MSc Program
Renewable Energy Systems

Integration of Renewable Energy Systems in the Future Built Environment

A Master's Thesis submitted for the degree of
“Master of Science”

supervised by
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Vienna, 19.11.2018

Affidavit

I, **KAAN KARABAGLI, BSC. MARCH.**, hereby declare

1. that I am the sole author of the present Master's Thesis, "INTEGRATION OF RENEWABLE ENERGY SYSTEMS IN THE FUTURE BUILT ENVIRONMENT", 73 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Abstract

Since the last century, technology has evolved like never before and entered to our lives. It has become more than a tool but a mechanism for survival of humankind. Renewable Energy Systems is one of the best examples for the technologies that play such a curtail role.

With technology, human life span has extended and populations have increased faster and more, like ever before in the history of humankind. With the increasing high levels of population, the demand for energy increased more than ever and the consumption of natural energy resources have came to a level where a new source of energy has become crucial for the survival of humankind. With the renewable energy systems, the solution for that new energy resource have been found. These are new technologies that sustain the way we consume energy and also help us produce energy for our needs. There are variety of different renewable energy systems. As the technology evolves, new and more evolved systems enter our lives, which enable more efficiency, less consumption and less investment.

Though renewable energy energy is not a new term, the technology of renewable energy systems has stated gaining popularity since the last two decades. One of the largest problems of this technology is its integration to our lives. While it started as a more independent technology, today it is becoming more smart and generalized. The impacts of its integration to the built environment is gaining more importance with the bureaucratic and commercial impacts are brought up to the grid systems.

This thesis opens up the possibilities of Renewable Energy Systems, its impacts in our lives and its future, by examining the integration of Renewable Energy Systems in the Built Environment.

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1 INTRODUCTION

1.1 Motivation

By 2050, it is expected to have a 2.5 billion urban influx. Architecture, as a profession and the built environment, finds itself at a crossroads in adapting to this world in constant flux. The societies and the cities where they live in is constantly facing changes environmentally, politically and socio-economically. This requires us to rethink the way we think of cities. For a long time, architects looked into renewable energy systems as an addition to the building which only benefits the individual structure, rather than a true integration that could benefit the built environment which the building exists at. Sustainable urbanization and a network of renewable energy share with in the city can be a very sufficient solution. It is expected that by the year 2050, about 25% of human population will be living in cities.

For cities and all urban environments, global warming is the biggest threat. The causes of global warming, the way energy is produced, industries, agriculture, transportation and buildings are all a collective that needs to be addressed.

1.2 Core objective and research question of this work

Integration to renewable energy systems is crucial for cities to survive the flux and for livable environments to sustain. The objective is to look into the current role of renewable energy systems in the city and investigate the future perspective through different references, questioning how the role of the Architect could play an interdisciplinary role for the future cities and the urban development.

1.3 Major References

A research and study on sustainable city models have been monitored, as well as several scientific articles have been reviewed. Papers that have been published in specialist journals and websites have provided significant inspiration for the present work.

The analysis of the existing urban data have been searched and by using the data, information and Information Technologies, the outcomes and expectations on the integration of Renewable Energy systems have been focused. Future scenarios have been brought by micro and macro scale examples on the urban and rural data of renewable energy system use.

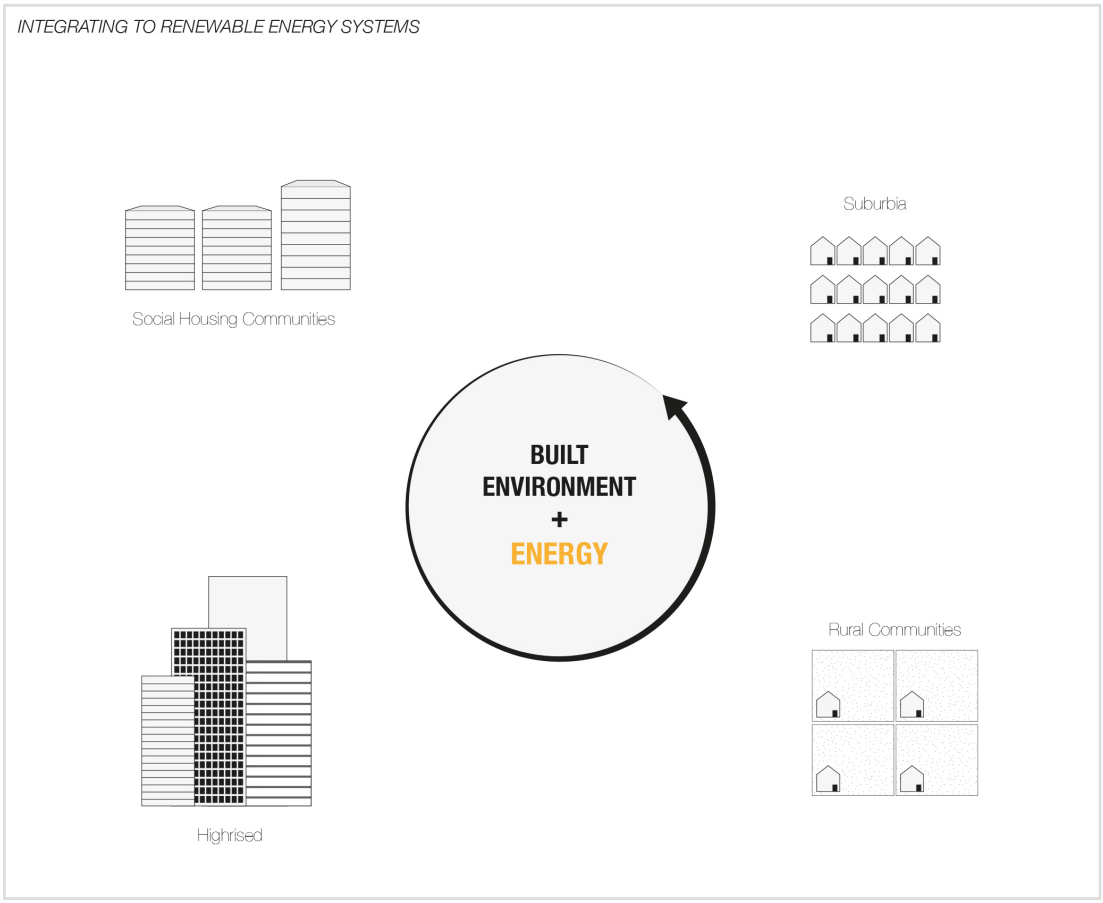

Figure 1: Interaction Diagram of Energy and the different built environments (own figure)

2 BACKGROUND INFORMATION

You can find the sources for Renewable Energy everywhere in our planet. From deep under the ground, to the sun, from air and in the oceans. These sources are a part of our planet, providing us the sustainable energy resources we need.

These sources also known as “alternative energy”. Due to the fact that these are the alternatives to the traditional fossil fuels like coal and oil, they’ve been named this way. Through the Renewable energy system technologies we could harvest these resources which can simply not run out as in means of being a part of the natural system of our planet. (1)

2.1 Types of Renewable Energy Systems

There are different types of Renewable Energy resources and Renewable Energy systems that we use. With the uprising technology, the access to these systems, the productivity and efficiency is rising.

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(1) Sunpower 2018, “Powering the World, A Complete Guide to 7 Renewable Energy Source”, https://us.sunpower.com/blog/2018/02/23/learn-about-seven-types-renewable-energy/

Figure 2: Renewable Energy Farm (from https://www.iselect.com.au/energy/renewable/wind-energy/)

2.1.a. Biomass

Biomass is the organic material that is coming from plants and animals. It is a renewable source of energy that contains the energy stored from the sun. This energy from the sun is absorbed by the plants and is called photosynthesis.

There are different ways to use Biomass. The most common usage is by burning the Biomass directly and using the chemical energy released as heat. You can also use Biomass as an energy resource by converting it into liquid biofuels.Some common examples of the usage of biomass for energy can be, processing the wood wastes by burning them to heat the buildings, or processing the heat to generate electricity. Other examples can be burning the agricultural wastes as a fuel by converting them to liquid biofuels or burning the extracted wastes in our garbage to generate electricity in power plants or to convert them into biogas in landfills. Also, burning animal manure or human sewage can be other ways to generate biogas, which can be burned as a fuel.

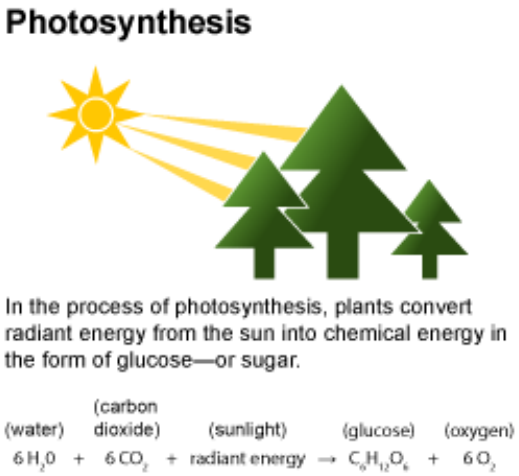

Figure 3: Photosynthesis Diagram (from The U.S. National Energy Education Project)

The process of converting the biomass into energy is one of the most commonly used ways of using Renewable energy. Soil can be found everywhere in our planet, unlike other sources like the sun or the wind. With the growth in human population, the amount of waste we have is growing. But our wastes are providing us more opportunities to generate energy from from Biomass. We can directly burn the solid biomass in our wastes by extracting them and burning them to produce heat. We could convert these Biomass into biogas or into liquid biofuels like biodiesel or ethanol which could later on be burned to generate energy that could be used in our vehicles. For instance, ethanol can be generated through the wastes of crops like corn and sugar which can be fermented to produce fuel ethanol. Biodiesel can be generated by plant based wastes like vegetable oils or animal based fats. (2)

United Staes can be one example to show the common usage of Biomass to generate fuels. About 5% of the total primary energy used in the United States in 2017 was by the fuels generated through Biomass.

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(2) Eia 2018, “Biomass”, https://www.eia.gov/energyexplained/?page=biomass_home

All these show the opportunities we create using Biomass as a Renewable Energy resource and the important outcomes this has for our cities, offering us to heat our buildings, use it to work our vehicles and to minimize wastelands.

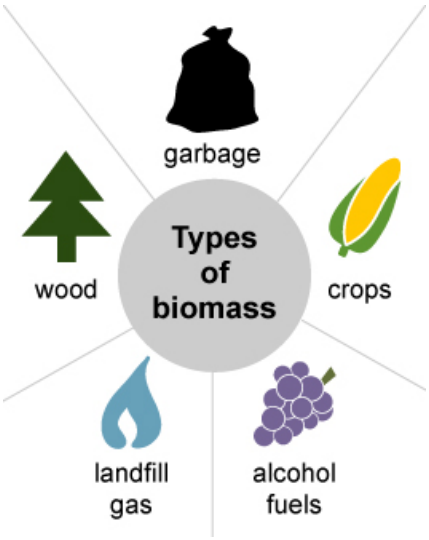

Figure 4: Types of Biomass (from The National Energy Education Project)

2.1.b. Wind Power

With evolving technologies in the Renewable Energy sector, wind has become an important resource to produce energy. Since decades, people have been using the wind as an energy resource by building Wind mills. Today we use wind turbines and generate electricity. For this reason, using the wind as a Renewable Energy resources has shifted into referring as “Wind Power” more commonly than referring as “Wind Energy”. Our atmosphere naturally generates air flows which we refer as winds. The wind turbines allow us to capture the kinetic energy from the wind and generates electricity. (3)

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(3) Awea 2018, “Basics of Wind Energy”, https://www.awea.org/wind-101/basics-of-wind-energy

There are three different ways of using wind to generate energy.

The Utility scale wind turbines is one of the most common ways of generating electricity through wind power. The sizes of the wind turbines can range from 100 kilowatts to several megawatts. The electricity generated is delivered to the grids and then distributed to the users by the electric utilities or the power system operators.

Figure 5: Utility scale wind power (from https://www.energy.gov/articles/energy)

Another way of generating electricity through wind is by the “distributed” or "small" wind turbines. Here, the single and small wind turbines are below 100 kilowatts and are used to generate power directly. Either for a home, a farm or a small business. these systems generate energy for their private owners only and are not controlled by a power system operator or connected to a grid.

Figure 6: Small scale wind power (from https://www.energy.gov/articles/5-things-you-should-know-about-wind-energy)

The other way of generating energy by using wind is through the “offshore” wind turbines. These systems are built in the offshore areas, commonly 10-40km away from land. The offshore wind turbines are much larger systems than the land based wind turbines. They also generate much more power compared to the land based sytems.

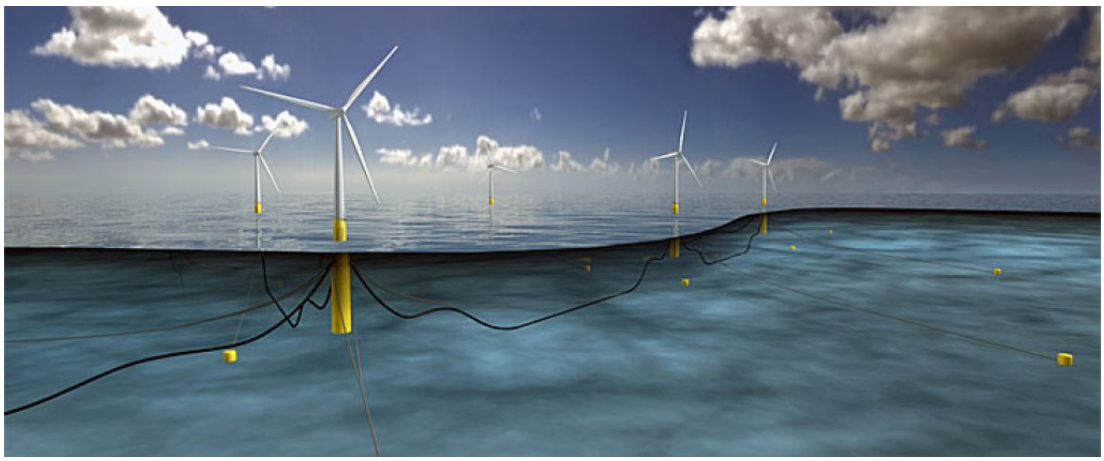

Figure 7: Offshore wind Turbines (from https://www.equinor.com/en/what-we-do/new-energy-solutions/our-offshore-wind-projects.html)

When we look into how the wind turbines work, the amount of wind plays the crucial role. To generate energy from the wind, the location that the turbine is built must have enough wind to blow past its blades to capture kinetic energy and rotate, turning it into mechanical energy. The internal shafts connected to a gearbox inside the system turns through this rotation, which allows for the speed of the rotation to increase by a factor of 100. That spins a generator that produces electricity.

The typical wind turbine stands at least 80 meters tall which change according to the type of system. The turbine is supported through a tubular steel tower. The collected wind measurements direct the turbine to rotate and face the strongest wind. The angle off the blades in the system is optimized to capture energy.

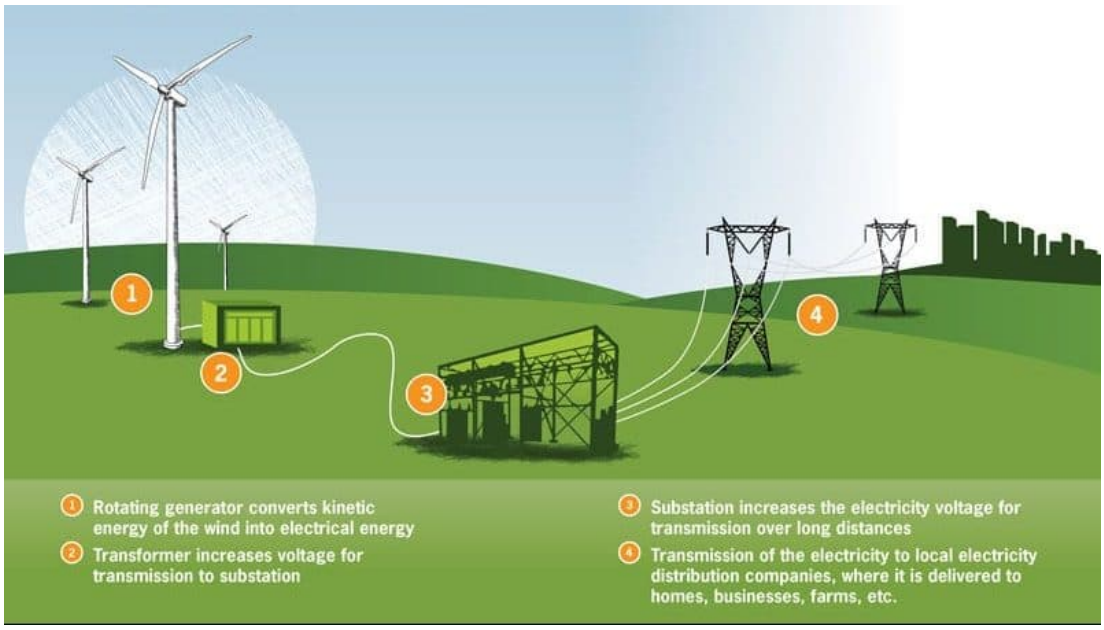

Figure 8: How wind turbines work (from https://canwea.ca/wind-facts/why-wind-works/)

For the typical wind turbine to generate electricity, the wind speed needs to reach at least to 6-9 mph. There is also a speed limit for the wind turbines to prevent equipment damage. Wind turbines will shut down when the wind reaches to 55 mph.

More than 90 percent of the time, wind turbines can generate usable amounts of power. When the wind turbine reaches the to enough speed it will start generating electricity. As wind speeds increase so does electricity production.

The amount of power generated through a wind turbine is measured through the capacity factor. The information regarding the amount of electricity produced by a wind turbine in a given time period is collected in this way.

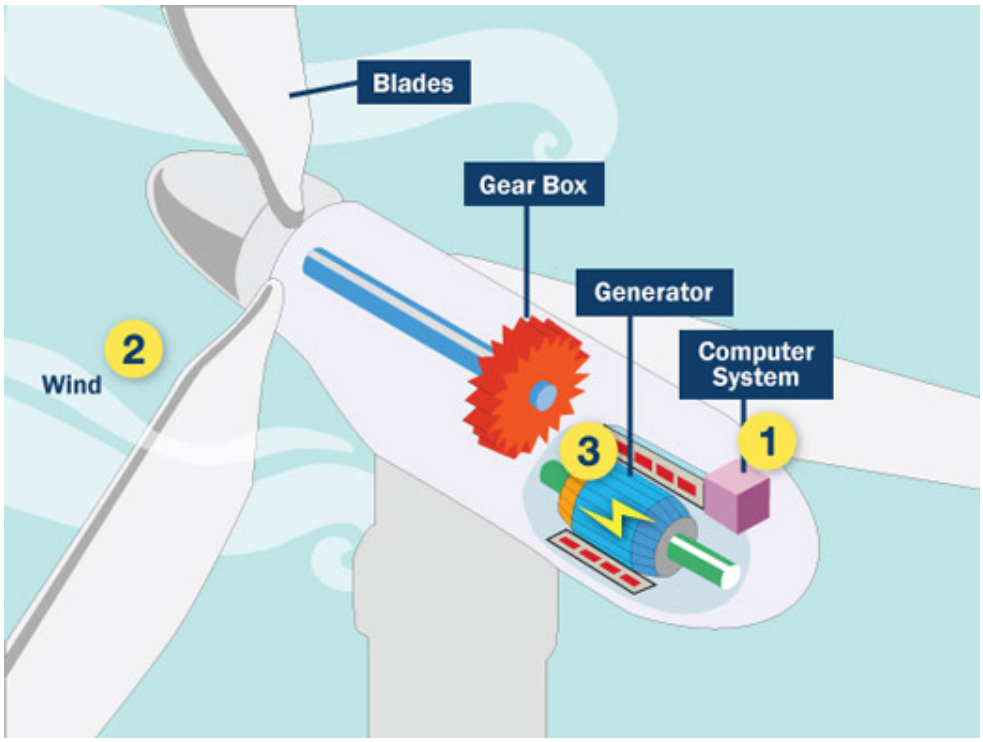

Figure 9: Components of a wind Turbine (from http://www.industrycrane.com/blog/.html)

The Windmills and Wind Turbines are very different ways of using wind as a Renewable energy resource. If we compare the two, we can see the differences easily.

Windmills and wind turbines are two different systems and technologies. Often times people seem to confuse these terms and use interchangeably. There are many significant differences between these two systems. Windmills have been used for decades and centuries, often times to grind grain or to pump water. The energy generated through the Windmills is mechanical and no electricity is generated. Windmills are still used today in rural areas but they are easily replaceable through industrial products we have today.

When we look into the wind turbines, they are much larger systems than be identified from long distances. They are not used to grind grain or to pump water but to generate electricity. Wind Turbines are highly evolved machines using the latest technologies allowing to harness the kinetic energy from wind, converting it into electricity.

Figure 10: Wind Power Systems (from https://www.quora.com/What-type-of-energy-does-a-windmill-use-How-is-it-produced)

Though we can see private usage of wind turbines through small systems, they are mostly used in wind farms, connected to a grid which then later disturbers the generated energy to the users, operated by power systems and electric utilities.

We can see offshore and on land wind farmers containing large numbers of wind turbines that are built closely together. The wind farms function as a power plant for the grid, sending the generated electricity These farms are most often outside the city due to sound and efficiency. Vertical buildings and densified urban areas block wind speeds from blowing. It is crucial for the wind turbines to have access to enough blowing wind to function and to generate electricity efficiently. For this reason, we can see the future of wind power more towards offshore rather than in an urban, densified environment.

Figure 11: Wind Farm (from https://www.sciencenews.org/article/how-wind-power-could-contribute-warming-climate)

The process of getting the energy generated from the wind and distributing it to the users is important. The process of building these connections to the grid can be as important as building the wind turbines. Especially in offshore projects which are 10 to 40 km away from the land, a big investment is required not only to build the systems but also to build the connections to the land.

The generated power in a wind farm travels through the connections between the systems, transferring to the grid which later distributes this power. The small transmissions are called distribution lines. These lines collect the generated power and transports it into the larger transmission lines called “network transmission lines”. The network transmission lines allow the generated power to transfer to grid where in long distances. There are also smaller distribution lines which directly transfers the generated power into homes, farms and small community areas.

2.1.c. Solar Energy

Solar energy is radiant light and heat from the Sun that is harnessed using a range of ever- evolving technologies such as solar heating, photovoltaics, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis.

Solar energy is a very important renewable energy source, due its accessibility and technological ease. The use of solar energy is distributed into two different technologies, depending on how they generate the energy from the sun light. Either by distributing the solar energy or by converting it to generate electricity, they are referred to as “passive solar” and “active solar”. (4*)*

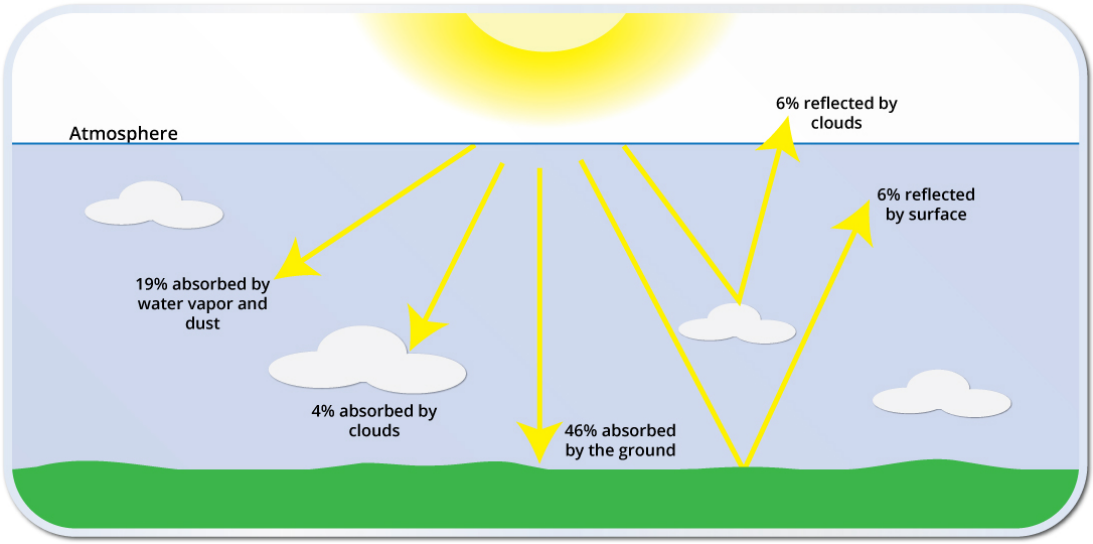

Figure 12: Solar Energy (from http://www.smartenergytoday.net/industryknowledge/solar-energy/solar-energy-absorbtion-2/)

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(4) Morse and Turgeon 2012, Solar Energy, National Geographic, https://www.nationalgeographic.org/encyclopedia/solar-energy/

When we look into the systems that use active solar these systems are the photovoltaics panels which are used to generate electricity and solar panels which concentrates solar power by heating water to harness the energy. The passive solar is rather than a system an approach such like orienting a building to the sun, or the choose of materials with high thermal mass. Designing spaces that naturally circulate the air are also a part of the passive solar.

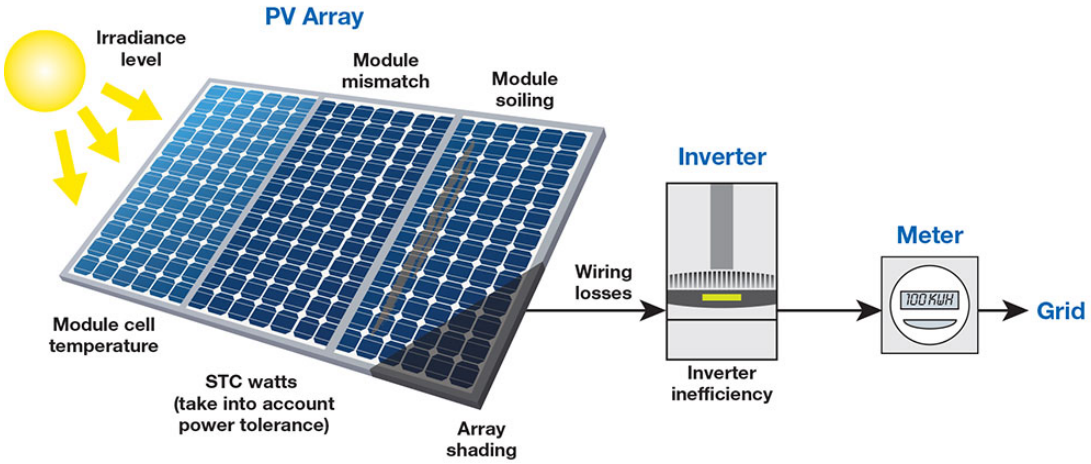


Figure 13: Active Solar Energy Systems (from https://www.homepower.com/articles/solar-electricity/equipment-products/grid-tied-pv-system-performance-factors)

Figure 14: PV Solar Energy Farm (from https://www.pv-tech.org/news/adb-back-cambodias-first-ever-large-scale-solar-farm)

The solar energy is a natural part of our planet, making life possible. The Greenhouse Effect is the process where the earth is warms up by the sun and filters the harmful light waves. With the greenhouse effect, these light waves reaching on to our planet is controlled. There are visible waves and waves which are not visible like the UV and infrared lights. Although these light allow for our planet to heat, if not filtered it is dangerous for life to sustain on our planet.

The greenhouse gasses allow for the heat to be trapped which is coming from these light waves, and reflects the lights back to the atmosphere. They function like as the glass coverage of a greenhouse. It protects the earth from all harmful lights while using their heat to warm the earth enough for life. (Figure 15)

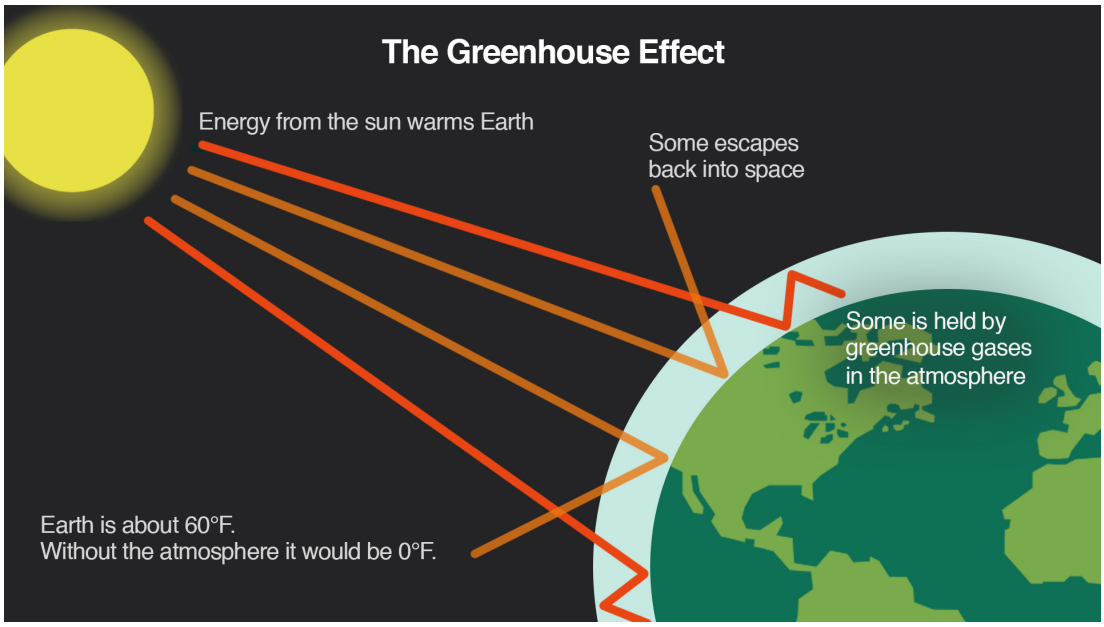
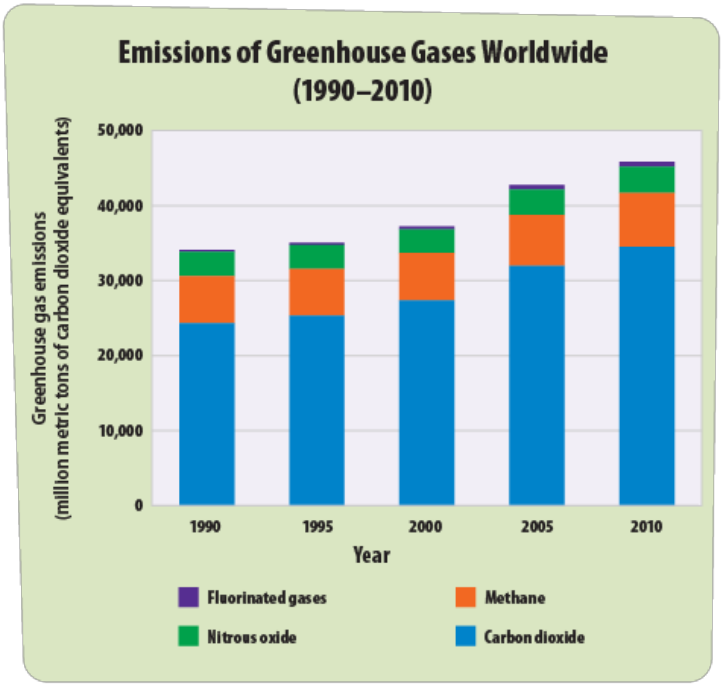


Figure 15: How Green House Effect works (from http://studioy.us/greenhouse-gases-diagram/wmo-annual-greenhouse-gas-bulletin-climate-central-throughout-greenhouse-gases-diagram)

About one thirds of the solar waves that reach on to our planet is reflected back into space. The rest of these waves are absorbed into the atmosphere and warms up the Earth's surface. (Figure 16)



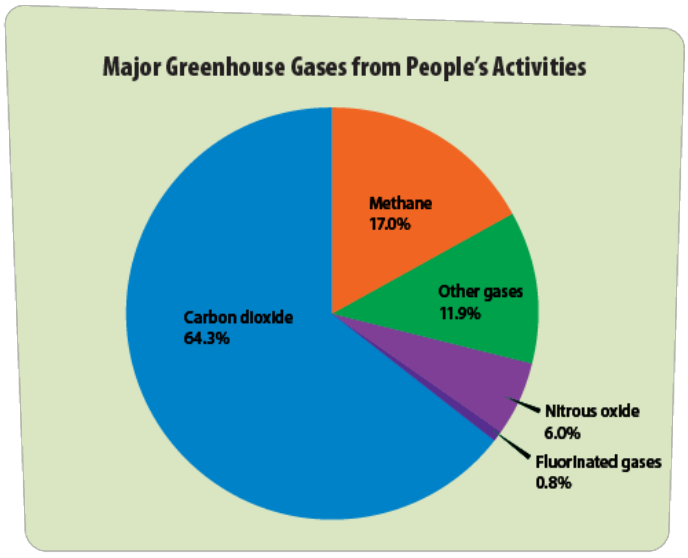


Figure 16: Green House Emissions ChartGreen House Emissions Chart (from https://www3.epa.gov/climatechange//kids/basics/today/greenhouse-gases.html)

Every process of life relies on to solar energy, either directly or not. Photosynthesis is another natural process that is crucial for life in our planet. It directly relies on to solar energy where the sunlight is absorbed and converted into nutrients. The producers of photosynthesis are autotrophs. From plants, to algae, bacterias to fungi, all are autotrophs and play a crucial role in the cycle of photosynthesis. All of the consumers are relying on to these producers for the nutrients. (Figure 17)

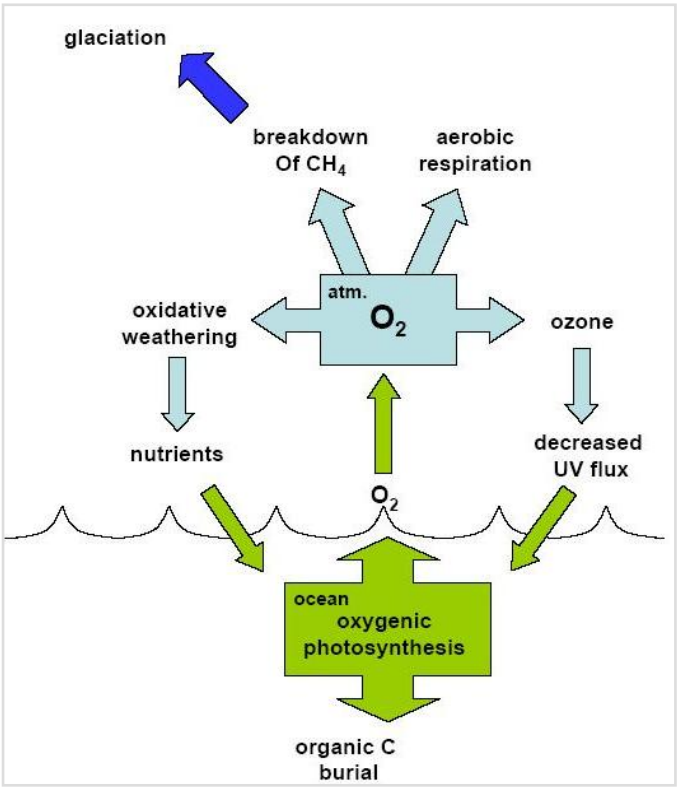


Figure 17: Photosynthesis Chart (from https://phys.org/news/2009-05-oxygen-earth-earliest-ice-age.html)

Another crucial role that photosynthesis takes part of is the responsibility it has for all the fossil fuels in our planet. It is estimated that around 3 billion years ago, sunlight allowed for the creation of plants to thrive and evolve on earth. They died, decomposed and shifted more into nature, going down into thousands of meters down the earths surface. This cycle kept on going for millions of years.

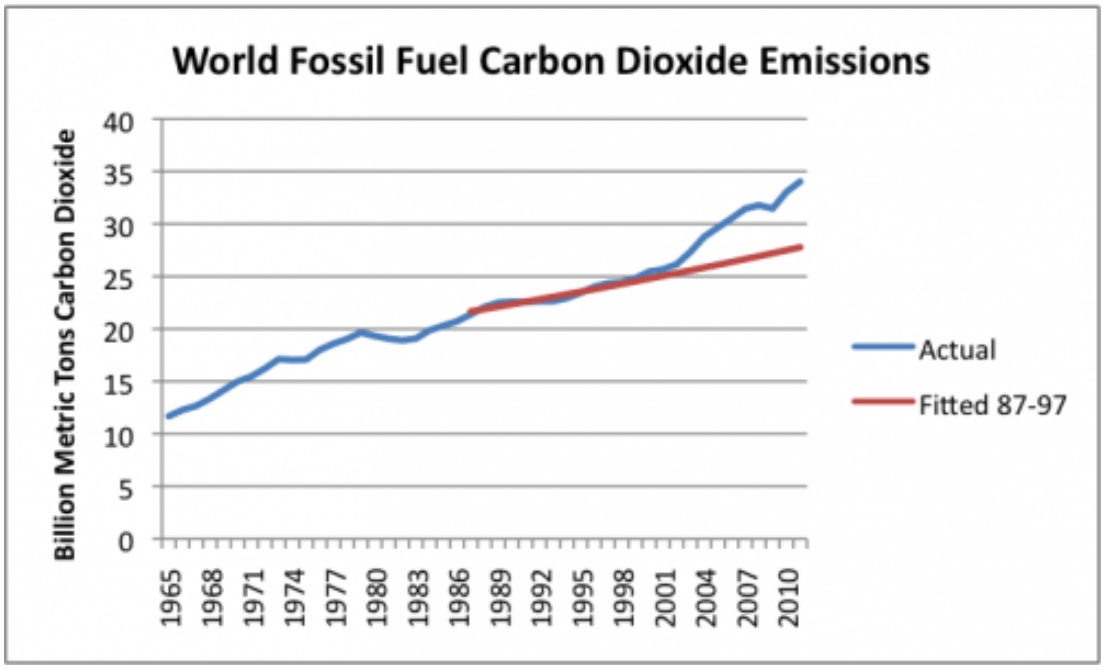


Figure 18: World Fossil Fuel CO2 Emissions (from https://ourfiniteworld.com/2013/05/23/oil-limits-and-climate-change/)

The high temperature and intense pressure down the earths surface allow these remains to convert into fossil fuels. All the microorganisms became petroleum, natural gas, and coal.

Different processes have been developed to extract these fossil fuels in order to generate energy. But the fossil fuels are limited energy resources and are nonrenewable. They take up to millions of years to form and this leads us to find alternative energy sources.

By mimicking the nature, technology has allowed us to harness the sunlight and generate energy, making solar energy an alternative energy resource. These technologies like the photovoltaic cells and solar panels allow us to use the solar energy in our homes, cities and all built environments. Today, the use of solar energy is gaining more popularity with the ease of access to this technology and its evolving efficiency. We can see this technology integrating into our grid as a power plant and also through private usages integrated on to our buildings. (Figure 19)

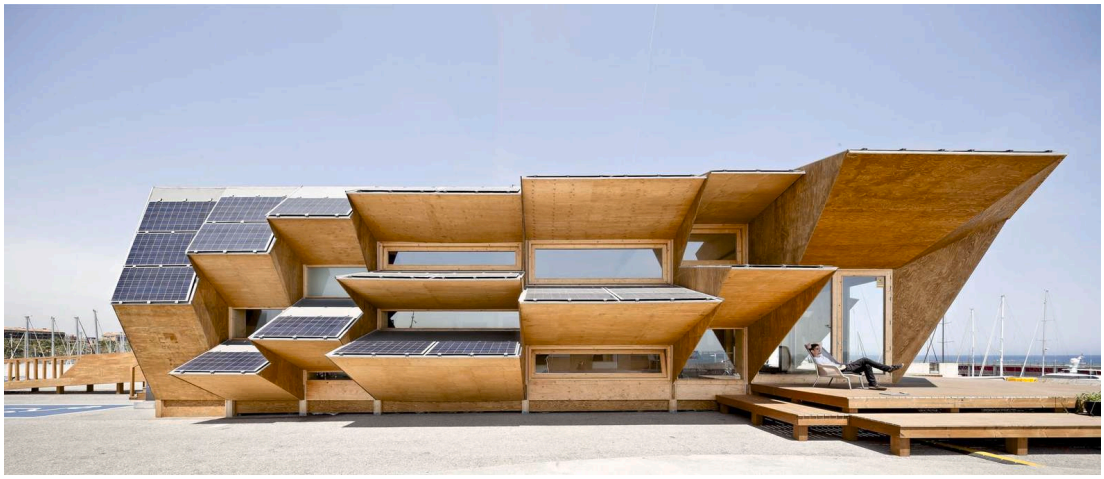


Figure 19: Solar Technology Pavilion (from https://www.plataformaarquitectura.cl/cl/02-190985/endesa-pavilion-iaac/505be65928ba0d2715000218_endesa-pavilion-iaac__mg_0113_14-jpg)

Different ways of capturing the solar radiation have been found with the technology that could allow converting it into energy that we can use. These methods vary by using either active or passive solar energy. (Figure 20)

The active solar system and technology uses the electrical or mechanical tools and devices to convert actively the energy of sun into another form of energy, which is most often heat or electricity. The technologies that use passive solar energy don't need any external devices. Passive solar energy is generated through taking advantage of the local climates. This can be used to heat buildings in winter, or used by reflecting the heat during the summer.

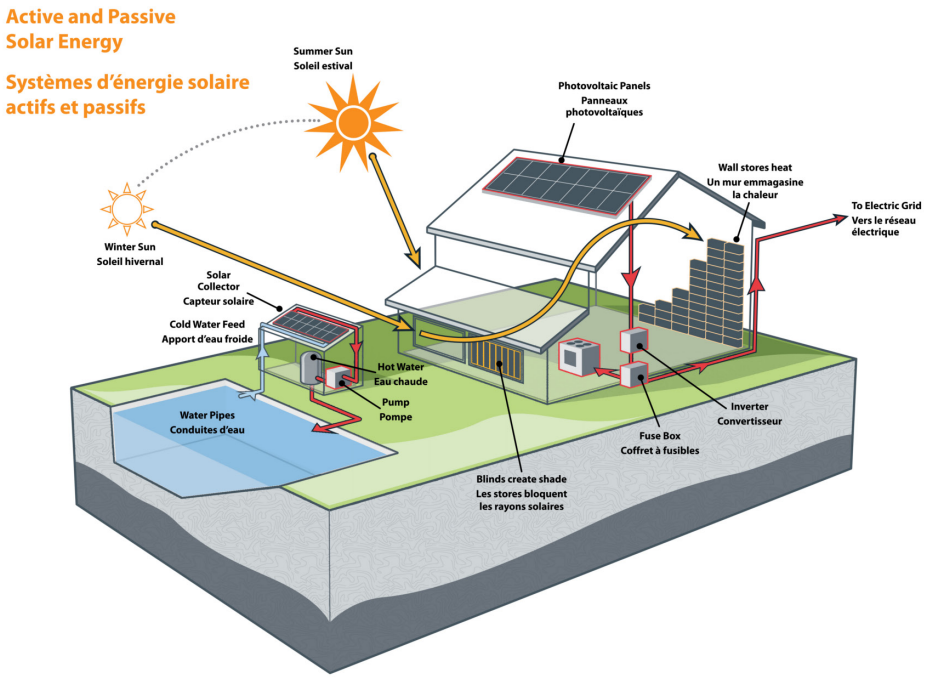


Figure 20: Use of Solar Energy Systems (from https://energy.techno-science.ca/en/energy101/solar.php)

The active usage of solar energy can be done by the use of solar panels. Photovoltaics is the most uprising technology using the active solar energy to generate electricity. It is a process of generating this electricity directly from the solar radiation which is also called the photovoltaic effect. These panels used to generate power carry hundreds of photovoltaic cells, reluctant for sunlight to produce energy, for this reasons, all panels are built in to face the south for efficient production. (Figure 21)

Figure 21: PV (from http://www.ercshowcase.com/renewable-energy-2/)

Though there are other types of solar panels that use direct sunlight and produce energy through the active solar, with the generation of electricity through photovoltaics, photovoltaic panels have become the most commonly used type of technology that harness's solar energy today.

All solar cells contain semi-conductors that are made out of silicon. While absorbing the sunlight, these semi-conductor knock the electrons loose. The loose electrons are directed into an electric current, flowing in one direction, by the electrical fields. There are metal contacts both at top and the bottom of the solar cells that allow to direct the current to an external object. These external objects can be a small tool such like a solar powered calculator or as massive as a station like the satellite stations we have in space (Figure 22). (5)

Figure 22: ISS PV usage in Space (from https://www.quora.com/Why-is-silicon-used-in-a-solar-cell?_escaped_fragment_=n%3D12&redirected_qid=20477195)

Photovoltaics was first widely used on spacecraft and satellites, such as the International Space Station (ISS), featuring wide, reflective wings made out of solar panels. The ISS has two solar array wings (Figure 22), each using about 33,000 solar cells. The photovoltaic cells on ints wings generate and supply all electricity needed in the ISS (Figure 22), which allows astronauts to live and operate in the station safely.

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(5) Garcia 2017, “About the Space Station Solar Arrays”, NASA: https://www.nasa.-gov/mission_pages/station/structure/elements/solar_arrays-about.html

When summed up, the photovoltaic wings of the ISS generate up to 84 to 120 kilowatts of electricity. This is large enough to provide power to more than 40 households. All together the arrays on the wings of the ISS, contains a total number of 262,400 solar cells and they cover up an area of 2,500 square meters. This is more than half the area of a football field.

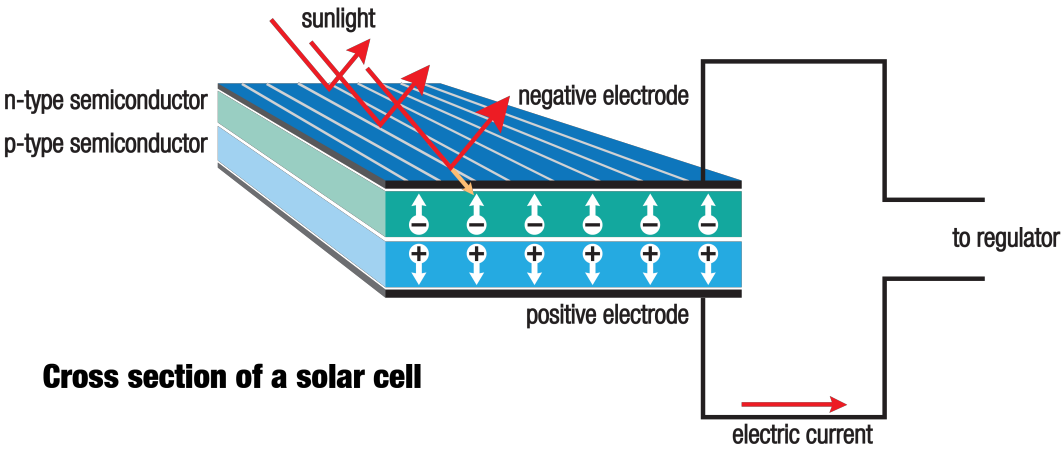

Figure 23: PV cell (from https://www.solarreviews.com/news/solar-cell-efficiency-levels-what-does-it-mean-for-me/)

The usage on the ISS has shown the potential this technology has. Today, we have built Photovoltaic power stations all around the world. Some of the largest photovoltaic power stations are in the United States, India, and China. The photovoltaic power stations can emit up to hundreds of megawatts of electricity, to supply our built environments.

Photovoltaic technology can be installed in various ways. While the power stations are large scale solar farms, also smaller scale installations can be found on our buildings. By fixing solar panels on to the roofs and facades of buildings, we can generate electricity for the buildings. Different ways of small scale fixing can also be seen placed along the highways for lighting and blocking noise. Solar cells are also seen on small devices, like calculators, parking meters, trash compactors, and on water pumps.

The concentrated solar energy is another way of using the active solar energy. It is a technology that concentrates the solar energy. Lenses and mirrors are used in the technology of concentrated solar energy systems ignorer to concentrate sunlight from macro to micro scale. The radiation it bodies heats a fluid, which then turns into generating electricity.

The example of concentrated solar power is Solar furnaces for instance. The different types of solar furnaces are such like the solar power towers, parabolic troughs, and Fresnel reflectors. They all use the same method which is to capture sunlight and convert into energy.

Solar energy power towers use heliostats to generate energy. Flat mirrors that enable to follow the sun's arc through the sky are used in the Heliostats. These mirrors are built around a central tower which is the collector. These help reflect the sunlight into a concentrating system on the collector.

The first solar power towers concentrated sunlight by heating a container with water, which produced steam that powered a turbine. Nowadays most solar power towers use liquid sodium, which contains higher heat capacity that retains the heat for a longer period of time, meaning that the fluid can reach high temperatures up to 500 to 1,000° C, and can also continue to boil the water and generate power even when there isn't many sunlight.

Concentrated solar power is also used by the parabolic troughs and the fresnel reflectors, but the mirrors they obtain have different shapes. The mirrors that the Parabolic troughs have are curved, and are shaped like a saddle. The mirrors of the fresnel reflectors have are flat and thin, allowing the system to capture sunlight and direct it on to a tube with liquid. The surface area the fresnel reflectors have are more than what the parabolic troughs have.

The concentrated power plants of solar energy are first developed in the 1980s. The largest facility in the world is a series of plants in California's Mojave Desert. This Solar Energy Generating System generates more than 650 gigawatt-hours of electricity every year. We can also see small scale usages of the concentrated systems. An example can be solar cookers, where heat is generated through. Most commonly in rural areas like the villages, solar cookers are used to boil water and to cook food.

Compared to wood burning stoves, solar cookers have many advantages. They do not produce smoke, since they aren't fire hazard. They also don't require fuel, and reduce the losses in the forests where trees would be used to harvesting fuel. Also they are more advantageous with the time, since there is no need for gathering firewood. The solar cookers are used all around the world like in Chad, Israel, India, and Peru. (6)

Solar Architecture plays an important role in the use of solar energy in our built environments. The solar energy is a part of the process of thermal convection, and the movement of the heat, from warm space to a cool space. Objects and materials on earth begin to warm when the sun rises. These materials absorb the heat from solar radiation throughout the day. When the sun sets at night, the atmosphere starts to cool down and the materials release their heat back up to the atmosphere.

The passive solar energy takes advantage of this natural flow where heating and cooling process's.

For the residential buildings and for other buildings use passive solar energy to distribute heat efficiently and inexpensively. An example can be how a buildings thermal mass is calculated. The thermal mass of a building relies on its materials heat. Examples of a building's thermal mass are wood, metal, concrete, clay, stone, or mud. The thermal mass releases its heat back into the room at the night time. The warmed air is distributed in the building by the ventilation systems, hallways, windows, and air ducts which allows to maintain a moderate, consistent indoor temperature.

Passive solar systems involve for the design of a building. An example can be the planning stage of a construction. During this phase, the engineer or at the architect may align the building with the suns daily path to receive valuable amounts of sunlight. It is very important to take into account the latitude, altitude, and the typical cloud cover of a specific area when applying this method. Buildings can also be constructed to have thermal insulation, thermal mass, or extra shading.

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(6) Morse and Turgeon 2012, Solar Energy, National Geographic, https://www.nationalgeographic.org/encyclopedia/solar-energy/, retrieved July 2018

Some other examples for the passive solar architectures are the cool roofs, radiant barriers, and green roofs. To cool down the roofs, they are painted to white so that the the sun's radiation is reflected instead of being absorbed. White surface s reduce the amount of heat that can reach into the interiors of a building. This method reduces the amount of energy needed to cool down the building.

The radiant barriers also work similar with the cool roofs systems. They provide the insulation with highly reflective materials, such as aluminum foil. Instead of absorbing, foil reflects heat, and this allows to reduce cooling costs. Radiant barriers may also be installed beneath floors, in addition to the roofs and attics,.

The buildings with green roof are roofs which are completely covered vegetation. They require soil and support for the plants, and a waterproof layer beneath. By using green roofs, the heat absorption loss can be reduced and also plantation can be made. Plants on the green roof buildings can absorb the carbon dioxide and emit oxygen through photosynthesis which allows to filter pollutants out of rainwater and the air. This also offsets some of the effects of energy used in that space.

For centuries, green roofs have been used in Scandinavia becoming a part of the tradition. It has started gaining popularity very recently around the world like in Australia, Western Europe, Canada, and the United States. Green roofs also help to reducing greenhouse gas emissions. (7)

Another one of the many advantages of green roofs and cool roofs is counteracting the urban heat island effects. In densified areas such as the city, temperature is consistently higher than the surrounding rural areas due to many factors. One of these factors is the materials used in the cities like asphalt and concrete which absorbs heat. Also vertical architecture plays a big role by blocking the wind from flowing and carrying its its cooling effects. By using the available space on roofs to plant or reflecting the heat with the usage of white color on the roofs, the local temperature increases in urban areas can be alleviated.

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(7) Wikipedia 2018, "Solar Energy", https://en.wikipedia.org/wiki/Solar_energy, retrieved September 2018

In most places, there is no constant access to sunlight. For this reason, how we use and store the power, generated by the solar energy is very important. Sunlight only shines throughout one thirds of a day in most places. For this reason, batteries have been used to store the energy generated through sunlight. Especially during night time, we need batteries to use power generated through the solar energy.

Paraffin wax and different forms of salt is used by the thermal mass systems to store the energy in the form of heat. Photovoltaic systems can transfer the electricity to the local grid. The energy generated can also be stored through rechargeable batteries.

There are many advantages and disadvantages using solar energy based systems. If we look into the Advantages;

A big advantage when using solar energy is that it is a renewable resource. It is possible to have limitless supplies of sunlight for the next 5 billion years. Our atmosphere receives enough sunlight that could allow for us to generate our electricity needs.

Solar energy does not require the need for fuel to work. This makes the solar energy a clean energy resource. By not emitting any toxic or greenhouse gases, using solar energy helps reduce the environmental impacts of energy consumption..

In some locations, solar energy is the most practical resource of clean energy. Where in areas with high amounts of sunlight and low amounts of cloud cover, buildings and the cities have the opportunity to harness the sun's abundant energy. The solar cookers provide an excellent alternative for cooking, rather than with wood fired stoves, which 2 billion people still rely on. Solar cookers are both safer and cleaner, using to sanitize water and cook food.

Solar energy complements other renewable sources of energy, such as wind or hydroelectric energy. Buildings that are installed with solar and pv panels can generate their own electricity. The owners of these buildings can also sell the leftover energy to the electric providers, reducing and even eliminating the power bills.

There are also disadvantages of solar energy systems. The solar energy systems require many equipments. Purchasing a solar system and installing its equipment is highly expensive and is a huge investments for an individual building. Most governments today offer reduced taxes for the solar energy systems in order to increase the popularity of its usage. Still, most people and businesses have started do not make the investment for it since the initial cost is too much for many to consider, even though it can eliminate most of the power bills. The equipment is also heavy in a solar system. Installing solar panels on the roof or facade of a building requires a highly strong structural system. Also there need to be space where the system can be built in the orientation towards the sun. Factors like the climate or the cloud cover affects both types of solar energy usages, active and passive. All solar technologies depend on environmental factors which are out of our control. Before installing a solar system, the location must be studied to determine whether or not it could be effective in that area. It's important that the sunlight is abundant and consistent to generate power from solar energy in an efficient way. In most places on Earth, sunlights variability makes it difficult to implement as the only source of energy.

2.1.d. Geothermal Energy

The heat coming up from the Earth is what we call Geothermal energy. It's clean and sustainable. (8)

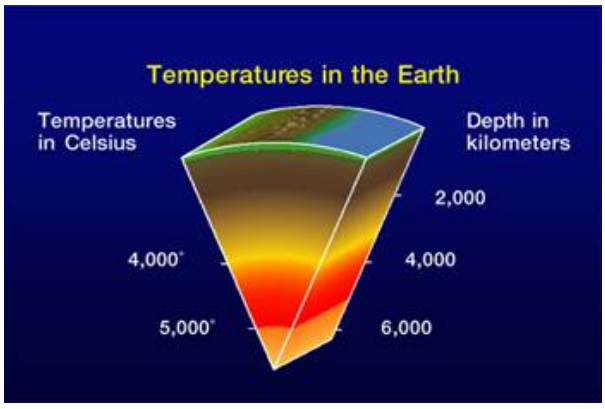

Figure 24: Geothermal Diagram (from http://geo-energy.org/basics.aspx)

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(8) Nrel 2018, "Geothermal Energy", https://www.renewableenergyworld.com/geothermal-energy/tech.html

The surface of our planet holds a constant temperature (Figure 25) and it is spread everywhere on the shallow ground. The heat pumps allow the Geothermal energy to be used to heat and cool our buildings. The geothermal systems consists of heat pumps, air delivery systems, and heat exchanger pipes buried down in the ground. In different seasons, Geothermal functions differently. During winter, heat pumps help remove the heat on the heat exchangers and pumps it up to the indoor air delivery systems, while during summer the process is reversed. The heat that is transferred and removed from the indoor air systems during summer not only allows to cool the indoor temperatures but also can provide hot water with no charge.

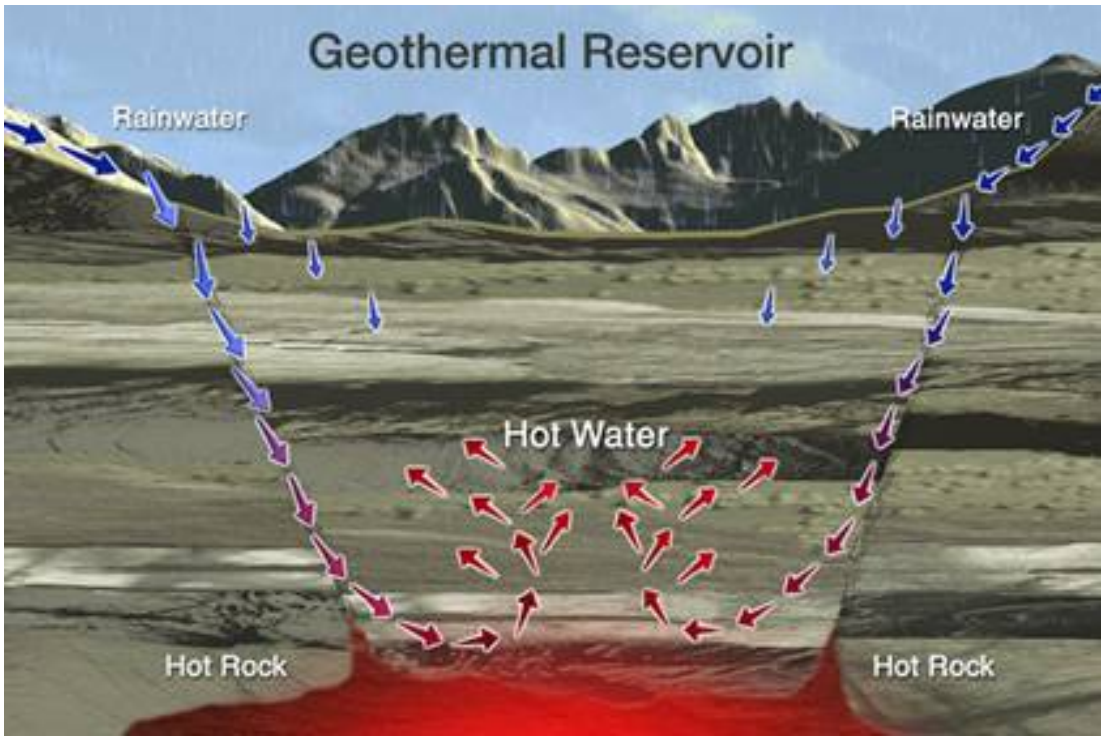

Figure 25: Geothermal Reservoir (from http://geo-energy.org/basics.aspx)

The way that a conventional geothermal power plant works is very simple. Before starting the construction of a conventional geothermal power plant, it is crucial to make careful analysis. Construction starts by drilling the wells which will allow to bring and convert the geothermal energy into electricity.

When we look into the Flash geothermal power plants (Figure 26), we see high pressure s separating steam from water. This is called a “steam separator”. Here, water rises and as pressure drops, it allows the steam to be delivered into the turbines where the power is generated.

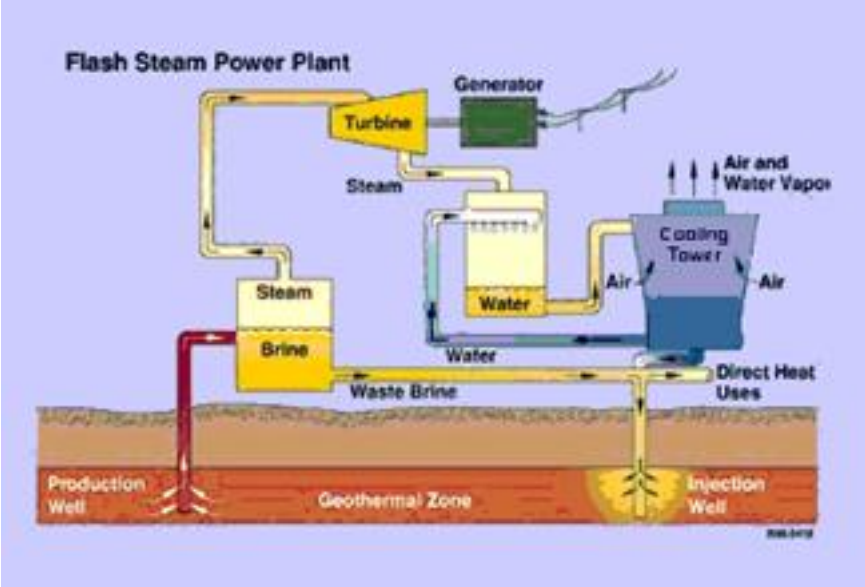

Figure 26: Flash Steam Power Plant System (from http://geo-energy.org/basics.aspx)

When we look into the Dry steam geothermal power plants (Figure 27), the steam alone is produced directly from the geothermal reservoirs. This is used for running the turbines to power the generators. Since there is no liquid, the steam separator used to flash a power plant aren't necessary in these systems.

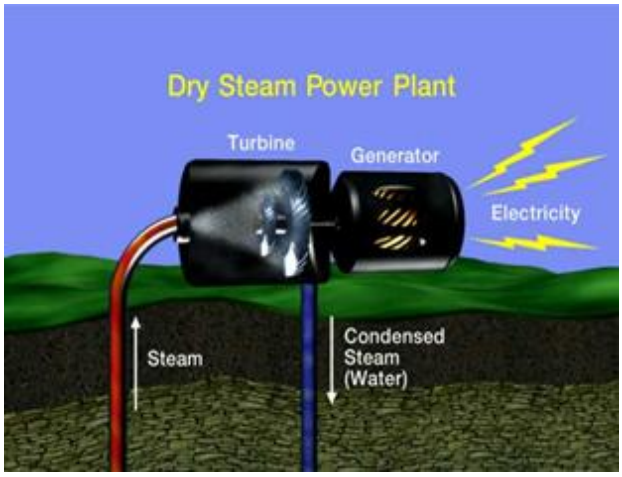

Figure 27: Dry Steam Power Plant Sys (from http://geo-energy.org/basics.aspx)

When we look into the Binary geothermal power plants (Figure 28), it consists of a system of organic rankine, where the geothermal water is used to heat a second liquid. This system boils the liquid at a lower temperature than the water. This is called a working fluid. There are heat exchanger that help separating the water. Water is separated from the working fluids while heat is being transferred, and the working fluid is vaporized. The force of the expanding vapor helps turn the turbines that power is generated. Most of the times, this could be done by generating steam.

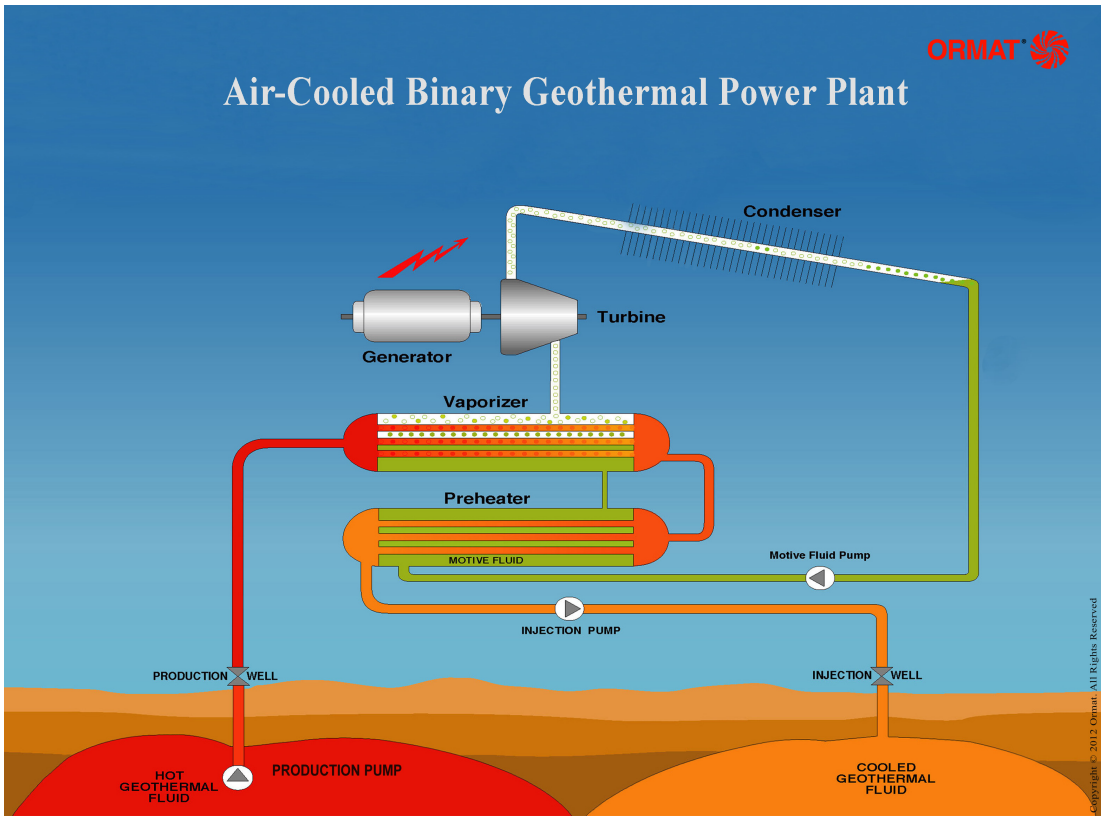

Figure 28: Air Cooled Geothermal Power Plant (from http://geo-energy.org/basics.aspx)

When we look into the Hybrid Geothermal power plants (Figure 29), they are combined systems working through the integration of multiple generating systems. An example for these power plants can be the Puna flash binary combined cycle system located in Hawaii. The plant is optimized by both flash and binary geothermal technologies, where the fluids are flashed into a mixture of steam and liquids inside a separator. The turbine is fed by the steam through the flash steam system, where the separated liquid is fed to a binary cycle generating system.

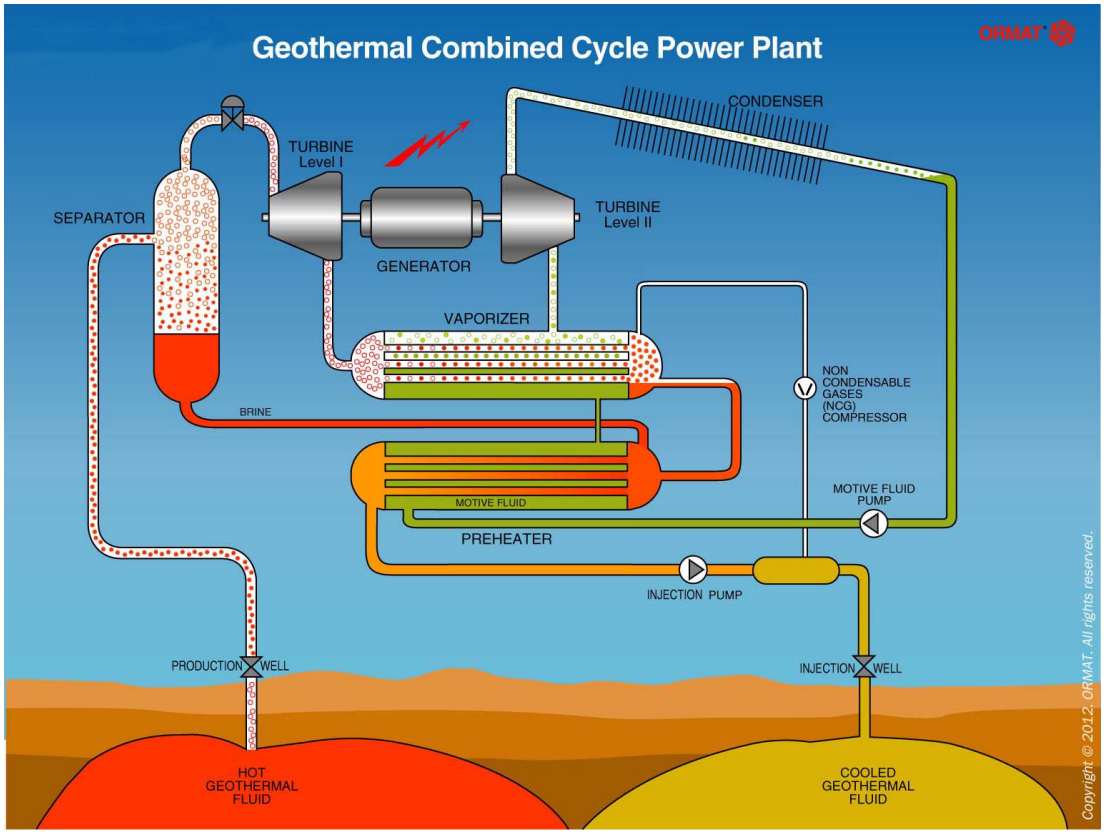

Figure 29: Geothermal Combined Cycle Power Plant (from http://geo-energy.org/basics.aspx)

There are also direct use applications using Geothermal. In these applications, the heat is directly used from the Geothermal without any heat pump or power plants. This could be used in space heating and cooling, as hot spring baths and in agriculture, aquaculture, greenhouses, snow melting, and industrial processes. You can make a geothermal direct usage by configuring the location of access to the geothermal source. (9)

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(9) Blodgett 2014, “Geothermal Energy”, http://geo-energy.org/basics.aspx, retrieved September 2018

2.1.e. Hydropower

Hydropower, also known as water power is the process of deriving power from the energy of fast running waters like from waterfalls and fast running rivers. There a many useful purposes harvesting this energy. Hydropower has been used since centuries, all the way back into the ancient times. Different types of watermills where used to harness Hydropower. Hydropower is a renewable energy source that operates many mechanical systems and devices. For example a trompe generates compressed air from waterfalls and is used to power other machineries at a distance.

In the late 19th century, hydropower became a source for generating electricity. Cragside in Northumberland was the first house powered by hydroelectricity in 1878 and the first commercial hydroelectric power plant was built at Niagara Falls in 1879. Back in 1881 in the city where Niagara Falls is, street lamps were powered through hydropower. Since the early 20th century, the term has been used almost exclusively in conjunction with the modern development of hydroelectric power. Big institutions like the world bank sees hydropower as a measure for economic development. (10)

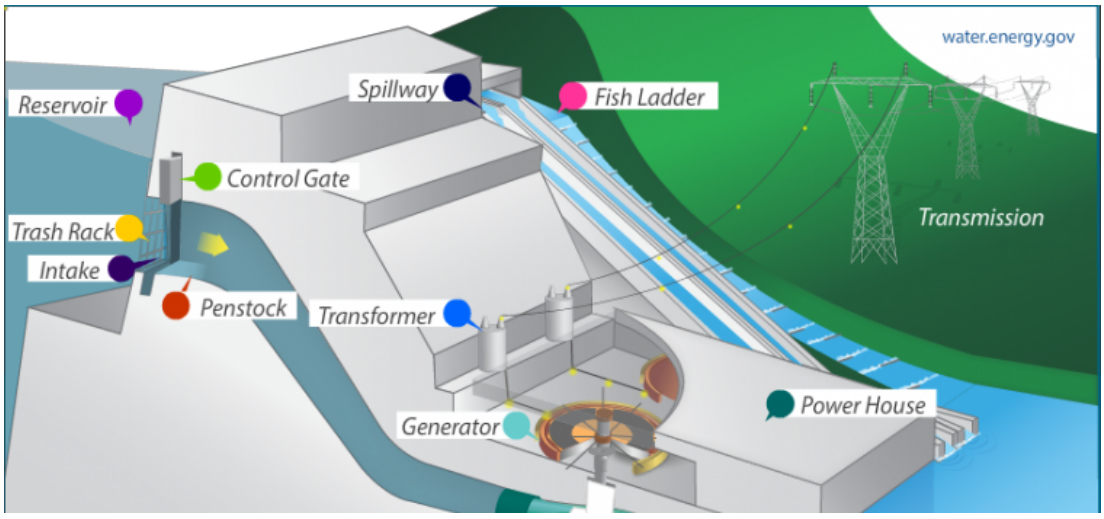

Figure 30: Hydroplant System Diagram (from http://gubik.abidingtruthministry.co/hydropower-works/)

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(10) Wikipedia 2018, “Hydropower", https://en.wikipedia.org/wiki/Hydropower

There are many forms of Hydropower plants in different sizes. Some plants are extremely large, while there are also small ones that operates through the water flows by the municipal water facilities or through the irrigation ditches. These systems also can run through river facilities that channel part of a stream through a powerhouse before rejoining to the main river. However the methods are, hydroelectric power plants are much easier to generate and are the most commonly used energy sources. The Hydropower plants generate the power by using dam and diversion structures that could alter the natural flow of a river and other types of body of waters. (11)

Figure 31: Hydroplant System (from https://thehill.com/opinion/energy-environment/396362-hydro-power-projects-get-lost-in-red-tape)

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(11) U.S. Department of Energy 2018, “Hydropower Basics”, https://www.energy.gov/eere/water/hydropower-basics

2.1.f. Tidal Power

Tides occur through the gravitational pull off the moon and sun along with the rotation of the earth. For this reason, in different locations on the planet, we see different measures of tides near the shores. Tides were realized and used over 1000 years ago in Europe, where people built systems that could harness the tidal movement of water and operate grain mills. Today, tidal energy systems generate electricity. To produce tidal energy efficiently, it's important that the tidal ranges at least 3 meters.

The turbines are installed in oceans and in places where there is high tidal current velocities. We can also install them in places where there is strong and continuous ocean currents. Some systems consist of twin axial flow rotors, where each drives a generator through a gearbox. The power units are fixed on to wing like extensions that could be on each sides of a tubular steel central pillar. (12)

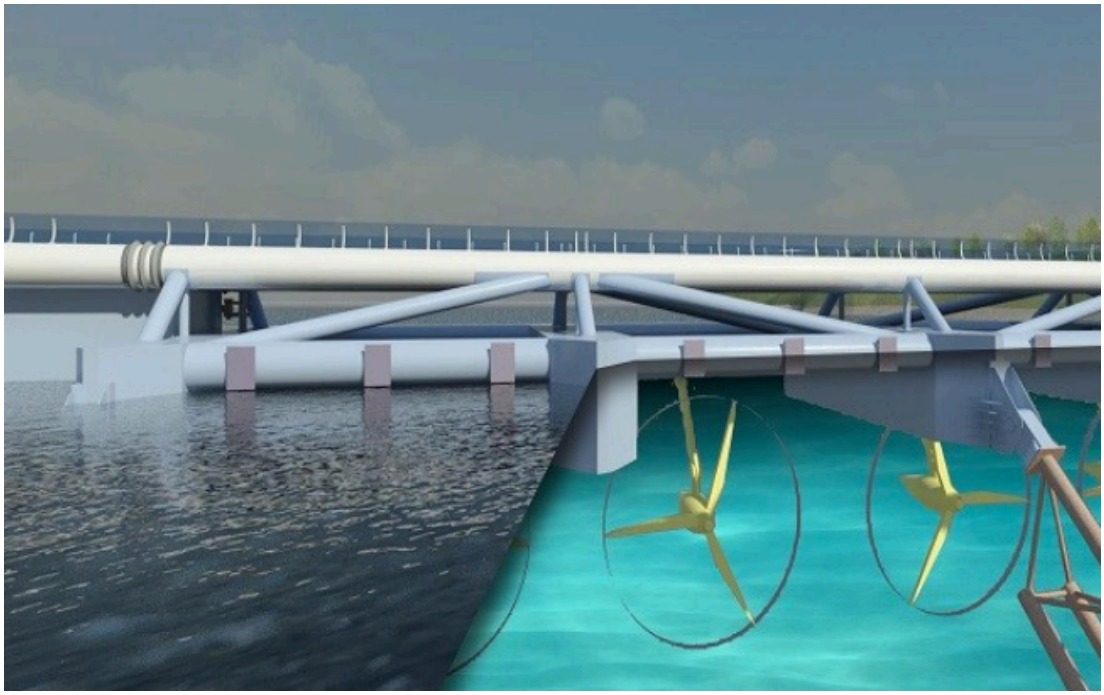

Figure 32: Tidal Power plant (from https://www.hydroworld.com/articles/2017/05/tidal-energy-project-in-indonesia-up-to-115-mw-at-us-550-million-begins-feasibility-study.html)

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(12) Rutledge 2011, "Tidal Barrages", https://www.eia.gov/energyexplained/index.php?page=hydropower_tidal, "U.S. Energy Information Administration"

The marine currents are consistent energy sources which are kinetic energy caused by the tidal cycles that are driven through different phases of the moon. Water is over 800 times denser than air so the force of the tidal flow, similar to that produced from a 300 mph wind on a wind turbine. The main difference in the density and on power means that the tidal turbines are significantly more small than the wind turbines. The tidal turbines can be placed close to each other and they still can generate the same amount of electricity. (13)

The studies show the environmental impacts of marine energy and that they relatively have little impact to marine ecosystems. There are multiple studies focusing on the negative impacts that the tidal turbines have such as the effects it has on seal population, or the benthic biological communities associated with the submerged rocky reefs, and also on the seabirds population.

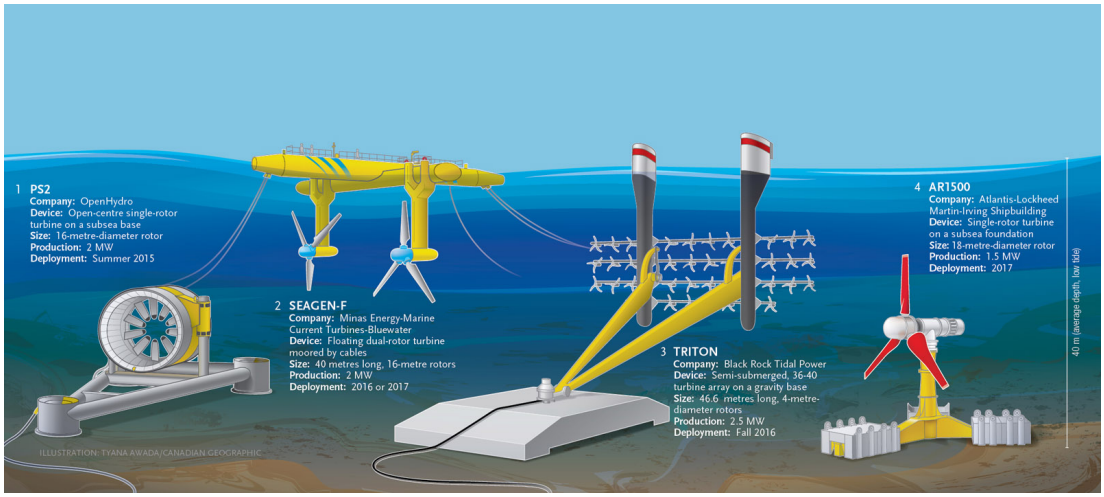

Figure 33: Tidal Power plant Systems (from https://www.canadiangeographic.ca/article/nova-scotias-first-stream-tidal-turbine-starts-producing-power)

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(13) Conca 2017, “Tidal Energy”, https://www.forbes.com/sites/jamesconca/2017/07/27/tidal-energy-all-renewables-are-not-created-equal/

2.2 Renewable Energy systems in the City

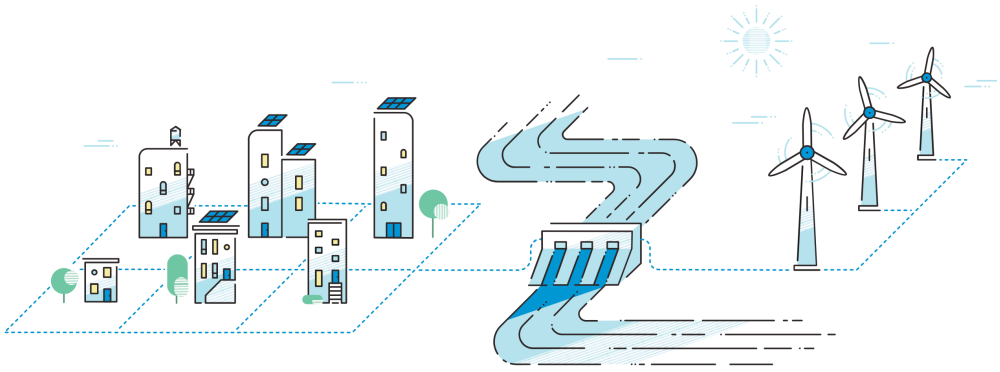

Figure 34: Renewable Energy Systems Integration to the cityRenewable Energy Systems Integration to the city (from https://www.coned.com/en/our-energy-future/renewable-energy-systems)

As cities lead the way in the circular economy transition, they face many challenges. We look at the latest developments - and major challenges - of building renewable and resilient energy systems for our cities.

Our cities leads how the circular economies transition. What it take to becomes for a city to be truly circular is a question interns of the integration to the Renewable Energy Systems. For that, it is important to identify the key services that cities need to adapt in order to become fully circular. These are energy, construction and physical resources, water, food and mobility.

Renewable energy sources used in small scale distributed generation systems are a sourcing new alternatives for other energy supplies for a smarter and more sustainable city structure. The integration of these systems as the new infrastructure of the smart city requires us to understand the architecture of the smart city idea. (14)

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(14) Sanz-Bobi 2014, “Use, Operation and Maintenance of Renewable Energy Systems”, “Springer”,

2.2.a. The Importance of Energy Systems in Cities

Most of the energy systems work the entire energy supply chain from energy generation to use. Energy systems make sure of the streets to be lit at night, for our waters to be clean and that the wastewater is treated, so that our factories can produce goods and our metros can run. Still, in order to become a circular system, the energy systems in the cities are facing significant challenges like the increasing demand where more than 70% of the worlds population are expected to live in the cities by 2050. The nature of renewable energy sources hold the lack of an energy storage and that can help redesign the energy efficiency. Here the biggest challenges are the transportation systems are also are the key. The biggest challenge here are that these issues are highly interconnected with one another and they are better as a whole rather than working separately.

In order to transmission into the circular, the cities must allow and support align innovations where there are key intervention points within the energy system. These intervention points include energy generation, storage, infrastructure, facilities and transport. There are many different examples of innovation which targets the intervention points which make the circular energy systems viable.

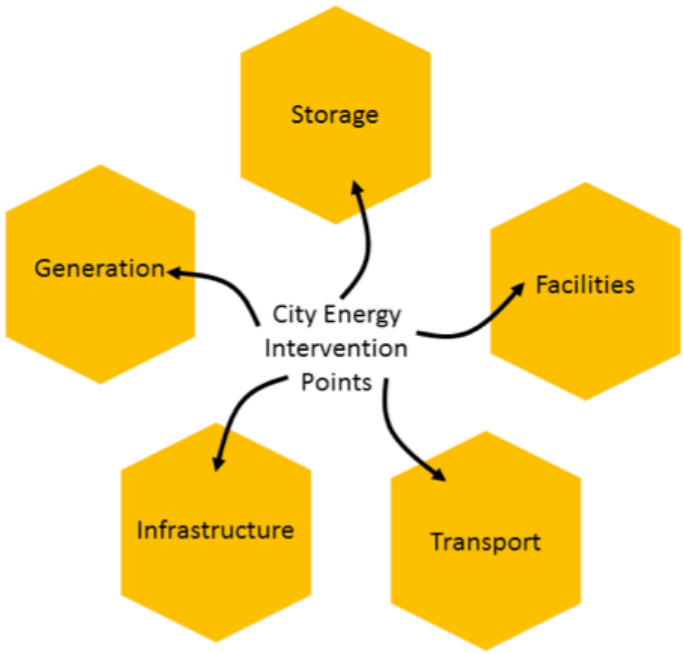

Figure 35: City Energy Intervention Points (from https://progrss.com/sustainability/20170223/energy-systems-circular-cities-power/)

Energy Generation

Nature has been inspiration by the way it uses decentralized energy generation. With that, initiatives started leveraging the blockchain to allow individuals with capable rooftops to invest on and generate energy, and sell it to each other when it's not needed. By doing so, the reliance on a centralized grid have been reduced. In some countries, city governments are also tackling the energy generation issues.

Las Vegas has become to be the first city government last year that powers its self by clean energy through the combination of a large solar farm and by utilizing its existing hydro power capacity. Also in Germany, the city of Munich pushed one step further by aiming to ensure there is 100% renewable energy supply for the city by the year 2025. This is done by forcing utilities to only source energy from renewable energy sources. The local utilities and companies here are now investing on renewable energy systems from all over Europe to meet the demand.They're promoting a pan European transition to renewable power.

Even though the cities in Europe are becoming more aware about the need for this transition to lower down the carbon and resilient the energy supply systems, the phrase what Europe thinks, Asia makes still hold its element of truth. For example a program has began for energy safe cities in east Asia. They are aiming to help urban areas including 12 mega cities and 100 super cities in the region. In total, 450 large cities, 450 small sized cities and some medium sized cities from China, Korea, Taiwan, Mongolia and Japan will be powered by 100% renewable energy, in less than 15 years through this program.

The Cities are required to increase the capacity of storege of the energy that is generated through the renewable energy systems. Maintaining a steady flow of energy into the grid also requires this. Today, the technologies that allows us to store this energy still requires a lot of investment.

The infrastructure plays an important role in the storage of energy that is generated from the renewable energy systems. After storing the generated energy, there is also a need to transmit this energy in an efficient way to the grid system and to distribute this power to the users. The Smart grids offer many benefits for the efficiency of the energy distribution through a innovative cutting edge communication

technologies which allows a real time communication between the energy utilities, generators, and the users. This leads to a much more efficient system for the energy. When the energy facilities transfer energy to the smart grids, the intelligence and efficiency that the energy facility systems allow is important.

For the energy facilities become more circular systems, buildings should be designed in more of a way were they barely require any energy. Therefore the demand for the grid will be significantly reduced since the buildings no longer will require any energy. An example for this can be in Vaxjo, Sweden where there are high rise buildings that have been built based on the passive house designs which require so little energy compared to the similar sized, traditionally built buildings. There is also the option to build smart buildings, that could leverage technologies. The energy demands can be reduced by 22% through building smart buildings.

Transportation is one of the largest consumption factors in the energy usage. Also the reason for pollution in cities, transportation system play a big role, but this is the area most ripe for disruptive innovation. The popularity of electric cars and vehicles is growing each day. The use of the electric vehicles is predicted to be extreme in the next decade which will have some consequences on the structure and performance of the smart grids. The electric vehicles will supply and draw their energies from the grid even though they provide a significant buffer to the intermittency of supply predicted from the renewable energy sources. Some car manufacturers in Britain are currently testing “vehicle to grid” systems where the electric vehicles are a part of the energy grid. (15)

There are other solutions as such where the city dwellers are encouraged to adopt more carbon neutral ways of transport by building more cycling infrastructure in the city so that bikes begin to outnumber cars or to redesign the entire city landscapes to be more pedestrian and walkable.

There are many different solutions that target specific intervention points in the energy systems. The question remains, however, how to integrate them all together to build a truly circular energy system for cities.

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(15) Jones 2017, “Energy Systems: How Will Cities Power Themselves", https://progrss.com/sustainability/20170223/energy-systems-circular-cities-power/

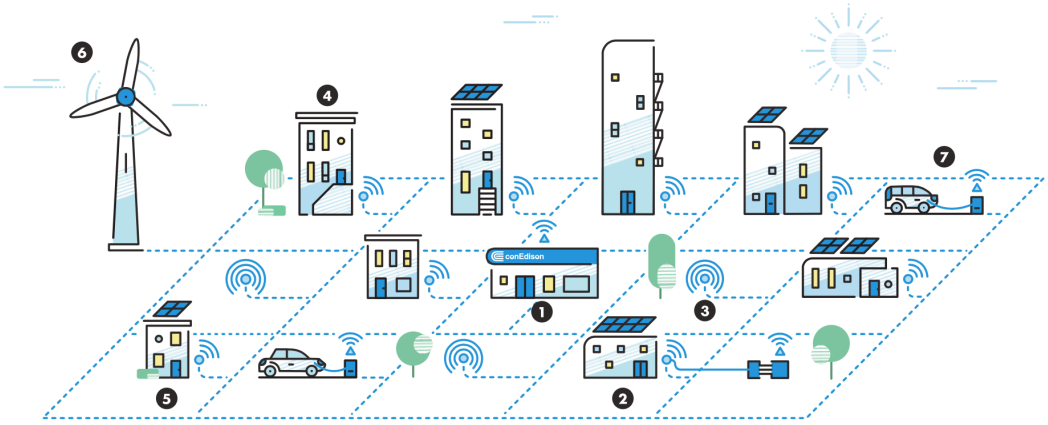

Figure 36: Smart City (from https://www.coned.com/en/our-energy-future/renewable-energy-systems)

2.2.b. The Smart Grid

The Grid Systems are mostly referred as “The Grid” which is a term used to describe the electric grid. This consists of a network of transmission lines, substations, transformers and more systems that distribute electricity from the power plant to the users homes, business’s and other structures. This what allows you to plug in your devices, switch on your lights and power your computers. Todays power grids were built in the 1890’s and as the technology got more advanced through each decade, they have been improved.

Todays grids maintain more than 9,200 units that generate electricity with a capacity that could generate more than 1 million megawatts which are connected transmission lines of more than 300,000 miles. (16)

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(16) Bari and Jiang 2014, "Challenges in the Smart Grid Applications”, “Google Scholar”

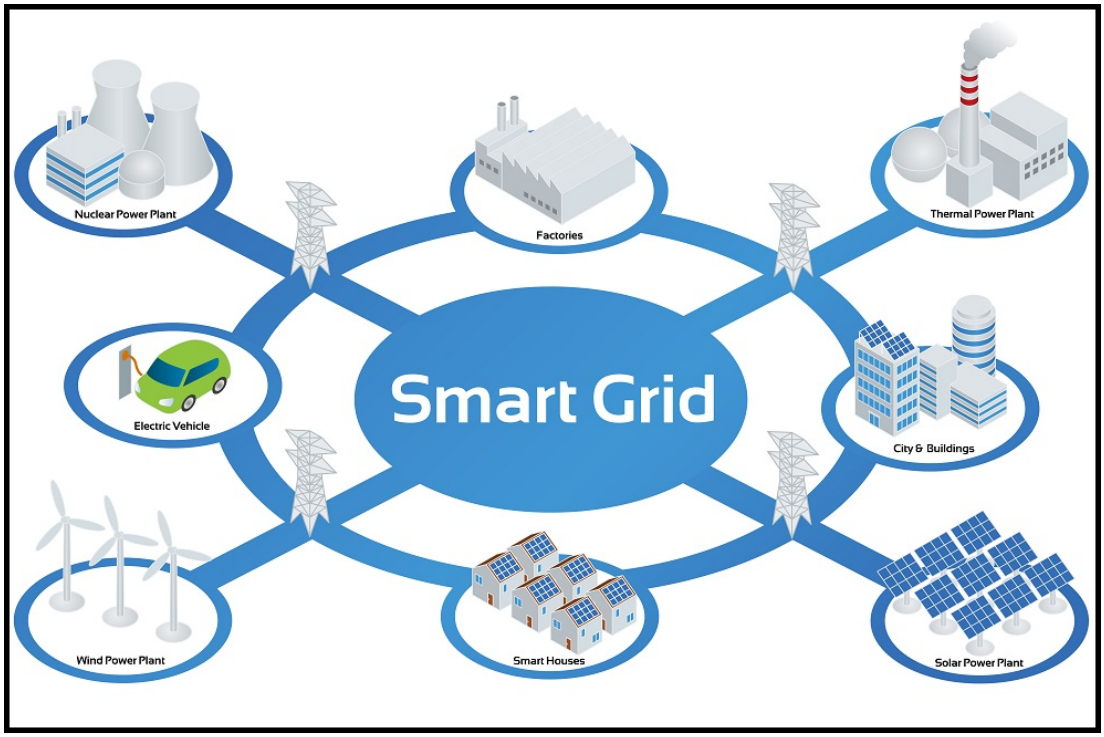

Figure 37: Smart Grid (from https://www.smartgrid.gov/the_smart_grid/smart_-grid.html)

For the adaptation of the built environment with renewable energy, the grid systems hold an important role. There is a need for a new kind of electric grid, one that is built from the bottom up to adapt to the renewable energy systems. A smart grid that could control of digital and computerized equipment and technology dependent on it. A smart grid system can automate and manage the increasing complexity and needs of electricity in the 21st Century which will enable for the city to adapt to the renewable energy systems.

There is an unprecedented opportunity that the smart grids represent which could move the energy industry into a new level, an era of reliability, availability, and high efficiency which could contribute to the economic and environmental health of the societies. While transitioning into this period, it is critical to carry out tests, improvements in technology, educating consumers, developing the standards, regulations, and information sharing between projects to make sure that the benefits we aim from the Smart Grid systems become a reality.

From efficient electricity transmission, to much quicker restoration of electricity after power disturbances, there are many benefits which are associated with the Smart Grid. Some other benefits could be listed as;

- Operations which cost more less costs in the operations and the management of utilities have an ultimately much lower power costs for the energy consumers.

- Much less and reduced peak demands Reduced peak demand, which will also help lower electricity rates.

- More increase on the integration of large scale renewable energy systems.

- More efficient integration for the consumers by the power generation systems with renewable energy systems.

Improvement in the security are crucial to make sure In case of a blackout and such electricity disruption can have a domino effect today. A series of failures could occur which can affect the banking, communications, traffic, and security. This is also a large risk during winter, where the homeowners might be left without heat.

There are many advantages of a smart grid. Such like more strength in the resilience off to the electric power systems, making them better and more prepared for emergency situations such as the severe storms, earthquakes, large solar flares, and terrorist attacks. Because of the interactive capacities, the smart grid allow automatic rerouting incases of when equipment fails or outages occur. This minimizes the power outages and also minimizes the effects of outages of power when they occur. If power outages occur, the smart grid technologies can detect and isolate outages and can contain them before it takes on to large scale blackouts.

The new technologies will also help enabling to ensure that electricity recovery resumes quickly and strategically after an emergency of routing electricity to emergency services first, for example. Also, smart grids allow for the privately owned, renewable energy systems which generate power to enable power produce in cases where it is not available from distributers.

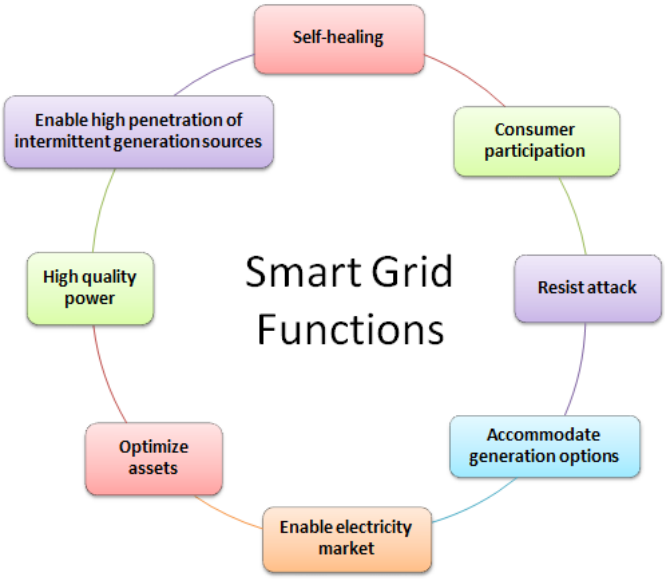

Figure 38: Smart Grid Functions (from https://en.wikipedia.org/wiki/File:Smart_-Grid_Function_Diagram.png)

The combination of the distributed generation resources allows for a community to keep its health centers, police departments, traffic lights, phone Systems, and grocery stores operating in cases of emergencies. Also, in addition to these cases, smart grids are capable to address the energy infrastructure that age which require to be upgraded or replaced. This allows to address the efficiency of power in the energy utilities and increases the awareness for the consumers about the connection between electricity users and the environment. Also, to bring and increase the national security in the energy systems, moving on with larger amounts of home-generated power is more resistant to natural disasters and other emergent cases..

2.3 The status of cities in terms of Renewable Energy

For the future of a smart built environment where there is a successful integration with the renewable energy systems, a sustainable and efficient urban infrastructure needs to be built where it wişlll allow smart cities that provides a high quality of life to its inhabitants through smart management of its resources by using the renewable energy systems. Renewable Energy Systems allow for the energy to be managed.

The management of Energy is one of the most demanding issues to allow smart urban centers owing to the complexity of the energy systems and their vital role. For this reason there is significant effort and attention that needs to be dedicated to these problems. The simulations and modelings are one of the most important tools which are most commonly used to assess all technological and policy vise impacts of smart technological solutions. Also, in order to plan the best solutions for shifting the todays cities to smarter ones in the future.

The integration of the built environment with the renewable energy systems allow for the transition to renewables cuts across the urban system, the energy landscape, from buildings to transport, to industry and power.

Renewables brings many tremendous advantages and benefits to the cities Cleaner air, modern services and improved living spaces are only some of them. Meanwhile the cities are highly important for the transition of a low carbon economy, consuming 65% of global energy use and 70% of the carbon emissions.

More than 100 Cities Worldwide are powered primarily by Renewable Energy. All of these cities generate more than 70% of their power from wind turbines, solar and other types of renewable systems generating clean power. Since the Paris climate agreement renewables have been gaining more popularity. (17)

With the accessibility and price drops on renewable energy systems, more cities are changing the way they consume fossil fuel based electricity.

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(17) Irena 2016, “Renewable Energy in Cities”, http://www.irena.org/publications/2016/Oct/Renewable-Energy-in-Cities

The full list of renewable energy cities

Akureyri, Iceland	Curitiba, Brazil	Montreal, Canada
Alba-Iulia, Romania	Dar es Salaam, United Republic of Tanzania	Nairobi, Kenya
Alcaldía de Córdoba, Venezuela	Estância Climática de São Bento do Sapucaí, Brazil	Nakuru, Kenya
Angra dos Reis, Brazil	Estância Hidromineral de Águas de São Pedro, Brazil	Niterói, Brazil
Aparecida, Brazil	Estância Turística de Guaratinguetá, Brazil	North Vancouver, Canada
Aracaju, Brazil	Estância Turística de ITU, Brazil	Nova Odessa, Brazil
Arendal, Norway	Eugene, USA	Nyon, Switzerland
Aspen, USA	Extrema, Brazil	Oristano, Italy
Assis, Brazil	Fafe, Portugal	Oslo, Norway
Asunción, Paraguay	Fernandópolis, Brazil	Palmas, Brazil
Auckland , New Zealand	Florianópolis, Brazil	Porto, Portugal
Bærum Kommune, Norway	Foumban, Cameroon	Prince George, BC, Canada
Bangangté, Cameroon	Gladsaxe Kommune, Denmark	Quelimane, Mozambique
Basel, Switzerland	Goiânia, Brazil	Quito, Ecuador
Belém, Brazil	Harare, Zimbabwe	Reykjavík, Iceland
Belo Horizonte, Brazil	Hobart, Australia	Salvador, Brazil
Birigui, Brazil	Ibagué, Colombia	Santiago de Cali, Colombia
Bogotá , Colombia	Inje , South Korea	Santos, Brazil
Bolzano, Italy	Jaboatão dos Guararapes, Brazil	São Caetano, Brazil
Braga, Portugal	Kapiti Coast , New Zealand	São Gonçalo, Brazil
Brasília, Brazil	Kisumu, Kenya	São João da Boa Vista, Brazil
Brotas, Brazil	Lausanne, Switzerland	São José do Rio Preto, Brazil
Brusque, Brazil	León de los Aldamas, Mexico	São José dos Campos, Brazil
Burlington, USA	Limeira, Brazil	Seattle, USA
Cabreúva, Brazil	Lorena, Brazil	Stadt Zürich, Switzerland
Cajamar, Brazil	Maceió, Brazil	Stockholm, Sweden
Campinas, Brazil	Mairiporã, Brazil	Tatuí, Brazil
Campos de Goytacazes, Brazil	Medellín, Colombia	Temuco, Chile
Canoas, Brazil	Moita, Portugal	Uberlândia, Brazil
Capivari, Brazil	Montes Claros, Brazil	Vancouver, Canada
Cascais, Portugal		Vinhedo, Brazil
Caxias do Sul, Brazil		Vitória, Brazil
Cerquilho, Brazil		Wellington, New Zealand
Chorrera, Panama		Winnipeg, Canada

Chart created by Kaan Karabagli by the sources from (https://www.cdp.net/en/cities/world-renewable-energy-cities)

Figure 39: Renewable Energy Cities Chart (from https://www.cdp.net/cities/world-renewable-energy-cities)

A report by the environmental group CDP claims that more than 100 cities worldwide now get the majority of their power 70 percent or more from renewables. CDP tracks the climate related commitments by corporations and governments. 570 cities across the globe where looked at for the report.

According to the reports by the CDP, there are over 40 cities which are powered through renewables entirely. One of these cities is Burlington, a city that which gets its power for electricity from multiple renewable energy systems. A combination use of wind turbines, solar panels, hydro and biomass facilities are used to power the city of Burlington. (18)

2.4 Looking into Sustainability in the built environment

Looking back in the past, renewable energy or sustainability has not been popular always and was not an important topic in the studies of urbanism.

The importance of an integrated approach to cities that are developed in a sustainable way as well as looking at cities as ecosystems, to their footprints, urban heat islands, and others gained popularity with the modern city of Le Corbusier, Frank Lloyd Wright's Broadacre city and with other megacities projects in general.

Its starting to be seen more commonly in cities where there is attention for greening the city, using renewable energy and recycling wastes. Also, sustainable forms of mobility is gaining more popularity. Many perspectives, visions and conceptual practices have been developed, since the rise of sustainable awakening. Taking sustainability into account in planning and designing cities in one way or another is crucial for the sustainable environments in cities which leads to a more healthy integration to the renewable energy systems. (19)

There are different periods showing how the concepts of sustainability have evolved over time. These periods are listed as in 7 types. (Figure 40).

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(18) Gustin 2018, "More Than 100 Cities Worldwide Now Powered Primarily by Renewable Energy", https://insideclimatenews.org/news/27022018/renewable-energy-cities-clean-power-technology-cdp-report-global-warming-solutions

(19) Roggema 2016, "The Future Of Sustainable Urbanism", "MDPI, Basel"

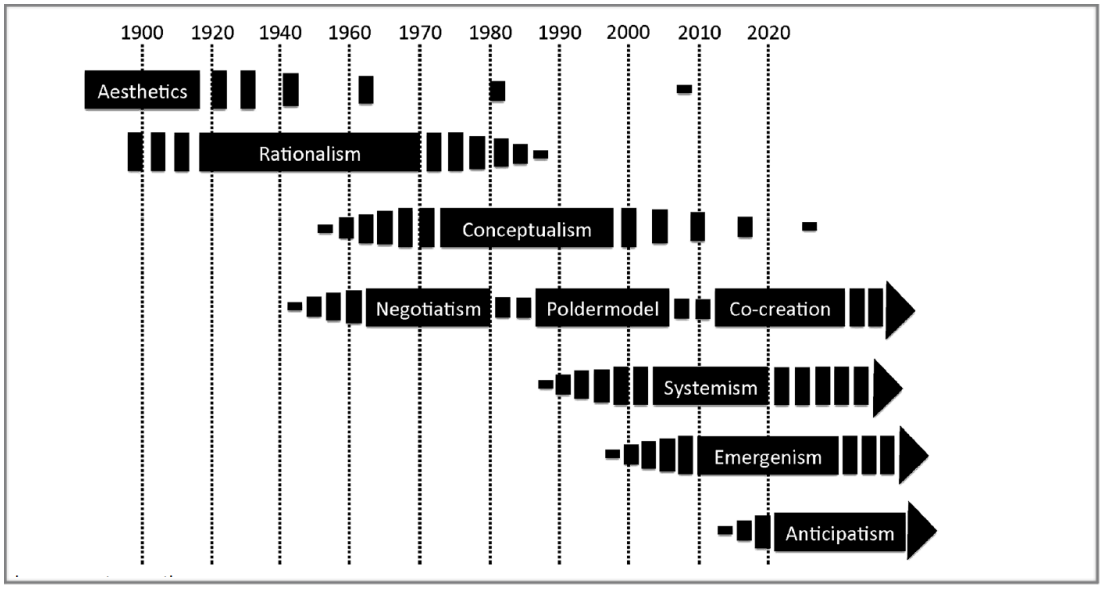

Figure 40: The seven Periods of Sustainability and shifting Concepts Over Time (from Roggema 2016 Article, The Future Of Sustainable Urbanism)

3 METHOD OF APPROACH

3.1 The Current situation of sustainable urbanism

Sustainable Urbanism is a term that has recently started to be used in urban design and city planning. In the contemporary city and metropolitan environments, the infrastructure studies of sustainability and integration to urban design and energy in a rapidly urbanizing world, terminology of sustainability benefits from the debates around the definition and meanings of what is renewable and the definition of sustainable city. This lacks a comprehensive understanding of urban infrastructural design.

Sustainable urbanism is defined as “walkable and transit-served urbanism integrated with the buildings of high performance infrastructure” (Figure 41).

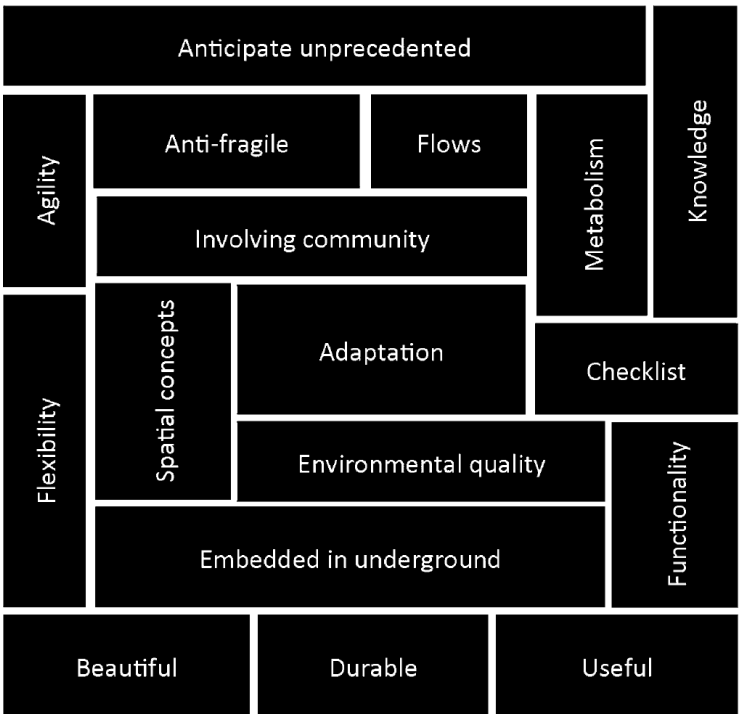

Figure 41: The strengths of sustainable urbanism (from Roggema 2016 Article, The Future Of Sustainable Urbanism)

Density and the human access to nature are two important questions to be considered for the core of sustainable urbanist values (Figure 42). Questioning the density and compactness as to become really sustainable is crucial for cities survival.

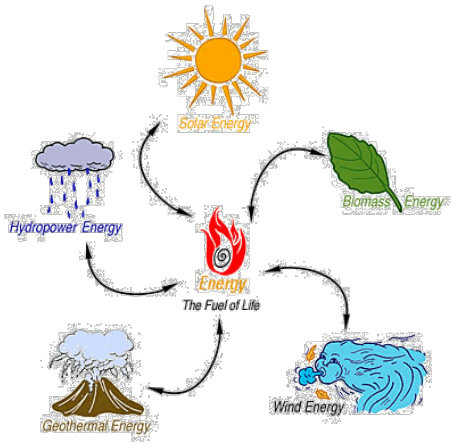

Figure 42: Energy Cycle (from https://melbournechapter.net/energy.html)

Still today, sustainability in urbanism focuses on the design of urban environments which aims to implement sustainable solutions through urban design. The Built Urban environments have uncertainties for the generation and sustainability of power (Figure 43). Renewable energy holds a strong place on the leading cities of sustainable urbanism. (20)

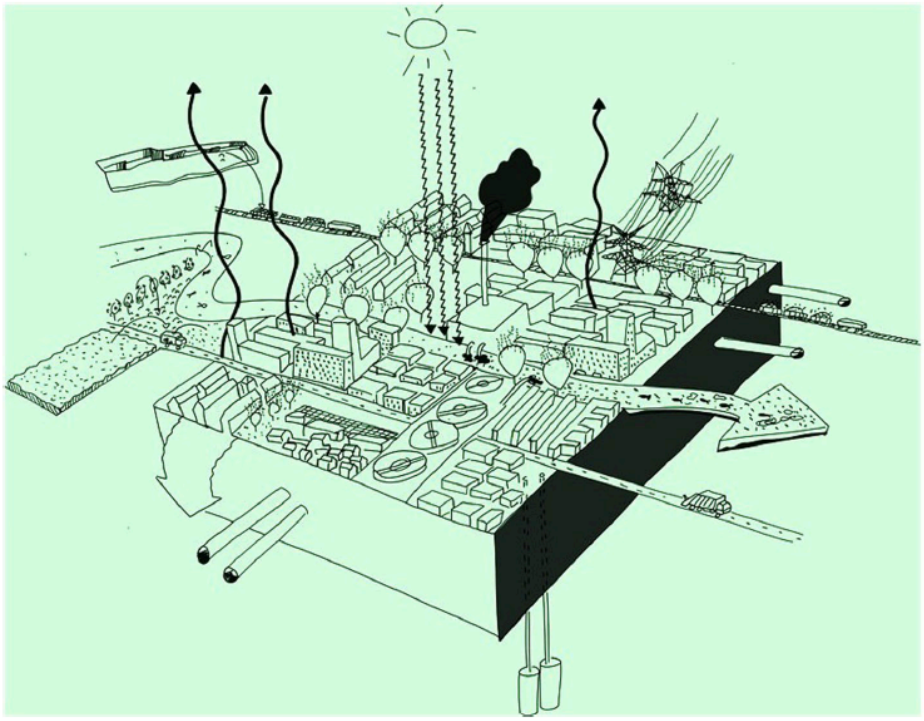

Figure 43: Energy Cycle in the City (from Dirk Sijmons /Jutta Raith, H+N+S Landschapsarchitecten)

3.2 The Current Role of Renewable Energy Systems in cities

There is a connection between the transition towards a renewable energy (Figure 44) future and the transition to sustainable cities where both are deeply related topics to one another when presenting a major challenge for research and practice. Sustainability measures are taken for the individual buildings. We could see this as an increased insulation levels for the building or as a solar energy based provision.

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(20) Stevens 2010, “Defining Sustainable Urbanism: towards a responsive urban design”, ”Scholars Middle East Publishers, Dubai”

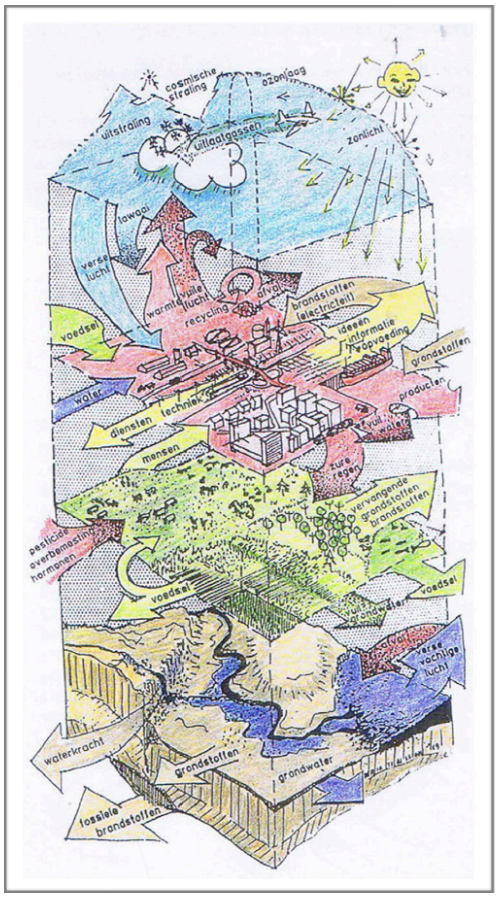

Figure 44: The environmental urban model (from https://www.fastcompany.com/40536335/watch-the-growth-of-cities-using-100-renewable-energy)

The integration to renewable energy systems can be observed through looking on different scales to the built environment. In some urbanized areas, it is the best solution to build solar farms outside the city for an efficient power generation and distribution. This would be a smarter approach than installing photovoltaic or solar panels on each individual building of the same district. There are multiple measures to consider such as location, land use pressure, spatial quality, orientation and shading. (21)

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(21) Pellorosso and Gonattoni 2014, “Sustainability and Planing. Thinking and Acting According to Thermodinamics Laws”, “INPUT"

4 DISCUSSION OF RESULTS

4.1 The discussion for Renewable Energy Systems in the daily life

About 70% of carbon emissions come from the cities which is why it is important to take account the cities role and function in consuming energy in order to fing solutions for the climate change. (Figure 45) The Sierra Club says if the whole U.S. Conference of Mayors, representing 1,481 cities, committed to 100% renewables, it would have a bigger impact than if the whole U.S. followed through on the Paris Agreement.

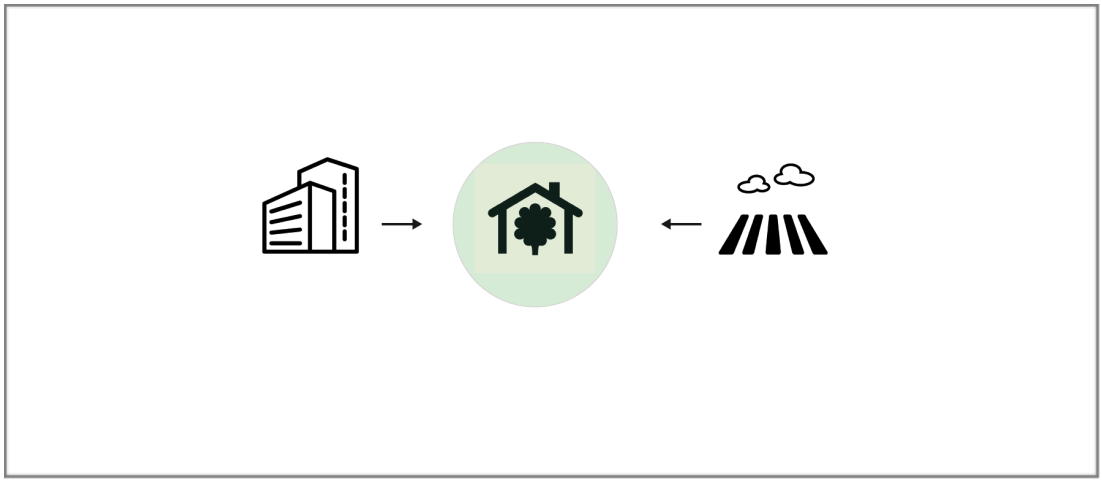

Figure 45: Renewable Energy Integration to the city (own figure)

Though somewhat aspirational, targets and commitments send a signal, says Appleby. It is important to make awareness that power utilities should transition into cleaner energy. It is important that energy consumers like the businesses and households to start switching. It is also a stand that cites and states start mandating the public buildings start switching to renewables. A city that could be example for that is San Francisco where it mandates that 15% to 30% of new roof space has to have solar panels or green roofs. (Figure 46)

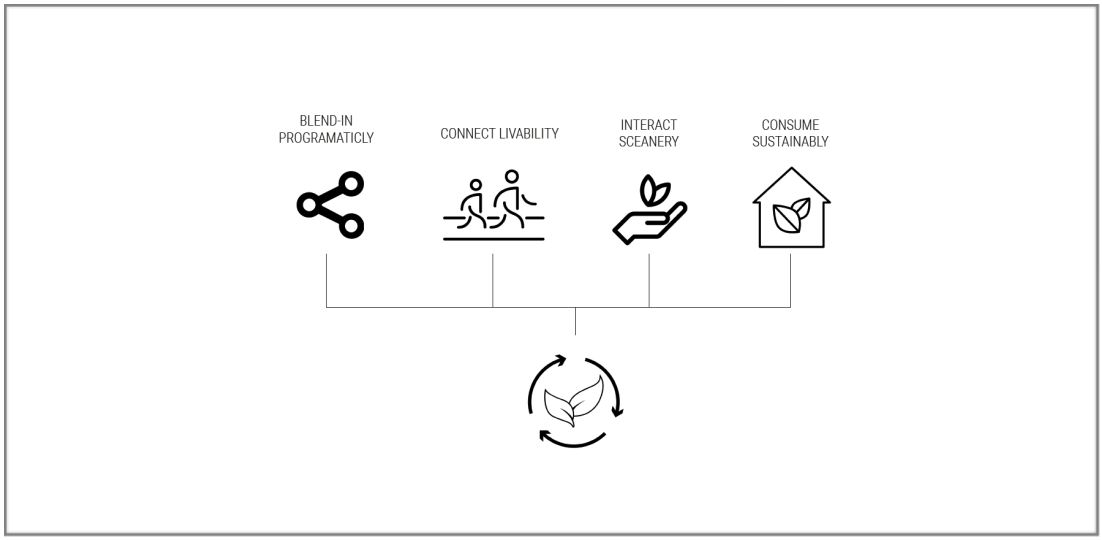

Figure 46: Renewable Energy Integration to the infrastructure (own figure)

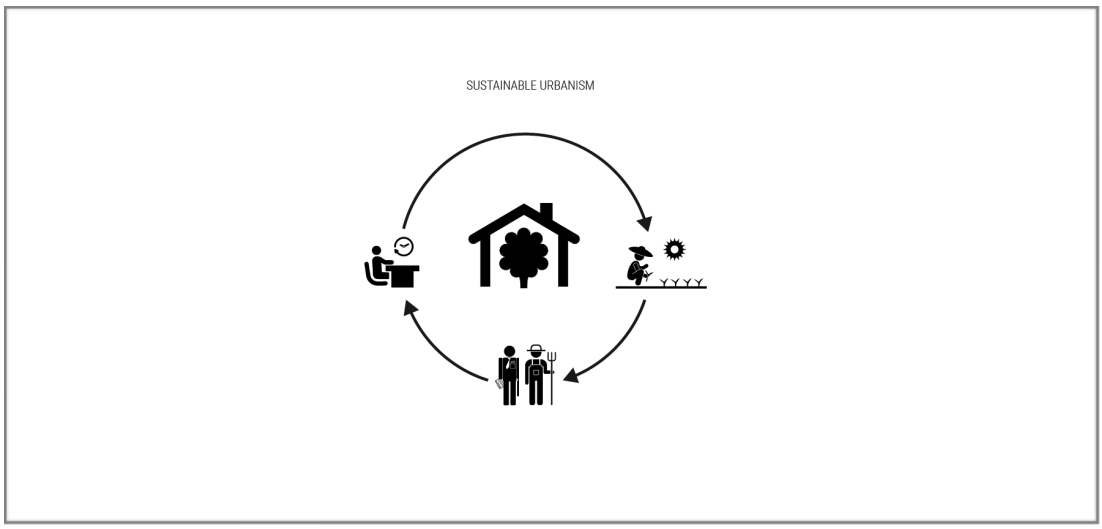

Figure 47: Sustainable Urbanism (own figure)

Sometimes policies and mandates by the governments don't work. In such cases, the cities are able to stoke demand. In some cities and towns in Britian, large campaigns were started such as "Big Clean Switch" where households where promised to have savings on their power bills if they switch to clean energy rather than fossil fuels (Figure 48). When cities do not make the act to raise awareness for switching into renewables, citizens have power to demand renewables by getting households to switch to clean tariffs. (Figure 47)

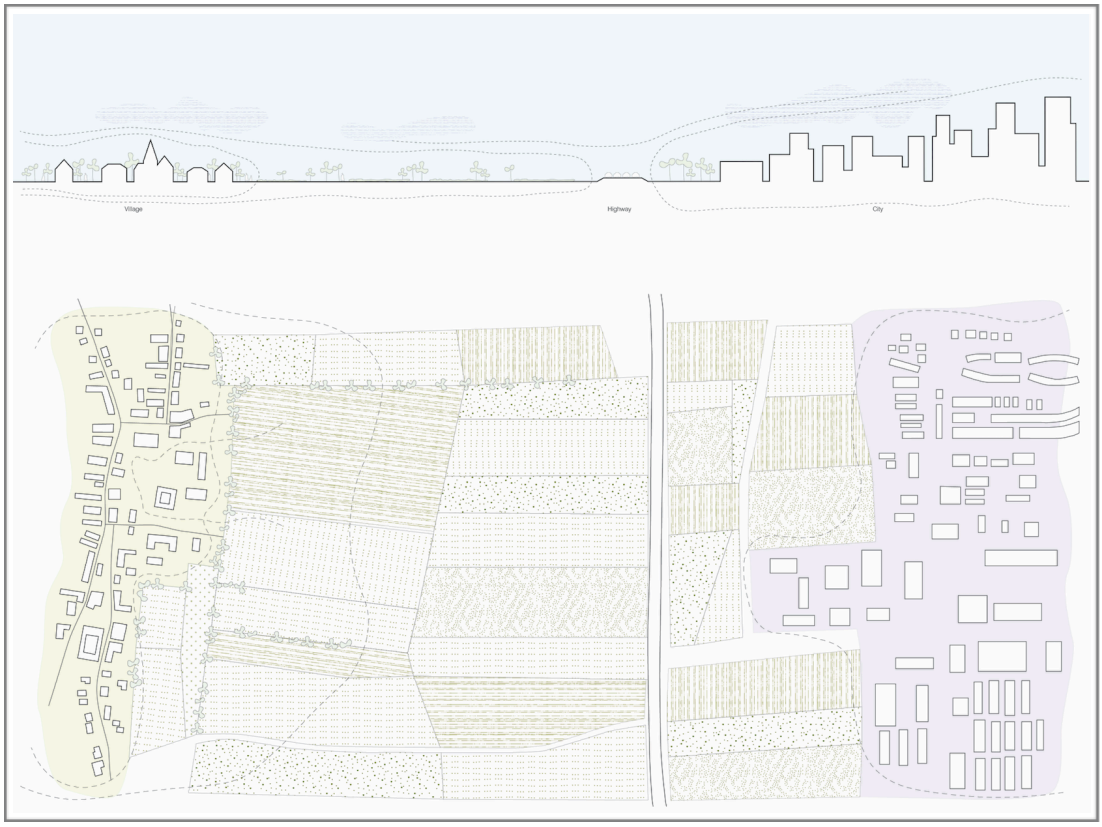

Figure 48: Powering the city, Renewable Energy Integration to the city (own figure)

When we look at the discussion on which systems are used and which Renewable energy systems are the most commonly used ones, Hydro is the most commonly used system. While the reason behind this can be due to the availability of its technology going back to a much longer time frame, today the popularity of hydro energy has went to a much lover level compared to the other trending technologies like solar and wind. (22)

The reason behind this is mostly the ecological affects hydro power facilities have. Looking at the time frame and cost of its construction, hydro energy again goes behind the other replacing technologies.

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(22) Schiller 2018, “The Growth Of Cities Using 100% Renewable Energy”, https://www.fastcompany.com/40536335/watch-the-growth-of-cities-using-100-renewable-energy

Figure 49: Solar Grid (from https://renewablesnow.com/news/adb-providing-funds-for-42-mw-of-utility-scale-solar-in-indonesia-613776/)

The renewable renewable energy systems of today, besides the independent solar panels that some buildings have and the silhouettes of the wind turbines, we do not see the renewable energy systems visually as much as their inputs to our daily life. Even while they're not apparent in the daily life of people living in the cities, visually they are a big problem for many. (Figure 50)

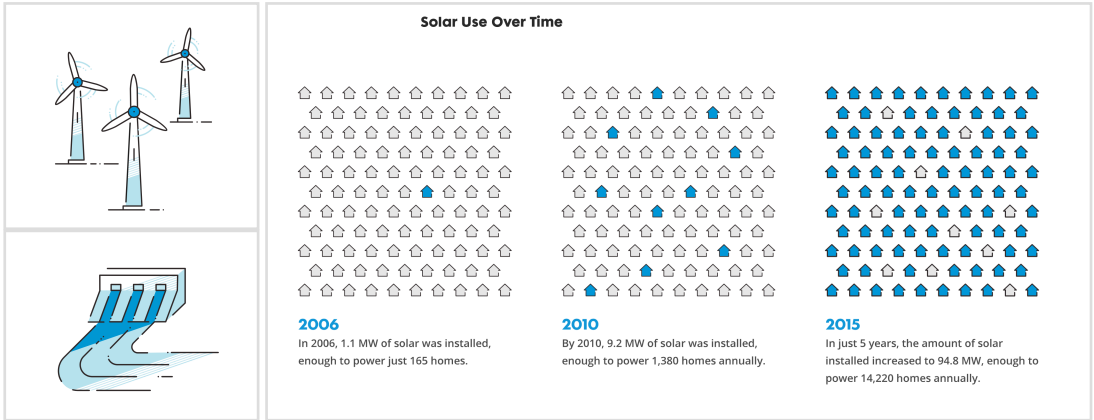

Figure 50: Renewable Energy (from https://www.coned.com/en/our-energy-future/renewable-energy-systems)

Renewable energy systems brought into the city, have not been successful interns of integrating due to the progress of the evolution of the infrastructure of the grid systems and the reasons of design evolution of the systems as much as they should have been. Design is a big part of life, in order for technology to integrate into the city and peoples life, they must be design vise be evolved as visually as interns of their technological evolution. (Figure 51) With that in mind, it is obvious to see renewable energy systems are not in the city anymore.

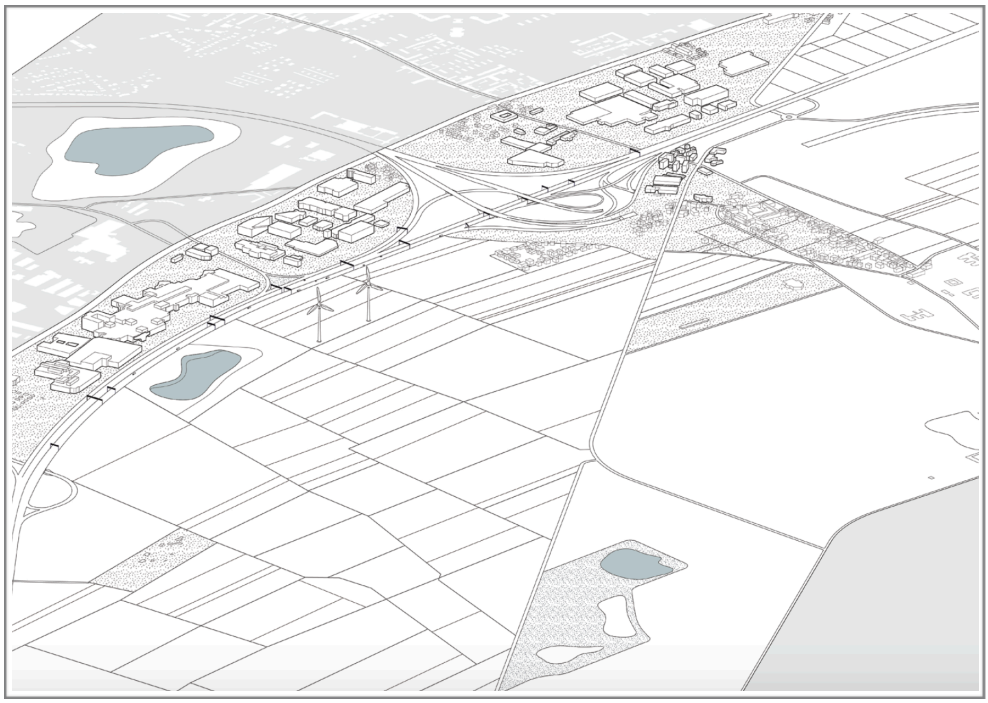

Figure 51: Energy Farms (own figure)

The outskirts of cities and rural sites are the common grid centers for renewable energy systems. Design and also access to sources are the reasons behind it. Still, the better renewable energy systems become a part of peoples daily use of energy, the better. Which brings up the question, are renewable energy systems just a part of the engineering field? Definitely not! It is a multidisciplinary field which must be considered more in its definition of a multidisciplinary culture.

As renewable energy becomes a cultural use, and integrates with in the daily used technology, it will be more substantial for the people. (Figure 52)

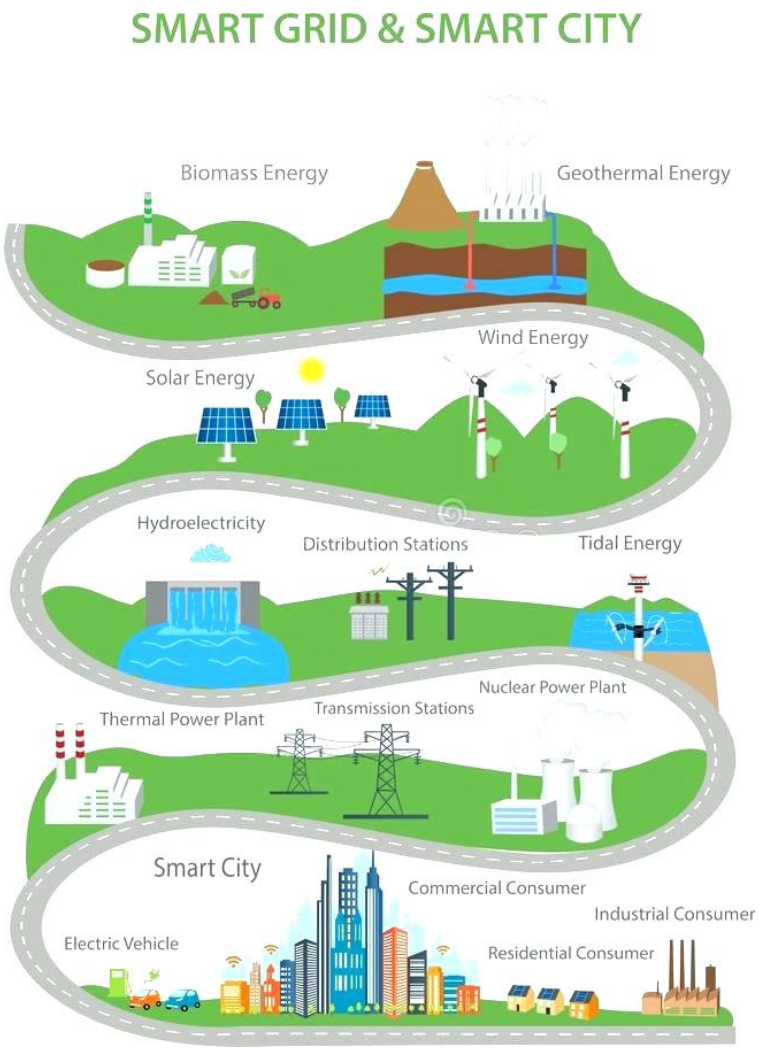

Figure 52: Smart Grid and Smart City (from https://www.fastcompany.com/40536335/watch-the-growth-of-cities-using-100-renewable-energy)

5 PRESENTATION OF THE RESULTS OF THE THESIS

As a result of the thesis the sustainability in the built environment has been reconsidered and the aspects of the integration of renewable energy systems have been visualized for presentation of the future built environments.

In Figure below (Figure 53) we see the important components for the production chain. Production chain is an important part of the energy cycle and how we create energy. As much as the production of energy through renewable energy systems, it is very important that renewable energy systems are integrated with the production chain elements such like the agricultural/food production, aqua body (rain water), connectivity systems, etc.

Figure 53: Production Chain Elements (own figure)

The Energy Environments of our production chain layout in our habitats of urban space and rural areas. The figure below (Figure 54) exposes the elements of our environments creating our energy environments.

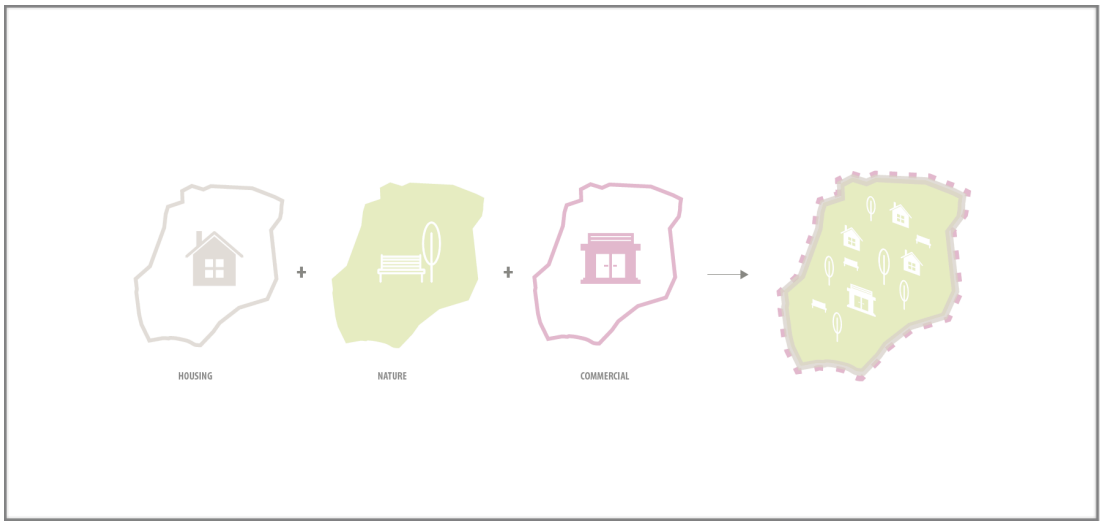

Figure 54: Energy Environments (own figure)

6 SUMMARY & CONCLUSIONS

For the future built environments to function, renewable Energy systems and the way they integrate to the grid will play an important role. Cities are complex systems, that are made up of technical, social and physical elements that interact as an ecosystem. In case of any problem that could go wrong with such a complex system as the city, it takes a long time to re-systemize the urban structure. For this reason, the changes on the infrastructures of the cities must start from today.

The main energy source of the city are Electricity. Electricity powers the cities. The future smart cities will be no different interns of its reliance on Electricity. The relationships for powering the future city will change with the integration and adaptation to new energy sources. Renewable Energy systems will be the main energy resource of the future cities. The integration of renewable energy systems with the cities play an important role especially when it comes to integrating to the distribution centers and grids. The smart grids which cut back on energy usage by delivering power only where it is needed, already have started being integrated to the infrastructure of the cities and are quickly supplanting older grid systems in many countries, and the intra-city grids offer even more development.

As the growth in population is increasing all around the world the consumption of energy is and demand are getting higher as well. This brings up the importance of new energy resources. Renewable Energy systems are the constant answer for this resource which will allow for further energy production. With the future of the cities becoming smart and integrating with the Renewable Energy Systems, power generation will change. By switching integrating to renewable energy systems like solar farms, the switch into clean energy technologies will allow for cities to not have to rely on fossil based energy any longer.

Renewable energy is obtained by the natural processes that are continuously replenished. The different systems of renewable energy are derived directly with the sun, or from heat generated deep from the earths core. The electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources is the main outcome of Renewable Energy Systems. The renewable energy technologies are the solar power, wind power, hydroelectricity, micro-hydro, biomass and biofuels.

According to global status report 2007, about 18% of global final energy consumption in 2006 came from renewables, with 13% coming from traditional biomass, such as wood-burning. Hydropower was the next largest renewable source providing 3%, followed by hot water/heating which contributed 1.3%. Renewable Energy systems like geothermal, wind, solar, and ocean energy are providing about 0.8% of the final energy consumption. For this reason the renewable energy systems have the extreme potentials, more than all other available sources.

Most of the energy systems work the entire energy supply chain from energy generation to use. Energy systems make sure of the streets to be lit at night, for our waters to be clean and that the wastewater is treated, so that our factories can produce goods and our metros can run. In order to have a circular system, the energy systems in cites must make challenges like increasing the demand. It is expected that by the year 2050, about 25% of human population will be living in cities. This requires to come up with solutions on storing energy, redesigning transportation systems, and improving efficiency on consumption of energy. With that in mind, people are also moving into cities day by day. For this reason, it is high priority that cities become smarter and integrate with the renewable energy systems which will allow for it to produce and sustain its energy.

Cities demand power, heat, electricity, These demands can be decreased with sustainable solutions on our buildings and changing the way we consume energy. We can install renewable energy systems to our buildings like solar thermal collectors and photovoltaic systems, especially in locations where there is direct access to enough sunlight. Other Renewable Energy systems are also gaining more importance. Other renewable energy systems like the wind turbines, biomass and hydrogen can be also integrated into our built environments and by minimizing the use of fossil based energy sources. There are multiple benefits of Renewable energy systems such as sustainable and secure energy supplies and long life span of energy sources. The reason behind the popularity of solar energy systems is due to the fact that solar technology is a very friendly one in environmental terms for buildings and for the urban environments.

Solar Energy Systems can be applied to buildings in many various ways and in more harmonic gestures on buildings to cover the heating, cooling, electricity and lighting needs. They can be applied on to the building facades and on to the roofs whether they are flat or inclined. Also buildings like hotels, malls and sport centers have the opportunity to use solar panels by installing them on to their ap-

propriate surfaces Switching to solar energy systems is extremely important for the economies of most countries as they allow to replace the expensive and imported conventional energy sources like oil, gas, coal and nuclear fuels.

Renewable energy sources and the nuclear energy can be considered the alternative energy sources to avoid greenhouse effect. Renewable Energy sources are clean and not harmful for the environment, where they can also be easily used with minimum market trust and ownership undertaking.

Looking back in the past, renewable energy or sustainability has not been popular always and was not an important topic in the studies of urbanism. Renewables brings many tremendous advantages and benefits to the cities Cleaner air, modern services and improved living spaces are only some of them. More than 100 Cities Worldwide are powered primarily by Renewable Energy today. As renewable energy becomes a cultural use, and integrates with in the daily used technology, it will be more substantial for the people.

7 OUTLOOK

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7.2 List of Figures