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DESIGNING FLEXIBLE OPEN SPACES WITH ENERGY EFFICIENT SOLUTIONS FOR A RESILIENT BEIRUT - CASE STUDY OF RMEIL MEDAWAR DISTRICT

Nehmat Karim
PhD Candidate, Faculty of Architecture - Design & Built Environment, Beirut Arab University, Lebanon,
nehmatkkarim@gmail.com

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Abstract

A news supplement produced by UNDP “Peace Building in Lebanon”, distributed along with An-Nahar newspaper had published in its December 2020 issue an article entitled “Urban Vacant Parcels as Opportunities to Reclaim Public Spaces in Times of Crises and Austerity” highlighting on the following: While Lebanon experiences a multiple crises and people are struggling more every day, solidarities are urgently needed and spaces where people can meet and connect would play a key role in this matter. Adding that Beirut, the capital, is considered a dense and rapidly urbanizing city, where shared spaces are scant, poorly designed, and ill managed. The current situation and stresses have contributed to the degradation of the urban environment and transformed neighborhoods in drastic ways at the expense of public life. However, the neighborhoods comprise a lot of vacant properties (built and inbuilt) includes public staircases, pedestrian alleys and building entrances neglected gardens and parks that holds a valuable opportunity for rethinking the public spaces. The aim of the study is developing design guidelines to obtain flexible open spaces and achieve urban resilience in densely populated areas using green technology. The main objective of the study is to enhance cities’ resilient factors through applying urban interventions into the public realm elements that contribute to achieving flexible open spaces, to identify the applicable green technologies that are most suitable for creating energy- producing open spaces in highly dense areas, and to achieve a balance between the aesthetic aspects of spaces and the needs and perceptions of residents using the participatory design approach. This paper is based on literature review, analytical quantitative study. In addition to a comparative analysis of international case studies done that helps in deducing the convenient tools that can be relied upon in the case of Beirut. The purpose of this paper is to emphasize that urban interventions based on modern technologies that are considered supporters to the urban lifestyle, i.e., green technology that involve: environmentally friendly, self-replenishing and non-polluting sources can work on stimulating the spatial practices and the public life through facilitating sustainable development for physically damaged congested – historic Beirut’s neighborhoods.

Keywords

Urban Resilience, Green Technology, Flexible Open Spaces, Renewable Resources, Energy Generation

1. INTRODUCTION:

According to the UN- Habitat response plan, as mentioned in a publication "Pandemic Recovered in Urban Settings: Planning for the Unplanned" published on the 28 of Oct.2020, that urbanization has a very important role in increasing most pressing global challenges over the last decades. Also, cities and towns with densely populated areas and deprived areas that suffers proper access to basic infrastructure facilities are places that continue to provide a ready channel for the reawakening of pandemics and ecological crises. Rapid population growth together with irreversible urbanization had created a significant challenge to both natural and built environment in urban areas. In addition, *UNISDR* [A] *(2012)* had mentioned that planning strategies of spatial elements has a great influence on the natural and built environment as they are directives of city's ability to absorb and recover from the effect disaster. Furthermore, to enhance the city resilience through interventions, the focus can be given on various spatial elements of a city such as parks, plazas, pedestrian pathways, streetscape, streets, gardens, waterfronts, building interfaces and infrastructure. For this reason, open public spaces are considered an important element in the process of *Urban Regeneration* [B] *(Mir,1986).*

Cities have to be developed not only in term of sustainability, since cities are facing more challenges in regards to dealing with extraordinary events of natural causes, terrorist attacks and socio-economic changes. However, spatial urban interventions in public spaces help in converting them into flexible spaces that have the ability to be suitable with extraordinary events where these events include all types of natural and human made disasters, crises and socio-economic and environmental changes. Therefore, flexible public spaces perform as a protection valve for cities in case of extraordinary events and act as vibrant and sustainable spaces that transfer social, economic and environmental functions (*Elewa, A., 2019*). "By developing sustainable public areas, we can both improve the urban environment and save resources for future changes, as people needs and experience evolve"; *Lilly Miller*. Furthermore, Cities are developing innovative public projects, merging the benefits of green energy innovations with ambitious infrastructure re-use. Where the use of these advanced tools has a positive impact on the people and places. Implementing of green technologies into spatial planning process works on finding new ways to achieve sustainable development through reducing the negative impact of human activities on the environment and moving toward development supported by green and eco-friendly ways of life in urban areas.

"Amid the COVID-19 Outbreak in Early 2020, Energy Efficiency have become a Key Part of the Country's Recovery Plan". *IRENA* [C] *2020*

In regards to Lebanon, as described by the World Bank Group, a country that can be described as a territory of untapped potential and compounded endemic crisis with the recent events lately have contributed in exacerbating long-lasting challenges in the area that had been ignored for a long time. Currently, Beirut the capital is facing a number of intersecting social, economic and environmental challenges caused by: The Syrian refugees; lock down that is resulted from the outbreak pandemic and lately the physical and health damage caused by the explosion of the port on the 4th of August 2020.

The purpose of this study is to highlight on several forms and types of green technology that may interfere in the regeneration of public open spaces. Also, determining best areas for the application of green technology in the public realm. On the level of Beirut, the use of green technologies as advanced innovations that involve natural resources that are environmentally-friendly, self replenishing and non-polluting that would work on creating spaces more resilient, livable and capable to absorb disasters impact while maintaining historical features of the city.

(Any Abbreviations and Terminologies Mentioned Above Are Explained on the Last Page of the Paper).

2. METHODOLOGY:

The research is based on a Theoretical Study and a Comparative Applied Analysis; A mix method between quantitative and qualitative is used. The Methodology of the Theoretical Part, is a qualitative method. The Methodology of the Analytical Part, is a qualitative and quantitative method. This part is divided into two main sections. The first section, is a Descriptive analysis,

the Second section is a Comparative Study, analysing and evaluating three international cases in three Sweden neighborhoods.

Finally, based on the theoretical study (literature and theories) and analytical study (comparison and application) guidelines will be developed accordingly. The diagram below summarizes the report methodology showing the content of each section and the tools used for data collection as well.

Fig.1: Research Methodology Showing Data Collection and Methods Used in the Theoretical and Analytical Part. Source: Researcher.

Theoretical Study: Four fields are of particular relevance to this report; (1) classification theories of open spaces, (2) urban flexibility, (3) urban resilience and (4) green technology innovations as an urban intervention. The aforementioned fields and their terminologies, provide the foundations for the study as well as strengthen the analysis presented in the sub sections below.

3. URBAN OPEN SPACES WITH GREEN INNOVATIONS AS A KEY FOR CITIES RESILIENT:

a. **Urban**

i. **Definition of Urban Resilience or what is called resilient cities:**

Urban resilience or what is known as resilient cities, is considered as a trending issue in the field of urban development. Urban resilience can be defined as the capacity of an urban system to absorb disturbance, while continuing in providing socio-economic and environmental functions. Moreover, in 2009 Hamilton, W. defined urban resilience as the ability to recover and proceed in providing the major functions of living in the face of hazardous issues. In regards to Desouza and Flanery in 2013, mentioned that it is the ability to absorb, adapt and respond to the changes in the urban system of cities.

ii. Definitions and Classifications of Urban Open Spaces:

Urban Open spaces are related to the social, political and physical health of urban habitants and communities. Moreover, open spaces had been defined as any unbuilt land, that has the potential to allow social, economic and environmental benefits to societies, through a direct and indirect way (Campbell, 2001). Al-Hagla (2008) had classified open spaces, defining the green spaces as vegetated land and grey spaces as hard surfaced. In Al-Hagla's scheme, the green spaces are any vegetated land or structure, water or geological features within urban areas. However, the grey spaces refer to more civic oriented spaces as urban squares, market places and other paved or hard landscape areas.

iii. Principles of Urban Flexibility and Urban Resilience:

The term flexibility refers to a system ability not to bend to changes and modifications, being compatible to different conditions (Till and Schneider, 2005). Urban flexibility in public spaces is deeply linked to the achievement of urban resilience in cities. Flexibility can be defined as the ability of urban system to comply to changes in the environment (Beirão, J., 2011). Flexibility and resilience, both share the same concept which is a system ability to deal and cope with changes or crisis. Furthermore, urban flexibility is considered as a driver of urban resilience. Hence, urban flexibility is a strategic urban tool that allows the use of available urban resources as public spaces in a way making them capable to meet the daily regular needs of users and the unexpected needs that may arise during crisis or unexpected events (Sanei, M., et al, 2018). Based on OECD D "A flexible urban system helps people, government and communities to modify actions in a way responding rapidly to changes". Thus, flexibility in public spaces is a necessary tool and a basic element not only to deal and adopt with crisis and issues but also to improve physical and functional features (Sanei, M., et al, 2018). Therefore, creating flexible public spaces for urban resilience is a mix of principles of urban flexibility and urban resilience as following:

Table 1: Principles of Urban Flexibility and Urban Resilience Source: E. Ahmed Khaled Ahmed, Flexible Public Spaces through Spatial Urban Interventions, Towards Resilient Cities,2019.

These spaces must be permeable; through being well connected physically and functionally with the urban context *(Ardeshiri, et. al, 2016), (Fallah, m., et., al, 2014).*
Spaces must be designed in a smart way to be able to transform to new spatial arrangements in emergency cases (*Sanei, M., et., al,2018*).
These spaces must be designed on the scale of a city; this means to deal with flexible public spaces as a network (*Fuentes, C., and Tastes, M., 2015) (Allan, P., AND Bryant, M.,2010*).

(Any Abbreviations and Terminologies Mentioned Above Are Explained on the Last Page of the Paper).

b. Green Technology as an Urban Intervention in Open Spaces:

i. Benefits and Types of Green Technology with Renewable Energy Sources:

Green energy is derived from natural resources, renewable and clean. Renewable energy as defined by The International Energy Agency IEA 2008, is obtained from natural processes that are replenished constantly. Renewable energy (RE) is the useable energy from natural resources mainly from sunlight, wind or energy generated and stored in the earth or naturally replaced in a suitable manner on a human timescale such as energy derived from wood. Hence, Green energy that is generated from the benefits of integrating green innovations with open spaces are diverse as it can offer economic, social, cultural and environmental benefits. However, Energy is one of the most important elements upon which life depends in modern cities and considered main engine of activities in the cities. It also considered the main cause of environmental problems in the cities since it is produced from non sustainable resources. Thus, the production of energy through using green technology is very important for achieving resiliency in cities. Consequently, open spaces with green innovations as energy generating furniture, materials, devices and systems can convert underutilised public open places into renewable ones as the following:

a- Asphalt Energy Storing and Generating Systems:

This technology uses the principle that at a certain underground level, the ground has the ability to store thermal energy for a long period of time. Warm storm circuit water will run to an underground ``warm energy`` store, this heat stored in the warm energy store and used during the winter. This system provides energy supplement and streets that will be cooled as well. Therefore, the outdoor environment will be better for people using it. Following the shutdown of Heathrow airport London in 2010 due to an extreme weather event lead to froze the infrastructure; Icax system had proposed a method that had been applied and tested in Hiroshima keeping the road ice free for two years. Moreover, these systems are mainly based on using the thermal energy for snow melting during winter to avoid road freezing and reduce heat retention in summer time.

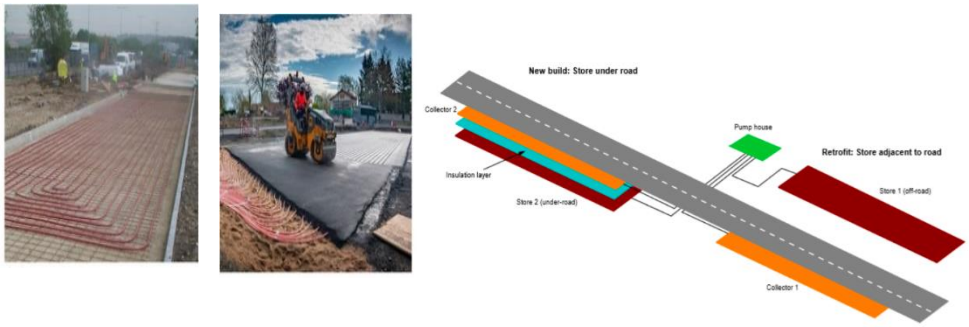


Fig.2: Icax prototype and 3D schematic view and the pipework installation.

b- Footsteps Energy Saving and Generating Pavements:

It consists of pavement blocks with embedded piezoelectric elements. The pavements blocks can be applied in urban areas where large number of pedestrian can generate electrical energy that can be used for lighting, way-finding routes, traffic lights and others. These pavements can be applied on streets, stations, pedestrian crossing, events and so on (Lopes-Ferreira,2012).

One of the most exciting innovations on London's Bird street in the heart of London's west end is the use of Pavegen Technology, generating data and electricity from the pedestrian movements. A 10 square meter array of an energy generating walkway which will initially power lights and bird sounds and also provide an energy data feed. This street is considered a place where retail, fashion and lifestyle meet technology and innovation.

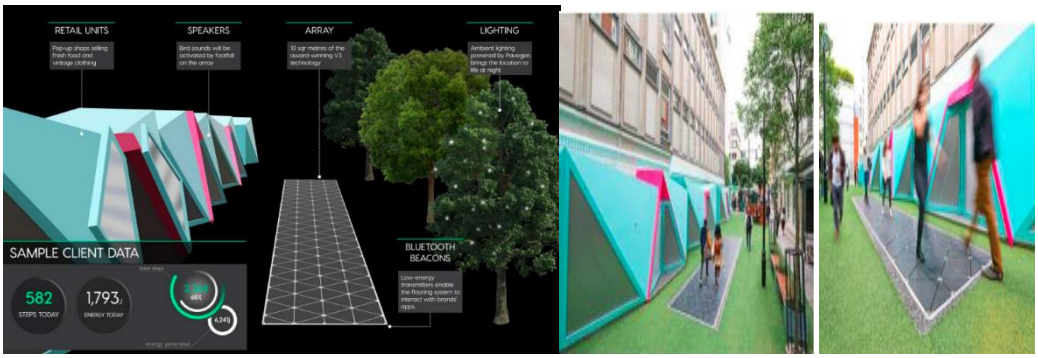


Fig.3: Energy Generating Pavement Transforming of the Environment at Bird Street, London west end.

c- Bike Pedal Power Generator:

It is harvesting energy from the small-scale motions of bicycling, such as weaving back and forth to maintain balance. Example of this energy generating furniture is the Wewatt bike; an outdoor cycling desk made of corten steel used to produce power based on human motion. This desk had been implemented at different locations of public spaces in europe cities as following:

Fig.4: Local Communities: Kerckebosch- Zeist , Netherland (NL), Source: www.wewatt.com

Fig.5: Parks: Gare de Bercy " Pa France. Source: www.wewatt.co

Fig.6: Festivals and events: Esperanzah Festival, Belgium.

d- Smart Solar Power Benches:

Solar powered outdoor furniture gives the cities a great opportunity to generate, store and use energy from the sun for multiple purposes in public spaces by mounting the solar powered devices in parks, playgrounds and other areas as well. A solar-powered bench can monitor environmental factors such as temperature, humidity, air pressure, noise. Moreover, through a phone application people will have the access to environmental data.

Litoměřice, small city in Europe, is the first Czech city provided residents with a smart solar bench called "CapaSitty" installed in the Václav Havel public park. The design purpose of this bench is not only for resting but to offer access to internet, charging stations for phones, tablets, monitoring production and consumption of energy and air quality as well through using solar energy.

Fig.7: Sit and Connect: First Solar Bench installed in Litoměřice City, Czech Republic,2016. Source: POCACITO, Post-Carbon Cities of Tomorrow, European post-carbon cities of tomorrow.

e- Powered Urban Wind Turbines:

The main issue of wind turbines is that they are imposing, an intrusive structure and don't work in light breeze. However, new inventions of wind turbine had been created that could bring wind power to urban areas.

The wind tree, it is a tree that have plastic leaves with vertical axis wind turbines that silently can turn the breeze to energy. It had been first installed in the Palace de la Concorde, a public square, Paris City in early 2015.

Another example is called Light up the night, is a project along the highway leading to the EL Paso International airport in Texas, USA, year 2014. It includes 16 towers of 50 feet tall with a blue light from the bottom. However, for the top side, a 10-foot-tall vertical axis wind turbines that produces energy to light up the aesthetic lighting around the airport area.

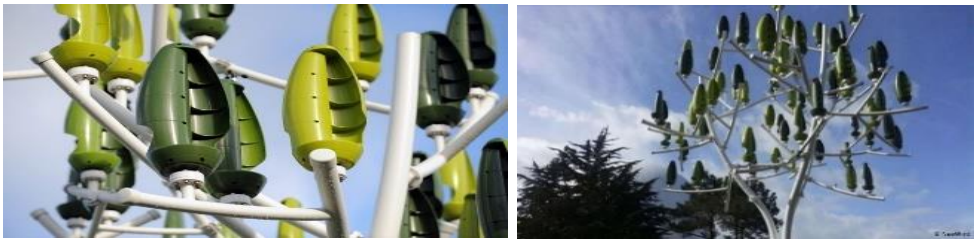


Fig.8: The Wind Tree located at the Palace de la Concorde, Paris. Source: Smithsonian Magazine, Alison Gillespie, 2016. WWW.SMITHSONIANMAG.COM

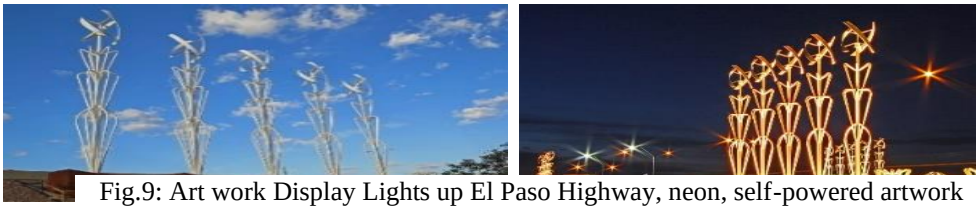


Fig.9: Art work Display Lights up El Paso Highway, neon, self-powered artwork near the El Paso International Airport in Texas City. Source: Tyler Morning Telegraph, Ruben R. Ramirez, 2017.

f- Solar Powered Hydroponics Grow System:

Hydroponic can be defined as growing plants in water containing nutrients and without using soil.

The Growbot (A small scale system): The purpose of the easy garden GrowBot is to let people grow food as much as possible with the least effort needed. It is a system that had been around growing food in people's backyards since 2015

in New York city. People growing this system had mentioned that this type saved them during the COVID-19 pandemic. This system gives people access to always fresh produce, even during world disruptions like storms and viruses.

Oaxis (A Large scale system): Barcelona engineers are trying to convert the sand swept Arabian Peninsula into an agricultural hub with solar powered hydroponic food belt. It is a modular hydroponic system that would cover a large area of a dessert to grow plants, reduce imports and fight food shortage.

Fig.10: Introducing GrowBot: A Robot that grows a garden automatically, New York City, Source: GrowBot – The Easiest Way to Garden, 2020. www.mygrowbot.com

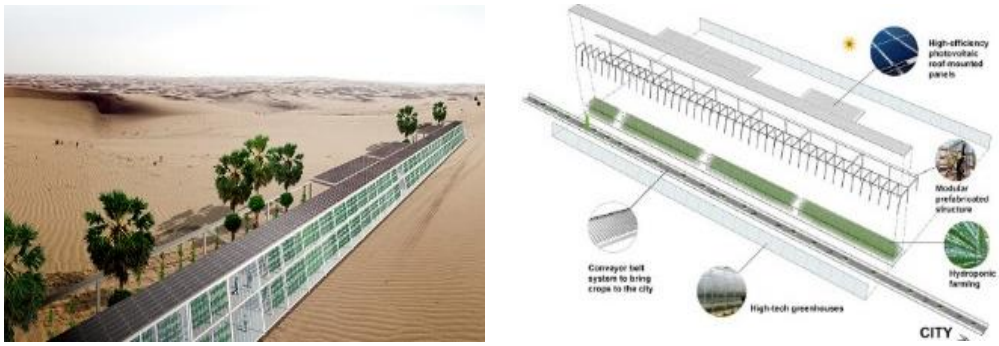
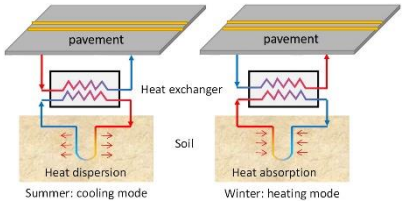
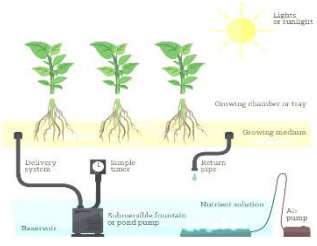


Fig.11: A Proposed Solar Powered Hydroponic Food Belt Greening the Entire Arabian Peninsula, Tafline Laylin, 2014. Source: INHABITAT a green design and lifestyle news, www.inhabitat.com

Based on the above analysis done in this section, types discussed can be classified into three categories consequently. The applicable green technology with renewable energy resources that is most suitable for the use in the open spaces are summarized in the table below as following:

Table 2:Green technology based on renewable energy sources. This means thermal energy, kinetic energy and electrical energy that will be considered in classifying the applicable energy resources used in open spaces. Source: Researcher

A- Thermal Energy Production: (Heat Energy Converted to Electricity)
Asphalt Energy Storing & Generating Systems: The buildings are considered the main beneficiary uses of this technology as well as streets through cooling down helping outdoor environment to perform better for people using it. **Application:** Street Networks and Infrastructure. Source: Performance Analyses of Geothermal and Geothermoelectric Pavement Snow Melting, Journal of Energy Engineering, Vol. 144,No 6 
B- Kinetic Energy Production: (Energy that an Object has by Reason of its Motion)
Footsteps Energy Saving & Generating Pavements: This can be applied in places where huge amount of people walks or high frequency of vehicular movement as roads, footpath, runways, highways, railroad tracks and outdoor open spaces. **Application:** Surfaces and finishing. Source: www.ecorenewablenergy.com.au , Solar energy floors for Smart Organisation and Communities, 2015.  
Bike Pedal Power Generator: Installing of smart street furniture, as smart energy bench that is considered as green energy innovation that provide the neighborhoods with renewable energy resources. **Application:** parks, gardens, side walks and squares. Source:www.ecorenewablenergy.com.au, Pedal for Power, Cycle for Change, 2015**.** 
Powered Urban Wind Turbines: Wind power is an abundant source of renewable energy but this source is not very common in urban areas. Fortunately, technology and design pull together to enhance the status of wind generation in the cities. **Application :** parks and squares. **Source: Wind Explained, Types of Wind Turbines,2020.**  
C- Electrical Energy Production: (Generating Electric Power from Source of Primary Energy)
Smart Power Benches: It is a great addition to the urban community furniture. The solar power smart bench is built on sustainability with a very low environmental impact since it is based on renewable energy resources that are economical, safe and good for the environment. **Application:** parks, gardens, side walks and squares. **Source:www.ecorenewablenergy.com.au,Smart Solar Benches to super charge outdoor spaces, 2015.** 
Solar Powered Hydroponics System: These systems require less space and less resources than traditional farming methods. Solar Hydroponic system uses 90% less water than traditional ways as the heat generated can maintains the growing process at 20 °C above the exterior temperature. **Application:** Public gardens, backyards, frontyard, roofs and balconies. **Source: Growing Soilless, The Basic Parts of a Hydroponic System, Abby Quillen, 2015.** 

Analytical Study: Northeast of Beirut city will be considered as the local case study; precisely, Rmeil and Medawar neighborhoods. Highlighting on the existing open spaces including green areas and public spaces as well. Also, international cases will be studied and compared in order to analyze the interventions and how it was applied in its context. Consequently, working on how interventions can be applicable on the selected local study case. Finally, based on the literature review (Theoretical Part) and the assessment and comparison done in the analytical part the guidelines will be proposed accordingly.

4. BEIRUT OPEN PUBLIC SPACES:

a. Role and the Situation of the Open Public Spaces in Beirut City:

The neighborhoods are composed of several urban fabrics, with distinct atmosphere and dynamics. Moreover, this area is composed of small houses, narrow streets and many gardens. It is characterized with significant heritage, as most spaces where created in the early 20th century during the Ottoman period. One of the most important features of these neighborhoods is the existence of traditional stairs and dead ends that constitute a very organic and warm urban fabric. However, for the residents these significant, priceless and remarkable features that exist in the neighborhoods enhance the feeling of place belonging to the traditional urban fabric. Furthermore, this area had been considered afflicted- damaged neighborhoods due to the port of Beirut Blast that happen on August 2020. The explosion caused material damaged in the urban elements within a 6 km radius of the blast in the neighborhoods adjacent to the port of Beirut that had been classified into moderate and extensive damage.

Fig.12: Beirut City, Study Limit District, Rmeil Medawar Neighborhoods, Beirut City. Source: Researcher based on Google map, 2021

b. Measuring the Degradation of the Green Areas Ratio in Beirut City:

The area of green spaces in the city of Beirut had been analyzed and studied based on a GIS tool that works on indicating the location of green spaces and its ratio as well. Moreover, satellite images had been selected in two different times and dates (March 1990 and March 2021); the data collected is then applied on the GIS system to get the NDVI maps using the NDVI tool that calculates the vegetation values. The NDVI E (Normalized Difference Vegetation Index) as a definition, is a simple geographic indicator that is used to target greenness and vegetation health. Consequently, NDVI values of year 1990 and 2021 had been obtained accordingly. Moreover, the two values obtained are compared to calculate the density of green areas; the density is then divided on the area of Beirut city to obtain the ratio of declination of green spaces.

(Any Abbreviations and Terminologies Mentioned Above Are Explained on the Last Page of the Paper).

Accordingly, the NDVI obtained for year 1990 based on the GIS system is 7.16%. However, the NDVI obtained for year 2021 is 3.79%. This mean that the declination in green areas ratio within the past 30 years is 3.37%, i.e. half the amount of green areas had been vanished in the city.

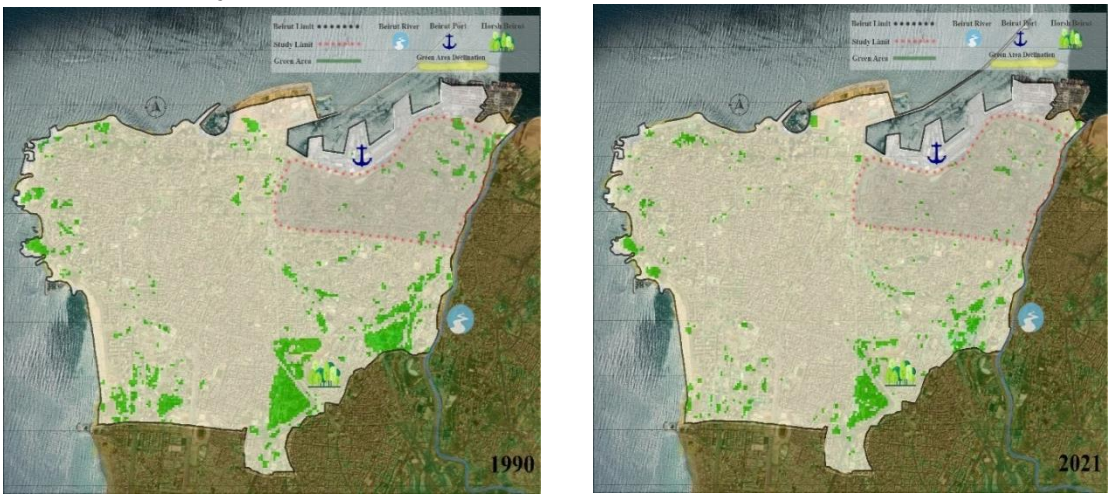


Fig.13: Map showing the Ratio of Green Areas for year 1990 and 2021, Beirut City. Source: Researcher based on Google Map, 2021

Based on the NDVI obtained for year 1990 and 2021, the two maps (Figure 12) had been overlapped to determine the declined areas of green spaces. Therefore, areas of significate declination had been indicated with yellow color as it is shown on the side map (Figure 13). Consequently, the intense green color refers to the year 2021, and the pale green color refers to year 1990.

Fig.14: Map showing the remaining Green Spaces in Beirut City, Based on the Comparison of NDVI 1990 and 2021. Source: Researcher based on GIS system and Google Map, 2021.

Based on the above analysis, Beirut is considered one of the most densified cities with a complicated massive road network infrastructure. Beirut has a very low green space ratio in the world (0.8 sq./inhabitant) which is below the world Health Organization ratio. Thus, green areas in Beirut are limited transferring it to dense city with a huge vehicular network.

c. Classification of Open Public Spaces in Rmeil Medawar Neighborhoods_ Beirut City:

Based on the survey and site observation done for the study area, location of public parks and historical stairs in the Rmeil Medawar district had been determined accordingly. The analysis in this part is a description of the current situation of open spaces; the existing stair cases, gardens and parks within the study limit.

Fig.15: Map Showing the Study Limit with the Existing Parks , Stairs and the Main Streets Surrounding the Area, Rmeil Medawar District, Beirut City. Source: Researcher based on site observation and survey, 2021.

After visiting and analysing the study area, the location of the main important and significant staircases, parks and gardens had been indicated accordingly (Figure 14). Below is a brief description of the features as following:

a-**Saint Nicholas Stairs:** Located between Saint Nicholas church in Sursock street and Gouraud street Gemmayzeh area. It consists of 125 steps and 500 meters' span stairs. Currently, coffee shops and restaurants are arranged along the two sides of the stairs.

Fig.16: The Saint Nicholas Stairs, Rmeil Medawar District, Beirut. Source: Researcher based on site observation and survey, 2021.

b- **Vendome Stairs**: Located in Geitaoui area, had undergone various changes in the last decades, due to the destruction caused by the surrounding construction projects. Coffee shops are located on the upper part of the stairs.

Fig.17: The Vendome Stairs, Rmeil Medawar District, Beirut. Source: Researcher based on site observation and survey, 2021.

c-**Massaad stairs**: Located in Mar Mikhael and are considered as important for life in the neighbourhood as it serve as a cross way for the surrounding neighborhoods. These stairs however, lack maintenance and cleaning, with broken steps and lack of lighting turning into a derelict and abandoned public space.

Fig.18: Massaad Stairs, Rmeil Medawar District, Beirut. Source: Researcher based on site observation and survey, 2021.

d- **Jesuits Garden**: A public park in Rmeil district that is located at Moscow street of 44000 square meters including ancient features as roman columns and mosaics with a small public library among the old pine trees. In 2013, the garden was selected for demolition by Beirut Municipality to create an underground parking.

Fig.19: The Jesuits Garden, Rmeil Medawar District, Beirut. Source: Researcher based on site observation and survey, 2021.

e-**William Hawi Garden**: Small space of 4000 square meters in Geitaoui street Ashrafieh area that was a leftover space between existing buildings. Consists of ficus trees with pin trees around the periphery and nine typical benches that exist since the garden was designed with circular water feature. The garden was renovated and re-opened in year 2013.

Fig.20: William Hawi Garden, Ashrafieh District, Beirut. Source: Researcher based on site observation and survey, 2021.

f- **Saint Nicholas Park**: Public garden located on Chrales Malek Avenue Achrafieh district. Area of the garden is 22,000 square meters, one of the largest parks in Beirut city. It can be considered as plaza than a garden as it has a central rectangular water feature with colorful mosaic tiles. Moreover, ten benches distributed in front of two long zig zag hedges (plant edges) on both sides of the water feature.

Fig.21: Saint Nicholas Park, Ashrafieh District, Beirut. Source: Researcher based on site observation and survey, 2021.

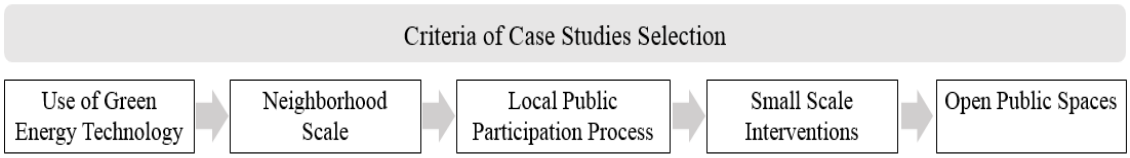
g- **Karantina Public Park**: Located in a low income neighborhood in Medawar district. It consists of big trees that provide shades for walking along the sidewalk that turn all around the park, with rectangular water feature at the centre and sandbox shaded by trees. The park was designed in year 2011 and built in 2016.

Fig.21: Karantina Public Park, Medawar District, Beirut. Source: Researcher based on site observation and survey, 2021.

As conclusion, Beirut suffers from a clear issue of untapped potential of the existing open public spaces. In this massive ignorance of the public realm; there are opportunities that may be exploited in the current situation that push through a sustainable development that is needed urgently in the city. Consequently, new tools must merge into the context that would help in improving the current situation; changing the existing open spaces into flexible spaces that are able to promote social cohesion and provide users daily needs from one side. From the other side, increase the cities' resilient factors making these spaces more capable to changes according to events and conditions.

4.1 Comparative Analysis: Studying the importance of Implementing an Integrated, Community Based Green-Energy in Open Spaces of Small Communities:

Below analysis focuses on emerging green energy in cities with dense built environments. The meaning of energy here is centered on the aesthetic and artistic values and expressions. Design interventions were proposed in three different neighborhoods across the city of Lulea F, in northern Sweden, to understand how the socio-material settings matters in activating the public engagement for enhancing the local energy planning process. With that said, the purpose of this comparative analysis is to understand the processes and tools used in the studied Sweden neighborhoods and what is the most applicable for Beirut case study area that may contribute in the development of its neighborhoods. The Criteria of Case Studies Selection are as following: Integrating green technology on scale of neighborhoods, through applying small scale interventions in open spaces while using a participation process.



Case I, Porsön Neighborhood, Sweden:

Stage 01: Participatory Mapping: Participants were provided with maps and asked to highlight on these maps the routes they take daily. From this exercise, the participatory mapping, contributed in making it easier to understand participant's perceptions and lived experiences of the existing public spaces in the neighborhood.

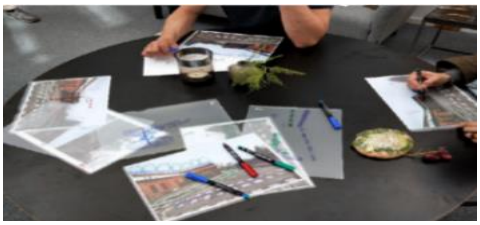


Fig.22: Participants' routes taken daily. Source: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Stage 02: Individual Sketching of Utopias: Participants were asked to imagine and make a sketch or trace their perceptions regarding how solar panels can be integrated into public spaces.

Stage 03: Group Discussion and Reflections: The process of analysis started post collected participants proposed sketches. However, the analysis had shown a various of options that the residents implicated with solar panels in place as following:

Fig.23: Process of sketching. Source: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021

Table 3: Proposed Locations of Solar Panels. Source: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Vibrant Aesthetic Attractiveness	Social Gathering Space	Utilisation of available and empty lots
Colorful solar panels on facades, using it as an interactive artwork.	Solar Panels as sheltered sitting areas for social meet-ups.	Solar panels that are not aesthetically pleasing in dead spaces.
		

(Any Abbreviations and Terminologies Mentioned Above Are Explained on the Last Page of the Paper).

Case II, Mjölkudden Neighborhood, Sweden:

Stage 01: Participatory Mapping: Participants marked on maps routes used to walk in neighborhood and perceptions of public spaces connected to routes they mentioned.

Stage 02: Envisioning Local Solar PV Design: Different proposals were provided through shading on maps most suitable locations for installation of solar panels. Participants suggested the installation of panels in the following spaces:

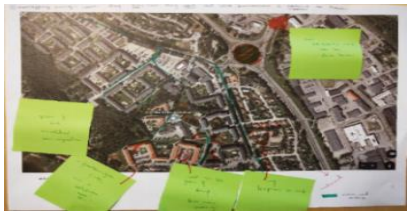


Fig.24: Daily routes and spaces frequently visited. Source: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Table 4: Participants Suggestions of Panels Installation in The Public Realm. Source: Energetic: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Panels at every bus stop at the main road in the neighborhood.	Utilisation of coloured solar cells along balcony facades.	Dead Spaces as roofs, parking garages and roundabout.
		

Stage 03: Group Discussion and Reflections: Participants conducted a back casting exercise that would help in making discussion easier through searching for possible steps that could help in achieving future imagined solar panel designs in their neighborhood. The mean of this activity was to transform unfeasible energy futures into a small strategic procedure. Three matters arise from the discussion as following:

Fig.25: Assessment of solar PV panel installations. Source: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Visibility Issues: Social access to open spaces. *Aesthetic Appeal:* A high value on the surrounding nature. *Experiences in the neighborhood:* The atmosphere it provides to the neighborhood and residents.

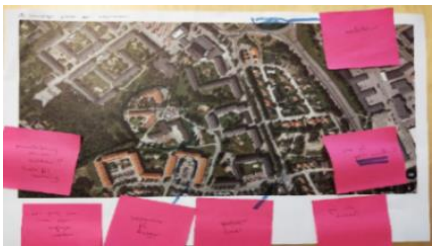


Fig.26: Kronan Neighborhood, Luleå, Sweden. Source: Google Maps.

Case III, Kronan Neighborhood, Sweden:

The first step, is a qualitative survey: The survey included an open ended questions asking people about personal experiences in urban public squares and thoughts on aesthetic experiences surrounding renewable energy in these spaces.

Fig.27: Pop-up workshop. Source: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

The second step, is a pop-up workshop: It was held at a bus stop along a high traffic pedestrian sidewalk on a weekend. In this way, it could be understood the local resident's activities they would like to do in the square, and how they could imagine renewable energy as a part of their activities in the new square.

The third step, is a design thinking workshop: Analysis of data collected was based on answers obtained from two large sheets includes answers of two different questions:

What do you want to do in the new square?

How could renewable energy be a part of the activities in the new square?

Table 5: Participants Answers Obtained from the Questionnaire. Source: Energetic: Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Image of a bench with solar panels and displayed on the sheet with "Heated benches in the winter".	Image of a seat in an urban park with a solar panel shelter shaped like a tree and mentioned "artwork" beside it.
 	

After analysing the three neighborhoods mentioned in this section through showing the tools used, the purpose of the study and the results in each case; a comparative table below is developed accordingly:

Table 6: Comparison Between The Three Studied Cases. Source: Researcher Based on Democratic Conservations and Aesthetic Makings for Emerging Energy Futures, 2021.

Case I , Porsön Neighborhood	***Case II, Mjölkudden Neighborhood***	***Case III, Kronan Neighborhood***
Purpose: Study the role of creative imagination in building renewable energy futures in the neighborhood through identifying users needs.	**Purpose:** Discuss possible designs and aesthetic practices of solar panel installations in the neighborhood through understanding users perceptions in the public spaces.	**Purpose:** Discover needs that can help in creating innovative urban services in term of renewable energy neighborhood experiences and designs.
Three public spaces: An under pass, children playground and the main square.	**Routes and places** that are considered attractive for residents had been marked on maps to be studied.	**A square** that would serve the needs of local residents of the neighborhood.
Participatory mapping as a visual communication platform. (understand perceptions and experiences within the spaces).	**Participatory mapping** as a visual communication platform (provide as a visual tool that support verbal explanation).	**Qualitative survey** of open ended questions asking people their thoughts of using renewable energy in the public square.
Creative process was followed while imagining the dimensions of solar panels installations.	**Creative process** was followed that help in bridging communication gaps between residents and decision makers.	**Creative process** for energy spaces as a new phenomenon in the urban environments.
Backcasting exercise was applied (converting intangible visions into tangible steps).	**Backcasting exercise** was applied (converting intangible visions into tangible steps).	Analysis of **data collection** was based on answers that were obtained from the questionnaire.

The results of the three Sweden study cases, had shown the capacity of local residents to engage with green energy based on their local experiences in the area with some inspiration. Moreover, the creation of energy spaces is a new phenomenon in urban environments and is considered not very familiar to publics.

5. GUIDELINES AND INTERVENTIONS:

Based on the literature review, analytical study and the comparative study; guidelines are proposed accordingly. The developed guidelines can be applied as a checklist for achieving flexible open spaces with energy efficient solutions. The general guidelines will be stated first and discussed, then address how it would be implemented to Beirut city open spaces.

i- Apply small scale renewable energy resources projects that contribute in ensuring energy needs.

Utilizing unused spaces through installing solar panels that would support street and traffic lights and outdoor operational signage. Natural- vegetative screen can be applied to minimize visual impact of panels.

Fig.28: (1)Charles Helou Avenue roundabout, (2)Gouraud Street Island, (3) Charles Malek Avenue traffic island (Figures are listed from left to right side). Source: Researcher based on study area site visits, 2021.

ii- Benefit from installing power efficient furniture in open spaces to improve energy performance.

Applying energy generating furniture (as the smart solar energy benches and bike pedal power generator) into open spaces of significant features available as existing small gardens and parks.



Fig.29: (1) St. Nicholas Park at Sagess street , (2) Jesuits Garden located Near St. George Hospital, (3) Karantina Park located in low income neighborhood. (Figures are listed from left to right side). Source: Researcher based on study area site visits,2021.

iii- Adoption of energy-generating spaces for self sufficiency and reflect modern technology.

Implementing energy generating walkways through installing footsteps saving pavements on the existing old stairs that consists of coffee shops and restaurants on both sides.



Fig.30: (1) St. Nicholas Stairs, (2) Vendome Stairs, (3) Small narrow steps within the neighborhoods. (Figures are listed from left to right side). Source: Researcher based on study area site visits, 2021.

iv- Issuing laws and regulations that support technology as an essential part of the municipal system.

Addressing renewable energy in municipality plan as system used to extract, collect and store energy from asphalt pavement on wide streets to give aesthetic character, functional and economical solutions.



Fig.31: (1) Charles Malek Street, (2) Charles Helou Avenue, (3) Emile Lahoud Avenue.(Figures are listed from left to right side). Source: Researcher based on study area site visits, 2021.

v- Conserve natural green and blue features through integrating creative energy produced systems.

Emphasizing ecological identity of Beirut city, through distributing wind turbines at HORSH Beirut gives an aesthetics attractive value to largest green area in city. Also, powered hydroponic grow systems work on stimulating agricultural lands of Beirut river preserving lands from real estate development.

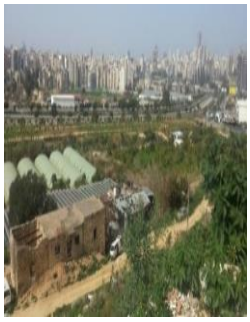


Fig.32: Beirut River. Source: محترف نهر بيروت، ٢٠١٤. الجامعة اللبنانية معهد الفنون الجميلة قسم التنظيم المديني

Fig.33: Horsh Beirut. Source: Google.

Table 7: Showing the Existing Issues in Beirut City and the Proposed Interventions for the Study Area Rmeil Medawar District. Source: Researcher.

Current Problems	Proposed Interventions
Weak Infrastructure	Integrate Solar Panels into Existing Roundabouts and Traffic islands to Provide Power Supply to Surrounded Utilities with Natural Screening to Reduce the Visual Impact.
Physical Damage	Consider Green infrastructure [I] Elements in Beirut Municipality Development Actions and Solutions that Would Improve the Neighborhoods Basic Services.
Neglected Public Spaces	Set Solar Energy Benches Along with the Traditional Existing Ones to Support the Space Performance and Enhance Social Cohesion.
Lack of Sustainable Development	Introduce Footsteps Energy Generating Pavements to Provide Power for Existing Shops that Would add a modern value to the city elements.
Social Disintegration	Fostering Green Energy Innovations that Can be Co-Located with Ongoing Agricultural Operations and Practices that Preserve Green and Vegetated Areas at the Edge of the City.
Economic Degradation	

6. SUMMARY OF FINDINGS AND CONCLUSION:

Above mentioned interventions in Rmeil Medawar district for the purpose of the study show that improvements can be possible if these changes are well applied. Existing problems would offer a window of opportunities to start moving toward building a better Beirut. People living and visiting Beirut have the feeling of sense of belonging and attachment to places, for that reason the participatory design approach has an important role in the development of neighborhoods as a method to democratize the planning of public spaces supporting the integration of energy-production installations in the urban context; while improving the design process through the collaboration with stakeholders and decision makers in order to make sure that residents needs are considered when proposing urban projects.

As a conclusion, the demand of electricity will grow and this will cause an increase in the use of renewable sources for power generation that will rise from 21% as recorded in 2012 to 33% by 2040 (International Energy Agency). Consequently, this rapid increase result in giving a great importance of renewable resources for energy production; contributing in developing several sustainable technologies. These systems have various technology installation tools, energy production and uses. Moreover, it can work in open spaces as visual terminate points, as it can be used as street furniture or landscape features. Moreover, the important is related to

focusing on process of participation that is attached to the aesthetics of emerging green energy technologies in urban public spaces through engaging multiple stakeholders in the design process while understanding how design as a tool and process can facilitate and encourage the integration of green technologies in the living environment. Hence, green energy in open spaces have a major role for achieving sustainable growth in urbanized areas that would increase the factors of resilience.

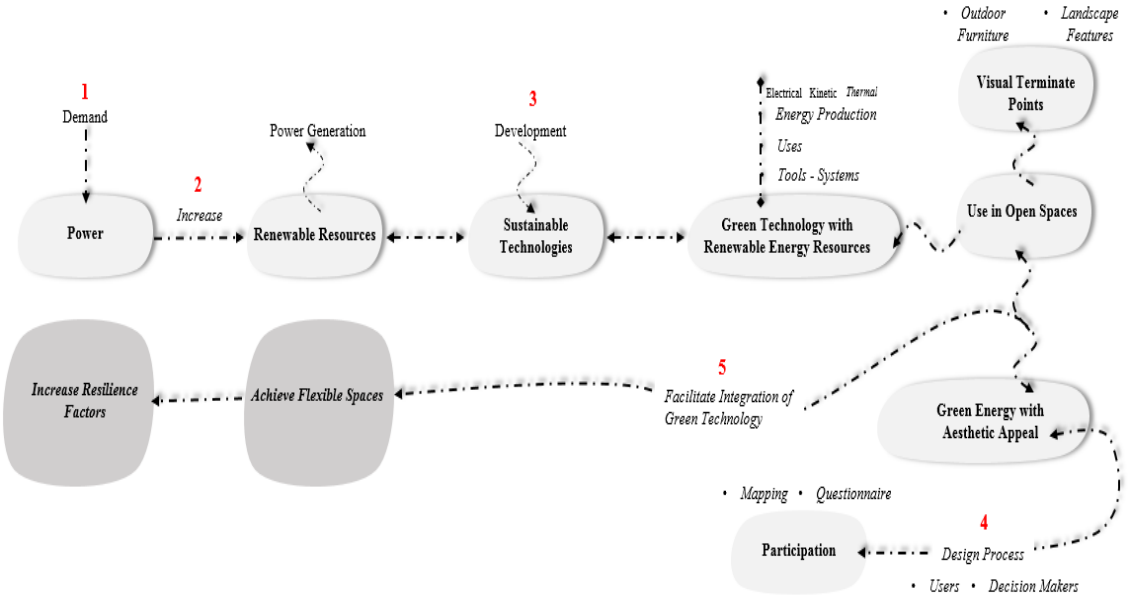


Fig.34: Diagram that Summarize the Overall Conclusion. Source: Researcher.

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LIST OF FIGURES:

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LIST OF TABLES:

ABBREVIATIONS AND DEFINITIONS:

[A] **UNISDR:** The United Nations (UN) International Strategy for Disaster Reduction Secretariat (UNISDR) was established in 1999 as the successor to the Secretariat of the International Decade for Natural Disaster Reduction.

[B] **Urban Regeneration:** Regeneration actions, policies and process within a city, which address interrelated technical, spatial and socio-economic problems in order to reduce environmental impact, mitigate environmental risk and improve environmental quality of urban systems and life style.

[C] **IRENA:** International Renewable Energy Agency is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy.

[D] **OECD:** Organisation for Economic Co-operation and Development an international organisation that works to build better policies for better lives. The goal is to shape policies that foster prosperity, equality and well-being for all.

[E] **NDVI:** Dimensionless index that describes difference between visible and near-infrared reflectance of vegetation cover and can be used to estimate density of green on an area of land (Weier and Herring, 2000).

[F] **Luleå:** Is a city on the Coast of Northern Sweden, and the Capital of Norrbotten County, the North Most County in Sweden. Luleå has the Seventh Biggest Harbour in Sweden.