value on the canvas, this value has to be a string. Alone as a string cannot be shown on the canvas the game runs, so it has to be stored as a value in a Text object. The counter which kept track of the player's correct answers through the quiz is named corrects. Corrects is an integer type of variable, which is turned into a string type with the function ToString(). The variable right holds the corrects value as a string and then it is stored in the txt.text game object.

Img 3.1.26 The Search Word Scene

In this game the player has to find the hidden word of the sentence. To do that the player has to tap on letters that are inside of a blue circle. The letters are random, plus there are other three letters which are wrong and do not belong in the hidden word.

When the player taps on the correct letter, it turns green. This is done with a script named ChangeColor. The TurnGreen function is attached at the button's OnClick() function at the inspector menu.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;


public class ChangeColor : MonoBehaviour
{
     public Button b;
      public AudioSource ButtonClick;


   void Awake()
{
       ButtonClick.gameObject.SetActive(false);
   }


public void TurnGreen()
{
       ButtonClick.gameObject.SetActive(false);
       ButtonClick.gameObject.SetActive(true);
       b.GetComponent<Image>().color = Color.green;
}
}
```

Img 3.1.27 The script that turns the buttons (where the letters are placed upon) green

Those buttons (with the letters upon), have another script attached where enables the chosen letter. In other words, the correct letter appears in the sentence.

```
public class ShowLetter : MonoBehaviour{
public Text txt;
```

Img 3.1.28 The script that reveals the correct letters in the given sentence.

```
void Start()
{
        txt.enabled = false;
}

public void RevealChar()
{
        txt.enabled = true;
}
}
```

Img 3.1.28 The script that reveals the correct letters in the given sentence. (part 2)

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UI;
using UnityEngine.SceneManagement;

public class Count : MonoBehaviour
{
public static int sum = 0;//static is VERY IMPORTANT cause without it the
// sum +=1 that happens with the click of the buttons won't add
//which means the result would remain only sum = 1 and won't add further with
//the click of other buttons. In other words the variable sum as a static is
//only one instance (belongs to the class) and not the object...
//In conclusion there is no multiple instances with the use of STATIC
```

Img 3.1.29 Script attached at the letter-buttons

```
bool press;//if the button is pressed
int click = 0;//shows how many times a button was pressed or clicked
public Image emoji;
public GameObject btn,txt;
public int desiredNum;//number of buttons
int sceneNum;


void Start()
{
	emoji.enabled = false;
	btn.SetActive(false);
	txt.SetActive(false);
	sceneNum = SceneManager.GetActiveScene().buildIndex;


	Nums();
}
public void Nums()
{
	if((click == 1) && (press == true))
	{
		sum += 1;
		Debug.Log(sum);
	}
	else if((click > 1) && (press == true))
	{
		sum +=0;
		Debug.Log(sum);
```

Img 3.1.30 Script attached at the letter-buttons (part 2)

```
else
        {
            Debug.Log("0");
        }

        if(sum == desiredNum)
        {
            emoji.enabled = true;
            btn.SetActive(true);
            txt.SetActive(true);

            if(sceneNum != 20)
            {
                sum = 0;
            }
        }
}
  public void Tap()
{
        press = true;
        click += 1;
}
}
```

Img 3.1.31 Script attached at the letter-buttons (part 3)

At the start of the game emoji image is not enabled, which means is set to false. The emoji image represents the Professor's happy face, which appears after the player finds the word withought losing all the 3 lives (hearts that are shown at the top of the screen). The variable sceneNum stores the index of the current scene. For example, if the player is at the first question of the Search Word mini game, the index of this scene is 15. This number, 15 is stored at the sceneNum variable.

To make sure that the player does not tap more than once at the letter-buttons the function Tap() is made. When the player taps on a button the integer variable click adds plus 1 in its stored value, and the boolean variable press becomes true. So at the Nums() function: when the specific button is pressed and this happened only once, the integer counter named sum adds plus 1 in its stored value. If the player taps more than once at the button (click > 1) then the sum's value stays the same. The sum represents the correct letter-buttons that have been tapped. When the sum is equal with the desired number, which is the total letters of the word that the player needs to find, the professor's happy face appears and a next button is shown for the player to continue on the next question.

However, when the player taps on the wrong letter-button it turns red and one heart is erased.

```
using System.Collections;

using System.Collections.Generic;

using UnityEngine;

using UnityEngine.UI;

using UnityEngine.SceneManagement;


public class NoMoreHeart : Count

{

        public Image heart;

        bool pressed;

        int clicks;

        public static int total = 0;//number of wrong buttons that where pressed

        public int totalFails;//max wrong answers


        public int reset;

        int sceneNumber;


void Start()

{

        reset = 0;

        sceneNumber = SceneManager.GetActiveScene().buildIndex;
```

Img 3.1.32 Script attached at the wrong letter-buttons

```
public void Erase()
{
	heart.enabled = false;
	pressed = true;
	clicks += 1;

	if((pressed == true) && (clicks == 1))
	{
		total += 1;
	}
	Debug.Log("wrong" + total);

	if(total == totalFails)
	{
		SceneManager.LoadScene(20);//goes to game over scene
		//sum = 0;//because when the player turns back again in this
		//scene the sum must be zero so the counting of correct buttons
		//pressed starts from beggining

		if(sceneNumber != 20)
		{
			total = reset;
			sum = reset;
		}
```

Img 3.1.33 Script attached at the wrong letter-buttons (part 2)

This script is used to erase hearts when the wrong buttons have been pressed. When one wrong button is pressed a counter named total adds plus 1 to its value. When total equals with three (which are the max wrong guesses a player can made), the program loads the game over scene by its index. When the player returns back to the game, the total and sum counters are set to zero, so the counting of the wrong and correct letters start again.

C. CONCLUSIONS

Education has always been the backbone of society's development. It provides knowledge, discipline, confidence, improves life, promotes good ethics, and broadens people's horizons. Being open-minded enables the acceptance of different ideas, which brings a desire to change the world and make it better.

The acquisition of knowledge is not a one-way root. There are many styles of learning, different educational systems, various ways to teach the same subject that could suit people's needs. However, the education of the youth has not changed a lot since many years before. The traditional school still remains. There have been attempts to change the educational system, modernize it and bring it to the current standards and needs of the world. Scientists and teachers have tried to introduce new methods of teaching. Video games are a hobby of many people worldwide, especially among the young. Taking advantage of this widespread phenomenon, Serious Games have been developed to teach and train people on a variety of subjects such as math, physics, art, marketing, management, and many more. The game's engaging nature makes people more willing to learn and improve themselves. The process of learning is not anymore mundane. Global matters, such as climate change and renewable sources, can also be taught and incite people, especially the current generation, to take action and provide solutions to major problems.

The earth's climate and the pollution of the environment are alarming topics that should not be ignored. The energy transition is the first step for a greener and healthier planet. Investments in renewable sources, such as wind and solar power, discovering other types of energy such as hydrogen, and improving the power systems, will not only save the planet earth but will also create new jobs, raise the economy and make countries more independent. Furthermore, energy efficiency, the development of electric vehicles, and energy management are additional tools for the implementation of the energy transition. Challenges to reach these goals still exist, but with the assistance of advanced technology, enhancement of research and educating people on these issues, societies will overcome the problems.

To sum up, the key to success and innovation is through education and research. Only then the revolution comes, bringing a new and better era.

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A. INTRODUCTION

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Image 1.2:

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Image 1.3.2

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Img 3.2.1, Img 3.2.2

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