Helsinki Metropolia University of Applied Sciences

SUSTAINABLE CITIES III

ERIC POLLOCK & ANA REINBOLD (EDS.)

Sustainable Cities III

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Editors: Eric Pollock, Ana Reinbold

Authors: Eric Pollock, Ana Reinbold, Marika Antikainen

Ahmed Ali, Mahmoud Hassan, Ahmed Aziz, Homa Javadi
(Sustainable construction)

Eduardo Vendrusculo, Masoumeh Ahmadi, Maya Ratnayake Lambias,
Oliver Purup, Raj Bir Kumar, Shamim Majidian (Passive housing)

Alireza Bazvand, Mohamed Ahmed, Neha Shireen
(Sustainable transportation systems)

Mohammad Mohammadi, Siu Kong Lau, Youngeun Kim, Ahmed Ghoneim,
Saurabh Dwivedi, Caroline-Julia Mastalerz, Maris Klose
(Urban planning)

Temitope Awotimoro, Fatemeh DaneshvarTarigh, Elnaz Taghipourarasteh,
Udham Singh, Shantanu Chauhan, Mahharaj Thiruvadu
(Sustainable design)

Illustrations: Homa Javadi
Layout in InDesign: Oliver Purup, Masoumeh Ahmadi

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For inquiries about copyright: julkaisut@metropolia.fi
www.metropolia.fi/publications

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PREFACE

This 2020 publication is the third volume of the Sustainable Cities trilogy. It is a collection of group works by the Case Studies course of the Construction and Real Estate Management International Master's programme. This Master's degree is jointly run by Metropolia University of Applied Sciences and Berlin University of Applied Sciences, HTW-Berlin. The students are from around the world, some researching sustainable cities for the first time in their academic careers. The groups work with cities from countries all over the world and search for the similarities with European cities, giving their inside view of language, culture and engineering. The cover and illustrations are made also by students.

The introduction contains expert articles by Metropolia educators in sustainability, construction and pedagogy. Course lecturers Eric Pollock and Ana Reinbold describe the pedagogic approach of the course and Marika Antikainen ties the course to the bigger picture of multicultural workers within the Finnish workforce. The student group chairpersons give their view on the success of the pedagogical approach.

This sustainable cities research contains five chapters focusing on the construction and built environment prism. The students, mainly civil engineers and architects, chose the topics, formed the working groups and researched together the cases from different cities around the World. The cities the students chose were often the ones they have lived in for most of their lives, thus enriching the discussion with the viewpoint of a professional that was also an inhabitant of the city, knowing it from inside.

The Construction and Real Estate Management programme (ConREM) is a 4-semester Master's Degree. When undergraduates of architecture and civil engineering begin their Master of Science studies in Europe, their lives and their future careers undergo a major change. They have come from around the world to study in Europe, to start their professional lives in the design, construction and management of the built environment.

They have come to Finland as individual students and very quickly they learn the value of teamwork, not only to survive in the academic and student life, but to increase their knowledge about other cultures and the construction industry around the world. Their language and research skills vary, but the teamwork enables them to learn from each other. The sustainable development studies begin in the first semester with individual projects. During the second semester the emphasis is on teamwork, as they know each other better by now. The students wanted to make a publication in groups on real sustainability questions in today's urban world. This publication is important to all students. Those going to work in the industry will be able to show how their teamwork skills have developed during the research and publication process and for those that aim to pursue an academic career, the publication is a requirement that opens doors to doctoral studies.

This shift of academic responsibility to the student groups was both innovative and a great deal of work. Some of the students produced a scientific article for the first time, and academic writing is always challenging. Thanks to the broad diversity of the authors, the book has been able to make justice to the title. This publication shows how international students from very different backgrounds can together research sustainable cities by teaching each other about their cultures and history.

Eric Pollock, Ana Reinbold
Lecturers of the course and editors of the book

TABLE OF CONTENTS

INTRODUCTION TO OUR SUSTAINABLE FUTURE

Preface

The sustainability discussion permeates our society in every aspect of our activities. This publication brings light to the following questions:

- *What is Metropolia doing about sustainability in its own operations?*
- *What can lecturers do in their teaching methods to get the sustainable message to students?*
- *What do students comprehend about sustainability and their future careers?*

The introduction contains articles by Metropolia experts in sustainability, construction and pedagogy. Career opportunities for international students are presented. The commitment of Metropolia to sustainable operations is given and the pedagogic approach is explained. The final article is a response by the students, how they organised their own group works and what else they learned besides sustainability. The students organised themselves into five research teams and their research is presented. The topics are Sustainable Construction, Passive Housing, Sustainable Transport, Urban Planning and Sustainable Design.

aunching a sustainable research publication
Eric Pollock, Ana Reinbold

European universities have a direct responsibility for sustainability studies in all faculties, why not globally as well. We need to educate young designers and managers to take the construction industry into the sustainable building era of energy plus, low CO2 emission structures. Architectural design and Civil Engineering works, whether they are new buildings, infrastructure construction or renovation projects, need to be developed with sustainability as their foundation. Buildings must have pleasant working environments with good indoor air quality. Cities must have sustainable transportation and good use of water resources. Cities must also respect and protect their heritage sites, as well as develop public services, housing and green areas.

Cities are the most complicated things humans have ever built. With climate change (the biggest threat our species is facing) the word sustainability has achieved more relevance than ever before. As the majority of the world's population live in urban environments, the sustainable city is the most important goal we have in today's world.

Learning without Traditional Lectures and Tests

After the individual sustainability research works of the first semester, the students chose the group research and publication in place of the traditional lecture and examination without hesitation in the second semester. The course outline was simple, starting with a series of lectures with the following themes:

1. *Polluted cities*
2. *Traffic planning*
3. *Aging Infrastructure*
4. *High-rise housing*
5. *Off-Grid Housing*

After the lecture series, the students chose their own topics, formed their own groups and selected chairpersons as well as fixed their deadline for completion. Some continued their first

semester topics; others changed their subject completely. They worked independently, and since some had more academic writing experience, teamwork in the groups produced five very good case studies on sustainability with research from cities around the world.

The research works presented here went through classic cycles of lack of information, then an overload of information and finally an understanding of what is important for the reader and what is not. ConREM graduate students needed only some feedback to keep the schedule as agreed.

Working in groups, all with mixed backgrounds, has led to really good discussions and has brought the students together as authors and researchers. The students are from all corners of the world, so it was easy to get comparisons of sustainable development from major cities on many continents. Climates around the world are different; some regions suffer from both drought and flooding, others have abundant solar energy, but no real solar energy industry. By sharing their local climate challenges, the possibility of global solutions become clearer. Lecturers often concentrate on past statistics, but students need to look more towards the future. They interpret their present situation with the future job market in the construction and real estate industry.

The basic goal of the whole publication is to look at the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development that became official in 2016. With these new goals that apply to everyone, nations can mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change. In particular, goal 11 states “Make cities inclusive, safe, resilient and sustainable“. Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically. However, many challenges exist in maintaining cities in a way that continues to create jobs and prosperity while not straining land and resources. Common urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing and declining infrastructure. (http://www.un.org/sustainabledevelopment/cities/).

Sustainable construction is defined in the first chapter. Sustainable construction must succeed in saving energy, time and materials. The concept of the zero-energy building, impact of precast systems on sustainable construction, recycled materials and eco-friendly bricks are discussed. A sustainable system optimizing energy use, reducing material waste, and managing the duration and cost of a construction project are described.

The **Passive housing** chapter describes projects in several countries. The passive house standard was originally implemented in residential buildings in Central Europe, but today it can be implemented on any type of building and in any climatic region. It is sustainable, energy-efficient while being affordable and not compromising the comfort of its residents. In contrast, practice has shown that passive houses provide a very high-level of comfort. Passive constructive techniques and materials have been evolving, with five determining principles: thermal insulation, air tightness, passive windows, ventilation systems with heat recovery and thermal bridge free design (Passive House Institute, 2015).

The **Sustainable transport** chapter presents projects in Iran, India and South Korea. Some similarities are given, with development related to sustainable cities. Sustainability illustrates the basic human urge to build a better society for the future.

It has become a challenge for the world, especially the developing countries to accomplish environmentally sustainable transportation systems. This chapter focuses on the major transportation problems in India, Iran and Egypt and provides reformative measures that can be adopted from developed countries so that these nations can become sustainable in terms of mobility.

The **Urban planning** chapter presents the influence planning can have on city development all over the globe. Although eastern and western planning varies depending on local economies, similar solutions for urban planning can be achieved. Urban regeneration, waterfront regeneration, waste management and renewable energy management are presented. Various urban planning concepts mainly address social, economic and environmental problems and provide solutions for such problems as sa-

tisfying the increasing housing demand, preserving the environment, revitalizing the history and culture of the urban community and conserving energy.

The **Sustainable design** chapter covers a very wide range of subjects such as research on housing in hot and arid environments, 3D printing and collapse of buildings in Nigeria. In Hot and Arid climates, structures have been built with suitable orientation and prevailing winds. 3D printing technology is in its initial stage in the construction industry for fabricating three-dimensional structures from a digital model. The impact of collapse in Nigeria's buildings is enormous waste, both in human lives and financial investment.

What are the global sustainable concepts students have developed? This book offers an in-depth understanding of several future cities to the reader. The book can also be used as sustainable coursework related to cities in any undergraduate curriculum. The authors were encouraged to back up their views with evidence, sources and reasoning debate. The issues covered are of timeless value and are relevant for our future cities.

PEDAGOGIC METHODOLOGY

The student chairperson responses

Sustainable construction
Homa Javadi

The topic of the course was related to sustainable development and the class was divided into five groups in which each aspect of sustainability was discussed including sustainable construction, sustainable transportation, sustainable housing, sustainable design, and sustainable cities. Each group consisted of 3-6 students with individual topics related to the group research interest. In the sustainable construction group, all members were responsible for completing their research by the due date of every assignment, and each assignment included reporting on the weekly progress of the final report. To ensure efficient coordination and monitoring, every group had a leader who was responsible for managing group meetings and editing the final work. In addition to corrections made by the course instructors in the classroom, the sustainable construction group initially had some face-to-face meetings outside the university in order for the group members to become more familiar with the task expectations and each person’s responsibility. Then, a WhatsApp group was created by the group leader to enable everyone be in contact with others easily and also to ease sharing files and asking questions. In general, the group atmosphere was very friendly, and everybody took care of their responsibilities towards the completion of the report very well.

Passive Housing
Shamim Majidian

The first step to our research was to choose a topic related to sustainable housing. When the subject was selected, the group started to write the structure of the report and each member chose one section to search and write in the report. Every week

based on the deadline we organized our group plan and decided about the report's progress. Based on the comments from two lecturers, some parts were added or omitted weekly. Every week in the sustainable cities course all members came together to talk about the layout of the report, sections and contents and shared their ideas about it. In order to be aware of each member's tasks and also updating the report, a folder was created in Dropbox and a group created in Whatsapp. Whenever any member changed or edited the report, other members had access to the updated file. As the university was closed due to the corona virus, we did not have a chance to meet each other but we still kept in touch to work on the report.

Sustainable transportation systems
Neha Shireen

Our group decided to write on Sustainable Transportation Systems. We focused our works on identifying major transportation-related problems in our respective home countries and finding the best possible solution for these problems from different parts of the globe. We discussed our concepts, identified our roles and set deadlines for each task. We used WhatsApp as a medium for sharing our respective files, feedback from the professors and took suggestions from each other to make our work look organized and satisfactory.

Professor Eric got the best out of us by always encouraging and motivating us to do better. He has corrected us and helped us to stay positive throughout. His teaching ways have had a massive impact on all of us. Professor Ana's valuable feedback in terms of organization of our topic's structure and referencing. Her interactive class sessions helped us to broaden our perspective and think creatively.

Even though our group consisted of three members, it was not an easy ride for us. There were differences of opinion and our individual approach to writing about the topic was not the same, but we all made our way out by negotiating our views and ideas so that the report looks suitable. This helped us contribute our ideas as well as value and respect each other's opinions from different backgrounds. Overall, it was an admirable learning experience for everyone in the team.

Urban planning
Maris Klose

It is always a challenge to work in cross-cultural teams. We formed our group based on the fact that we had previously written a report together on a similar topic. But just having a similar topic does not mean that we have similar ways of working. Meeting deadlines, for example, can have a wide interpretation. But despite different working methods, we have succeeded in working in a focused manner and meeting deadlines. This required clear instructions, regular reminders and a good organisation from the team leader. Apart from that, we defined the tasks for everyone at a very early stage. This included also tasks beyond writing the text, such as doing the layout, rereading the text and preparing a presentation. A progress report reminded us regularly of the tasks which were still ahead. Initially, a weekly group meeting was held for this purpose. After everyone knew what to do, the communication and exchange of files took place mostly via WhatsApp. These working methods helped us to be organized and efficient together.

Sustainable design
Mahharaj Thiruvadi

The foremost objective of every master's program student apart from learning is the application and imparting of knowledge. The best method that was given to us was to have our research published in our University book. We chose the unconventional way of combining unique ideas from different areas under a common theme. Our team consisted of six members with diverse topics but common interest, 'innovation' and bringing a change to 'sustainability ' in the early stage of construction conceptualization and design. We decided to collaborate and organise a chapter that would impart knowledge on the importance and different approaches to sustainability. This led to our topic of sustainable design which was quite new and interesting for us.

We arranged face-to-face meetings with each other to discuss new possibilities. Initially, we met twice at the university to weave diverse topics together, and to piece our ideas together, we had

one face-to-face meeting per week and also many virtual meetings. A WhatsApp group was created to communicate and share our work progress. A chairperson was appointed for the group, and important tasks were delegated to each member based on their strengths and interests. The first few meetings were to understand each other's ideas and point them towards a common direction, while later meetings were more objective with clear agendas. Microsoft teams, WhatsApp, and email were utilized to share interesting research materials and documents.

CONREM: SKILLED MANAGERS TO FINNISH LABOUR MARKET

Marika Antikainen

The Construction and Real Estate Management Master's programme (ConRem) responds to several current, even urgent, needs in the Finnish society. Finland is struggling with a rapidly ageing population and a shortage of skilled workforce. Part of the solution for this challenge is turning the focus on international talents. (See e.g. Government Programme 2019, 8-10, 147-148, 174-175). For ConRem graduates this opens an important prospect: the labour shortage is acute particularly in the construction management sector (Occupational Barometer 2019b). On the other hand, an increasingly international workforce requires certain skills also from managers. This, as well, is crucial for the construction sector where the workforce is already as such highly international, particularly in the Uusimaa region (Confederation of Finnish Construction Industries RT 2019). The international learning environment of ConRem therefore enables its students to develop important and relevant skills already during the studies. Thus, the work life relevance of the ConRem programme is evident: it produces international graduates to a labour shortage sector and equips them with knowledge of Finland and the required skills set. What is needed now is joint efforts to make student transition to the labour market more efficient not just in the field of construction, but in all sectors.

ConRem – Graduates for Finnish Labour Market Needs

The ConRem programme responds to the call for global workforce for Finland in a unique manner. Firstly, it not only attracts international students to Finland, but also trains them precisely for a labour shortage sector. In the Uusimaa region in Southern Finland, construction supervisors are in the top 15 professions with a high labour shortage (Occupational Barometer 2019a).

The demand is high nationwide, as well (Occupational Barometer 2019b). Recently the construction sector overall has been suffering from the lack of workforce (Ministry of Economic Affairs and Employment 2019). Construction is strongly dependent on economic cycles, and activities have been increasing in Finland since 2015, though currently slightly slowing down (Confederation of Finnish Construction Industries RT 2019). Despite the recent improvements in the labour balance, the shortage of workforce still remains the most important factor limiting the growth of construction companies (Confederation of Finnish Industries 2019, 8).

International degree students are often mentioned as an important, yet not sufficiently utilised, resource for the Finnish labour market (e.g. Ministry of Education and Culture 2019, 9; Technology Industries of Finland 2018, 3). They can directly improve the labour balance. In the case of construction and ConRem, the need for balance is urgent.

Multicultural Skills Required in the Construction Sector

Managers in the construction sector in particular need intercultural competence as part of their diverse skills set. In Uusimaa, every third and in Finland every tenth employee has an international background (Confederation of Finnish Construction Industries RT 2019). This means that construction managers need to be equipped with the right interpersonal and intercultural skills (Rantamäki 2018, 28). Indeed, the National Forum for Skills Anticipation (2018) identifies multicultural and internationality skills as key competences in the construction sector.

The ConRem graduates have a genuinely international education, providing a solid understanding of both Finnish and German construction sectors and the international management context. The students study in two countries, Finland and Germany (Metropolia University of Applied Sciences in Helsinki and Hochschule für Technik und Wirtschaft in Berlin). The student community is international as well: the class of 2019 (approx. 40 students) consists of ten nationalities from Asia, Africa and Europe. Both the country setting and the peer group thus provide real-life learning environments for intercultural communication

and teamwork. As one student puts it:

As the students are from different countries, they bring with them unique perspectives, cultures and ideas. When we work as a team, we understand how people from different environments react to a common problem. Communication, flexibility and critical thinking are by far the most important competencies that we have acquired.

Naturally, also the programme content is designed to serve the purpose: it enables students to cooperate with people with diverse backgrounds, focusing on management abilities in international work environments (Metropolia University of Applied Sciences 2020).

The Big Picture: Finland's Demographic Challenge in a Changing World

The current demographic challenge does not limit to construction only, but impacts the Finnish society at large. Finland as a whole faces the same pressing demographic challenges and requirements for changing skills (e.g. the Government Programme 2019, 8-10). Overall, two out of three Finnish companies say the shortage of skilled workforce causes challenges to their business operations (Finland Chamber of Commerce 2019). Similarly, over 50% of small and medium sized enterprises say that the lack of suitable and skilled workforce limits their growth (Federation of Finnish Enterprises 2020).

The employability issue is naturally vital for the Finnish government as well. Tax paying citizens and well performing companies mean revenues. Moreover, a meaningful employment has a huge impact on an individual's wellbeing. Skills, continuous learning and employability thereby are at the core of the current government's aim to "transform Finland into a socially, economically and ecologically sustainable society by 2030". (Government Programme 2019, 8-10, 14-15, 152-153.)

Joint Efforts Focusing on International Talents

International talents are crucial for solving the labour challenge. Finland must increase both education and work-based immigration. (e.g. Ministry of Education and Culture 2019, 9; Technology Industries of Finland 2018.) In addition to their unique skills set, international graduates already have experience in this country and an internationally recognisable degree. Nonetheless, their employment rate is much lower than for Finnish nationals: for instance, in the university of applied sciences sector one year after graduating the percentage is 40% as compared to 80% of Finnish graduates (Vipunen 2019). We need to do a better job at helping our international graduates find employment in Finland.

Boosting the internationalisation of the workforce also requires a change of mind-set and rethinking of some ways of "doing things in businesses and the industry". This includes diversity awareness among the staff, inclusiveness in policies and operations and interculturally competent management (Helsinki Region Chamber of Commerce 2018, Technology Industries of Finland 2018). Furthermore, it requires changes to bureaucracy and perhaps adjustments to daily operations. Several tools and services have been launched to support businesses and the industry in the transition. For example, Business Finland (2020) coordinates the Talent Boost program, which provides e.g. Talent Explorer Funding for recruiting international talents. The Talent Boost Index developed by the Helsinki Region Chamber of Commerce (2020) helps companies evaluate and improve their international preparedness. The International House Helsinki (2020) provides services for settling down to international talents as well as legal services for employers. Different organisations across sectors are working together to reach the same goal in an unprecedented yet coordinated manner.

What Next? – Collaboration Needed between Businesses and Institutions

To sum up, on the one hand we are faced with a pressing need for skilled workforce and on the other hand, we have international graduates from Finnish higher education institutions motivated to work here. Only one fourth of the final year students are planning to move abroad, whereas half want to stay in Finland either to work or to continue their studies. One fifth is undecided. (EDUFI 2018.) Also, among ConRem students the motivation to work in Finland is high, as one student explains:

Finland is developing at a good pace, making room for more people and industry, which means there will be more construction work and activity. Transparency in industry and government, peace, and Finnish people's helpful attitude reassures us about the safety and security Finland offers. Also, the construction industry in Finland is open to adopt new technologies, which makes working here interesting.

The biggest barriers to working in Finland tend to be language skills and the lack of networks (e.g. Ministry of Education and Culture 2019, 35, 38). Together we need to develop measures to tackle the barriers and to have the motivated professionals enter our labour market more smoothly. Metropolia has launched two projects in the autumn 2019 to improve the employability of international students (see Antikainen 2019). However, reaching better employment rates also requires businesses and the industry to join the effort. Better networking opportunities, concrete work-life projects and shared industry knowledge not only help the students in finding employment, but also provide an excellent chance of employer branding for companies.

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Eduardo Vendrusculo, Masoumeh Ahmadi, Maya Ratnayake Lambias,
Oliver Purup, Raj Bir Kumar, Shamim Majidian

1. PASSIVE HOUSING

ABSTRACT

Due to the climate changes, global warming, increase the level of energy consumption people are facing new challenges and issues which threaten human's lives. The concept of passive house and subsequently passive house standards and criteria raised as a new approach for architecture, engineers and contractors to alleviate and solve environmental and energy-related issues. Innovated solution and techniques and produced model to determine the feasibility of the concept of a passive house is an undeniable major step taken in the architecture world. In this report, briefly mentioned about the definition and principles of this method. consequently, looking to the application of a passive house in a cold climate zone by describing case studies. Finally, mentioning the economic aspects and challenges may be faced

INTRODUCTION

DEFINITION OF PASSIVE HOUSING

How to make our planet sustainable?' is one of the biggest questions of the 21st century. As the population of the world increases, so does the energy consumption of the world. The increased level of energy consumption is the reason behind climate change and global warming. These problems highlighted the importance of not depending entirely on fossil fuel reserves for energy. (Edwards, B., & Turrent, D., 2002).

To solve this crisis the EU proposed energy efficiency targets to protect the environment and reduce the dependency on fossil fuels for energy. As a result, the EU has set a 20 per cent energy savings target by 2020 under the energy efficiency directive. This is equal to turning off approximately 400 power stations in the EU (Energy efficiency directive, 2019).

The construction industry is responsible for 40 per cent of energy consumption and 36 per cent CO2 emissions in the EU. One-third of modern energy consumption is being used for heating buildings. As it became clear how much impact buildings have on the environment, measures to make our buildings sustainable started to be implemented. The climate change issues and shortage of energy have led many countries to start exploring the construction of low-energy buildings. The construction industry has presented a solution to this problem by proposing concepts for sustainable housing, low-energy and zero energy buildings. It is estimated that, by improving energy performance, the EU could reduce its greenhouse gas emissions up to 70 per cent (Energy efficiency directive, 2019).

CERTIFICATES AND CRITERIA

GREEN BUILDING CERTIFICATES

Many green building standards have been created to rate the energy efficiency of buildings. In the early 1990s, the green assessment standard known as BREAM was created by Great Britain to evaluate the energy performance of buildings (BREEAM, 2020). The USA followed by formulating a green building certification called LEED to rate energy efficiency (Usgbc.org, 2019). The German passive house certificate is a similar standard for measuring energy efficiency. The aim of these green buildings certificates was to encourage building owners to be sustainable by becoming resource-efficient.

The passive house standard is at the forefront of energy-efficient standards of the world. Although in the beginning it was implemented in residential buildings in Central Europe, today it can be implemented on any type of building and in any climatic region. This is a green building standard that is sustainable, energy-efficient while being affordable and not compromising the comfort of its residents. In contrast, practice has shown that passive houses provide a very high-level of comfort. (Passipedia, 2019)

One of the first passive houses was built in the early 1990s in Darmstadt, Germany by Professor Feist, who is considered as the father of passive housing. Since then many countries including Germany, Austria, UK, France, Sweden and Italy have followed the example and started constructing passive houses (Passipedia, 2019). The construction of passive houses in Germany became more widespread after the government initiated high-energy saving standards (Sun, X.,2019). This report aims to provide information about how passive housing technology could be used in the housing industry. A passive house is the best available solution to decrease the energy consumption of buildings with high energy demands (Passipedia, 2019).

DEFINITION OF PASSIVE HOUSE

According to the German term ‘Passivhaus’, a passive house can be defined as “a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to fulfil sufficient indoor air quality conditions (DIN 1946) - without a need for recirculated air” (Feist W., 2006). As the definition of the passive house states, passive houses can provide a high level of comfort for daily living standards while using very low amounts of energy (Sun, X. 2019).

Passive House buildings achieve vast energy savings by using especially energy-efficient building materials and a high-quality ventilation system. (Passipedia, 2019). A passive house is well insulated and therefore does not require a conventional heating system. The majority of its heating demands are met through ’passive’ energy sources such as solar radiation, renewable energy sources and heat of the occupants of the house and electric appliances. Thus, a passive house uses 90 per cent less heating energy than a conventional building and 75 per cent less energy than average new construction. (Passive house conference, 2017)

CRITERIA OF PASSIVE HOUSE

Constructing new passive houses are extremely cost-effective. The main characteristic of a passive house is providing a high level of thermal insulation with a minimum amount of energy consumption. The following table shows the criteria that should be met for a building per year to be considered as a passive house.

table 1.1 Standards that should be met by passive houses (passipedia, 2020)

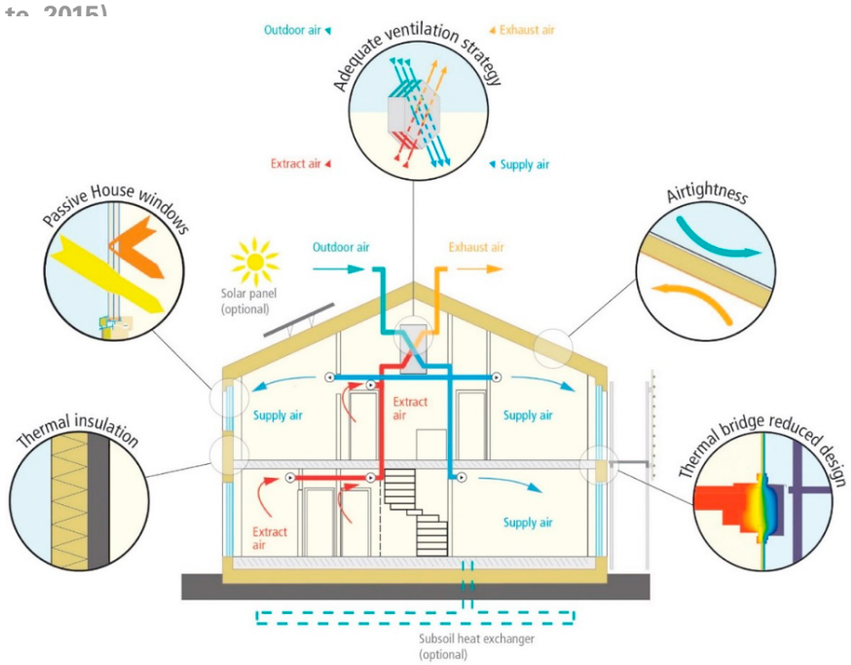
Energy demand	Standards that should be met by passive houses per net living space
Heating demand	≤ 15 kWh/m2 or ≤ 10 W/m2
Cooling demand	≤ 15 kWh/m2 or ≤ 10 W/m2 + dehumidification contribution
Airtightness	0.6 air changes/hr at 50 Pa pressure

PRINCIPLES AND TECHNIQUES FOR PASSIVE HOUSES

Following the pace of increasingly sustainable and technological housing systems, passive houses are developing rapidly. Its constructive techniques and materials have been evolving since its creation according to five determining principles to the classification of a house as being passive or not. As illustrated by figure 2.1 of a house section these basic principles are thermal insulation, airtightness, windows system designed for passive houses, ventilation systems with heat recovery and thermal bridge free design (Passive House Institute, 2015).

The success in bringing together all of those 5 elements on an efficient form is what defines a passive house achievement. Great comfort and excellent health conditions, consequences of the enhancement of fresh air quality, are the key success of this system. Its residents can enjoy a much higher quality of construction when compared to a house built upon traditional construction techniques (Passive House Institute, 2015).

Figure 2.1 Basic principles of a passive house. (Passive House Institute, 2015)



THERMAL INSULATION

The main feature of passive houses is that they are well insulated and require a minimal amount of space heating. Ideally, they do not carry a heating system; the house is insulated enough not to require one. The body energy (heat) of dwellers and the energy provided by the sun will be warming up and holding the inner temperature and comfort of the building. The entire package of well-insulated windows and efficient building envelope keeps the heat throughout the winter within the house – and keep it out along summer. The result is a house that typically uses 90 per cent less heating energy compared to a conventional house and 75 per cent less than a new building (European Embedding of Passive Houses, 2008).

Passive house insulation is obtainable in new buildings as well as in refurbishment processes. As a new construction site, the insulation can be applied under the floor slabs, in the external walls and ceiling or roofs. In a refurbishment process, the insulation is more challenging. Its application depends directly on the type of house as well as factors such as historic facades, a common circumstance in Europe (Passive House Institute, 2015).

As an alternative, the insulation can be applied in the inner walls, which does not keep the same efficiency as applied in the external ones, although still offering satisfactory coefficients. Challenges are also for floors and basements of existing buildings. Insulation is forced to be applied above (instead of below) the floor slab and/or, when the application in external walls is possible, make use of an insulation skirt. This “skirt” consists of an insulation layer coming all the way down from the external wall to house foundation. In the case of basements, a thermal barrier installation process is held, remaining it outside of the thermal envelope and being neither heated nor cooled. In new projects is an easily built process, but in existing basements, this can become an expensive alternative (Passive House Institute, 2015).

To prevent the house from losing its internal temperature will depend strictly on the insulation material and its application, which – as already mentioned – will vary again from new house construction to a refurbishment project. To be enveloped, all

the extremities of the house (internal/external walls, floor/slab, openings and roof) must be connected and well insulated. Joints then play a big role. The junction within those different parts of the house corresponds to a big heat loss when not well executed. The insulation material used on the floor has to be well connected to the same insulation material found in the walls and so on. The result is a large sealed box that prevents the internal temperature from undergoing drastic changes resulting from external ones (Feist, 2006).

Regarding insulation or heat losses, the thermal heat loss coefficient or the best-known “U-value” is the pattern definer. Applied to materials, this coefficient shows the lost values of heat (in Watts) per squared meter at a standard temperature difference of 1°K, therefore corresponding to the unit of “W/m2K”. The calculation is nothing more than the area of the wall in m2 multiplied by the U-value of the used material (Feist, 2006).

The insulating material to be chosen in the construction will reflect directly into the design and thickness of the walls, requiring wider attention in order to reduce space losses. The table below contains some materials and thicknesses necessary to meet the considered U-value of 13 W/m2K. This value is extracted according to the average value for passive house walls respecting Central European constructions, which should attend to a range between 0.10 to 0.15 W/m2K, varying according to different regions and climate conditions. Considering nowadays the energy price market, such variations express the “most cost-effective values” (Feist, 2006).

Table 2.1 Insulating Materials applied for Passive Houses (Adapted from Feist, 2006).

Material	Thermal Conductivity W/mK	Thickness Required for U=0.13 W/(m²K) m
reinforced concrete	2.3	17.30
solid brick	0.80	6.02
perforated brick	0.40	3.01
softwood	0.13	0.98
porous brick, porous concrete	0.11	0.83
straw	0.055	0.41
typical insulation material (mineral wool, polystyrene, cellulose)	0.040	0.30
high-quality conventional insulation material (polyurethane foam)	0.025	0.19
nanoporous super-insulating material normal pressure	0.015	0.11
vacuum insulation material (silica)	0.008	0.06
vacuum insulation material (high vacuum)	0.002	0.015

Analysing the table, the highlighted materials belonging to the lower section would be the so-called “ideal materials” for the construction of passive houses due to their considerably lower thickness. Although not included in the search, combined materials also provide good heat loss coefficients and can be widely used in buildings (Feist, 2006).

Therefore, to restrict the heat flow is the insulation main duty. The pre-disposition of the house concerning the sun will also contribute to great parts to its efficiency. Clear and easy examples are sunshades in summers and sun radiation in winters. During those two seasons, especially at their peaks, the envelope prevents the intense exchange of heat or cold, crea-

ting considerable internal thermal comfort. The minimum amount of heat loss from passive houses is compensated by processes which will be further detailed within the next sub-chapters. It is worth mentioning that good thermal protection is achieved on-site for all the constructive methods and types of construction, is that it follows all the norms and regulations foreseen for its execution (Feist, 2006).

AIR TIGHTNESS

Airtightness is a must in passive houses, meaning that there would be zero air leaks and the airflow within a building is in all controlled. This ensures that the heating and cooling demand of the house is decreased to a minimum during winter and summer seasons. In the course of cold seasons, for example, the house is not losing its warm internal air and it is not prone to the infiltration of cold air from outside (Page, 2016).

The building envelope, as already mentioned prior in thermal insulation, it becomes again the major actor. According to Feist (2015), the basic and key principle of the construction of a building containing airtightness is that of the “continuous uninterrupted airtight building envelope”. In another word, when one is faced with a section which is cutting throughout the building, the whole inner perimeter of walls, floor and roof should be represented as a continuous and impenetrable line. Airtight connections must be realized with total perfection. A 1mm gap allowing the airflow from inside out would set the whole project into malfunction (Blagojevic, 2015).

Although the importance of airtightness in passive buildings, it is not yet the most important one. Thermal insulation holds this place and they must not be confused and misunderstood. Despite to a few exceptions (as foam glass panels) insulation materials are not airtight and do not correspond for this function in passive housing. Therefore, the airtight envelope should be considered as a work apart, which must be carefully designed and constructed separately. Its execution is based on the 3 planning stages described below (Feist, 2015):

1. External building components: Each of the components which will be responsible for the airtight layer of the building

should be specified. Considering that same section mentioned prior, the continuous line representing the airtight layer must enclose completely the heated (winter) or cooled (summer) space. Basic examples cited by Feist (2015) are the “OSB board in roof construction, the interior plaster for a brick wall or the concrete ceiling between the basement and the ground floor”. Many other materials can be found among the market nowadays, varying in cost and applications methods.

2. Ends and Joints: When an airtight component is chosen, its ends and joints must be highly specified and conducted. Walls, roofs, floors and especially windows require extremely attention onto the execution of this impermeable layer. Simple connections represent failures. Those elements must be permanently joined within their airtight layers.

3. Penetrations: As in every construction, electrical cables and plumbing pipelines are common through floor slabs, external and internal walls, etc. The installation of these systems creates penetrations all around the building. Instead of airtight all of them, the first step is to analyse if those penetrations are necessary or they can be avoided or reduced. Alternative systems for many times can replace the traditional methods and greater improve the airtightness. When not possible, the penetrations should be at its maximum concentration in a few places as possible. Focusing on its solution, tried and tested materials are already available in the market targeted especially for this purpose.

To check the efficiency of the house concerning its airtightness an air pressure test is needed. The test - also called n50-value - is a tool to measure the total leakage through the building envelope based at a differential pressure of 50 Pa. To create this pressure between the inside and outside of the building, a “Blower Door Test” is used. A compressor attached to a door blows air within the house while the rest of the house is completely closed and sealed. The building is subjected to a pressure of 50 Pascals for circa one hour measuring the overpressure ratings (Page, 2016; Feist, 2015).

The same procedure is done with the fan turned around and blowing the air out of the building, measuring so the under pres-

surization. With the two tests already performed, experts analyze the values and calculate the average between both tests, thus defining the measurements of airtightness of the building. Certifications are usually given for houses reaching the standard of 0.6 ach-1 @50Pa. In other words, during the one hour of the test, there must be an exchange of air of less than 0.6m³ per square meter of floor area, obeying always the pressure difference of 50 Pa (Page, 2016; Feist, 2015).

According to Page (2016) among the many benefits of airtight are the significant reduction in heat loss, which directly reflects into the cost savings - as energy expenditures to keep the internal temperature stable -, generates considerable thermal comfort and enhance the thermal performance of the structure, preventing so the wicking of insulation. As Blagojevic (2015) points out “nowadays the level of airtightness in newly constructed buildings is usually too low for damage-free envelope components and at the same time too high to allow for sufficient gap ventilation”. The design and construction of the airtightness concept is essentially applied and projected over a long-term basis.

WINDOWS SYSTEM

An essential part of the thermal envelope, the passive hou-

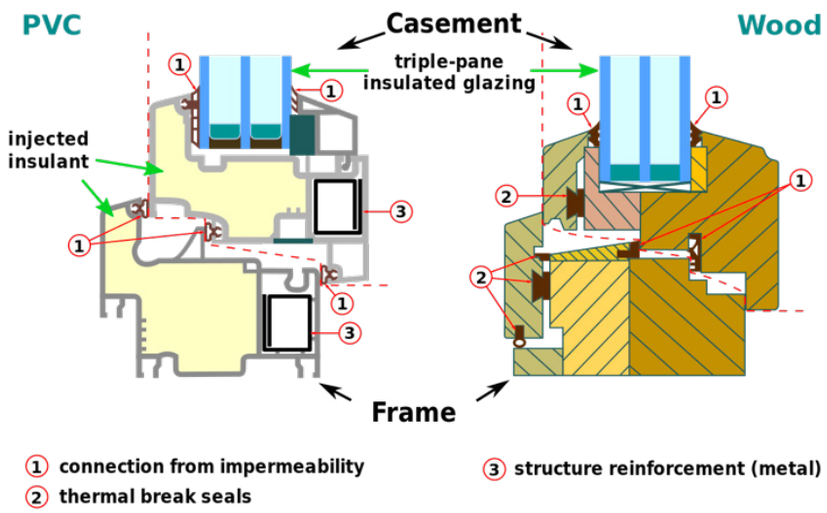


Figure 2.2 Passive house window diagram (Michka B, 2016)

ses window system has two major requirements. Firstly, they are required to be twice as efficient as conventional windows and, secondly, the predisposition of the windows throughout the house must be arranged to offer the maximum of natural sunlight during all seasons. Their positions will define directly their efficiency and, as considered the main glazed element of the building, the windows will play an important role arousing the three big standards of comfort and health of residents, energy efficiency and durability (Burrell, 2015; Insulation Superstore, 2018).

Solar gains rely on the type of glasses being used as well as the sun orientation. The g-value is the coefficient of measure of heat gains. Standard passive houses in cold-temperatures such as the ones found in Europe typically obey a g-value of 0.5 or higher, which means that 50% of the heat generated from solar irradiation is transmitted through the glasses while the rest is dissipated (Burrell, 2015).

The windows are certified and approved based on an "entire window structure”. Glass and glass spacers, frame and the installation in the wall form the necessary package to achieve high performance as depicted by the figure 2.2 below. The g-value is balanced between the U-value, working as a mediator between the optimisation of solar heat gain and minimising heat loss. It is important to reaffirm that the U-value considers the entire structure of the window as a parameter for measure and not just the glass. Again, the temperature conditions in which the house is being built will define such parameters (Burrell, 2015).

The glass system is usually composed of three panes of glasses - also illustrated in figure 2.2. Glass spacers are used in between these panes, holding them in place and providing a necessary gap for the windows thermal function. Aluminium, which is often used in normal windows, due to its high heat conduction is replaced for other components, for example, plastic. Fulfilling the gaps, inert gases as Argon or Krypton are used in replacement of air, regarding their higher efficiency against heat transition. The selected gas is sealed in between the panes and, eventually, a layer of low emissivity coating is applied on the surface of the inner and outer glasses. This coating is usually extremely thin and acts as a minimizer of the amount of infrared

and ultraviolet lights that come across the glasses. According to the certification standards for low-temperature climates, a glass must obey a U-value correspondent of 0.7 W/m2K (Burrel, 2015; Stanek Windows, 2017).

Common windows frames feature U-values around 1.5¬ - 2.0 W/m2K. Pacing the evolution of new high-technological frames - which are becoming smaller, thinner and best thermal resistant - such value decreases to around 0.7 – 0.8 W/m2K, providing efficiency enough to not to compromise the whole window installed U-value. Despite not offering the same level of insulation, window frames that are no insulated may still be wrapped from the outside with a thick layer of insulation material. As a result of its difficult application, they will be considered the weakest point of the entire window structure. Also, frames and glass spacers are considered together as the opaque elements of a window, being so combined for certification purposes. A linear heat transfer coefficient (Psi-value) from the combination of both must stand within 0.2 W/mK or bigger (Burrel 2015, Krick, 2015).

The installation of passive housing windows has a big matter and must be held by professionals to avoid weakening the envelopment of the building, resting the junctions between the wall and the window the biggest installation issue. According to recommended installation guides, the wall insulation should overpass some sections of the frame, covering and connecting both elements (Burrel, 2015).

European standards determine installed U-value for windows as being equal or lower than 0.85 W/m2K. Such value does not normally reflect the value of the project, but provides important information in a passive building execution. The installed coefficient considers all of the parts composing a window and its independent values, which are glasses, frames, glasses spacers and window installation. Even though the Passivhaus certification does not require the use of certified passive windows, its application in projects is fully recommended and efficient (Burrel, 2015).

VENTILATION SYSTEM

The maximum health and comfort from the internal building's environment cannot be achieved without a well-planned ventilation system. Although not considered mandatory in passive housing, ventilation and air exchange are necessary for its higher benefits. According to the location on which the house is being built, a mixed-mode ventilation system could also produce considerable health and comfort results using natural ventilation combined with mechanical ventilation. This is the case in places where seasons as summer and winter are well defined, varying between the natural method for hot days and mechanical for cold ones (Burrel, 2014; Lamar, 2006).

Natural ventilation within the building envelope occurs usually through two forms of exchange. Firstly, made up by residents, the ventilation is controlled and based at the opening of windows and doors to provide airflow within the building. This technique requires certain expertise for humans to identify the duration and amount of air being blown inside the dwelling, creating a need for opening the windows a few times a day during short periods. It is a difficult task and impractical in most of the situations, resulting yet in bad indoor air quality due to increased humidity or drought and, hence, huge heat losses. Secondly is the uncontrolled natural ventilation which is according to poor execution installations and results in unintentional gaps and openings in the envelope (Feist, 2006a; Level, 2019).

Mechanical ventilation is attached to the principle of ensuring draught-free indoor comfort with heat recovery. It is based on a controlled supply and exhaust air system planned and distributed within the building, resulting in a crossflow ventilation which allows optimal handling of fresh air. A heat exchanger (counterflow) ventilation unit is placed usually in the attic or basement of the house. Inside of it, the fresh, cool outside air and the warm, dirty indoor air cross but never mixed. The process happens through to the proximity on which the ducts of air flows inside the unit cross next to each other, becoming the cold air warmer and the warm being cooled down. Currently, there are highly efficient heat exchangers developed especially for passive houses, meaning a heat recovering of at least 75 per cent of the heat and reaching sometimes values over 90 per cent and even 95 per cent of efficiency. The unit should always work in clean conditions and silent mode (Feist, 2006a).

Wherefore, the building needs to get rid of all the pollutants from its inner environment which nor mally include moisture, volatile organic compounds and carbon dioxide. Such pollutants are originated from common human activities as cooking, cleaning, using the toilets and any other household activities. Hence, the air extractions are carried out through extract valves from the places that produce them the most, i.e. kitchen, bathrooms and any other room related to activities generating of such pollutants (Level, 2019; Lamar, 2006).

On the other hand, the fresh and pure air supplies all other facilities such as sleeping rooms, living rooms, workrooms, dinner room, etc. Air insertions occur through supplier air valves replacing the bad indoor air quality for purified air, leading so to high levels of indoor air quality and, therefore, internal comfort. This exchange of air happens in a gently and low-speed process, where the fresh air is blown inside the house almost imperceptibly, generating no kind of draughts or uncomfortable sensations in where is being supplied. It is worth also bearing in mind that no recirculated air will ever be supplied through this system, only quality outside air (Burrel, 2014; Lamar 2006).

Finally, passive houses delivering maximum efficiency and comfort will always make use of integrated mechanical ventilation with high-efficiency heat exchangers and low electricity consumption fans. Increasing the supply temperature to values near to the conditions of the rooms in which is being delivery minimizes the peak heating load, reducing considerably the costs regarding the heat distribution of the dwelling. As soon as there are no longer cold draughts and more energy is being saved the operational purpose of the ventilation is succeeding (Feist, 2006a).

THERMAL BRIDGE FREE DESIGN

A thermal bridge is a section or element of an enveloped building where heat transmission is more favourable, i.e. the insulation is not as effective or present at other places. This heat flows result in loss of heating in winter times and undesirable additional heat passing through the envelope in summer, hence resulting in a decreasing in the internal building's comfort (Burrel, 2015).

When subject to several thermal bridges the building will face a list of issues as increased heat losses, low surface temperatures and impaired thermal comfort. In extreme cases, the risk of mould growth and condensation will require even more attention upon repair techniques. According to passive housing standards, this sort of problems must be non-existents, preventing damage to the high-quality building envelope (Passive House Institute, 2020).

Thermal bridges are based on two very distinct models, the geometric thermal bridges and the construction thermal bridges. The geometrical thermal bridges will occur where the insulation changes its directions or the thickness of it is changed, usually being present at crucial joints around the extension of the building envelope. These junctions depicted as external wall corners, eaves junction, roof ridges, openings joints – windows and doors –, the junction between the floor slab and external walls and foundation connections. Geometrical bridges are an existing element in all types of buildings without exceptions. What can be done in order to minimize thermal damage is to develop a house within most basic designs, containing fewer curves and, consequently, less geometrical joints (Burrel, 2015; Passive House Institute, 2020).

Constructive thermal bridges are visually easier to comprehend and identify. All elements or sections of the insulated envelope which are being penetrated by a physical element or anything which creates a gap into it will be considered a construction thermal bridge. Different materials mean different thermal conductivities, and, that is where the bridge is defined. Elements with higher heat conductivity generate lower temperatures and increased heat losses within the building, conducting higher amounts of heat from the outside to the inside. A good and common example of it is concrete hanging balconies, which work as an extension of the inner slab, sticking out of the building. Minimization of such thermal bridges are only possible through careful design and construction methods. Additionally, geometric and construction models can be combined forming the same thermal bridge (Burrel, 2015; Passive House Institute, 2020).

Buildings are considered as thermal bridge free design when

their bridge elements respect the value of thermal bridge loss coefficient (Ψe) as equal to or lower than 0.01 W/mK. After all values have been calculated, their sums should not add extra values to the building's overall heat loss sum. Three basic rules that must be followed in order to achieve such standard: the connection rule, avoidance rule and penetration rule. They respectively correspond to a building envelope where the insulation connections are following perfectly the connections between components – merging within each other through entire surfaces –, elements which interrupt the continuity of the insulation are averting as much as possible and, when the penetration is required, materials should be chosen according to their lowest thermal conductivity, avoiding though considerable heat losses (Passive House Institute, 2020).

Once solved, thermal bridges will be essential for the high performance of passive buildings providing exceptional levels of comfort and cost savings - associated with energy efficiency and building sustainability -, fulfilling the high-performance thermal envelope ambitions upon the enclosure of the entire inner heated volume (Burrel, 2015)

CURRENT PASSIVE HOUSES (CASES OF STUDY)

SINGLE-FAMILY HOUSING – VALDA HEBERG, SWEDEN, 2012

There is a Swedish residential area called Vallda Heberg, where all the houses are constructed and certified based on the Swedish passive house style. The national standard requires unique structural features in the construction of the buildings, namely as highly isolated buildings with airtight envelopes and heat recovery system including exhaust ventilation in all houses. These components cooperate with reasonably low energy consumption. The suburb consists of 26 single-family homes which are completed in 2012.

DESIGN METHOD

Each detached house has 140 m2 and divided into two floors. The style of designing these detached houses is according to the standard sample of a single-family house which is consist of

the first floor with kitchen, living room, laundry and toilet. There are three bedrooms on the second floor with dressing room, bathroom and small living room. Also, there is a glass-enclosed vestibule that acts as an additional hallway and a carport with a storeroom within close vicinity to the house (Fahlén, Olsson, and Kilersjö, 2015).

CONSTRUCTION COST

Total expenses for one single-family house were roughly 190 k€ (with the exception of VAT, using a currency rate of 9 SEK per €), of which 13 per cent was projected to be extra expenses for energy efficiency steps. The final cost per m2 is calculated at almost € 2.450 (which include VAT and taxes), just 10 per cent more than a single-family house in Sweden (Fahlén, Olsson, and Kilersjö, 2015).

ENVELOPE PERFORMANCE

A single-family house construction framework includes load-bearing timber stud walls with a truss frame on top of the timber roof. The walls are insulated with natural wool as well as the cold attic roof with isolated blow-in wool. The foundation is made of a concrete slab on the ground and the slab between the two floors is consist of lightweight composite log beams (Fahlén, Olsson, and Kilersjö, 2015).

Element	W/m2K
External walls	0.106
Ground floor	0.08
Roof Attic floor	0.07 0.055
Windows (frames included)	0.75
External entrances and balconey doors (frames included)	0.7 - 0.8

Table 3.1 U-values of the fundamental factors in a conventional detached house (Fahlén, Olsson, and Kilersjö, 2015)

- The timber stud walls were covered with 29 cm thick natural wool and 8 cm of glass wool (U=0.11 W / m2 K), whereas the roof was covered with 60 cm of blown wool (U=0.07 W / m2 K).

The house features triple-glazed windows.

- The function of balcony and carport is being used as a solar shading panel for windows which are set up on the first floor. horizontal timber panel is the main component of houses facades.
- The glass-closed vestibule acts as a "breezeway" (standard U.S. term) and prevents heat leakage when open doors (Fahlén, Olsson, and Kilersjö, 2015).

ENERGY USAGE

The estimated specific energy usage (60 kWh / m2/year) for detached single-family homes includes space heat demand (39.2 kWh / m2/year), property electricity for building services (5.6 kWh / m2/year) and domestic hot water (15.4 kWh / m2/year).

It should be noted that domestic hot water is used in washing machine and dishwashers in a passive house. Regarding Swedish building standards, the energy consumed by the appliance is a part of the domestic energy, not particular energy being used for this reason which means the rate of particular energy usage is lower than the number is mentioned before (Fahlén, Olsson, and Kilersjö, 2015).

Uses	Final Energy (kWh/m2year)	Systems	Primary Energy (kWh/m2year)
Heating	33	Solar energy	0
Hot water	17.6	Biofuel	30.4
Cooling	0	Wind energy	0
Ventilation	5.1		
Lighting	n.d.		
Electrical appliances	n.d.		
Total	55.7	Total	30.4

Table 3.2 Observing misallocation in 2013 (Fahlén, Olsson, Kilersjö, 2015)

The project demonstrates effective cooperation with the measured values at the planning phase and the dweller was satisfying with the indoor climate.

	Heat (kWh/y)	Units	Solar collector area (m2)	Total (kWh/y)
Sub Station 1	7,800	19	142	148,200
Sub Station 2	7,800	7	38	61,600

Table 3.3 Overview of 2013 Solar Thermal generation (Fahlén, Olsson, Kilersjö, 2015)

ENERGY SYSTEM

All buildings are supplied with heat recovery unit. Inside the buildings, there is a hot water loop which is utilized both for space heating (the heat exchanger provides and transfers the heating coil in the air processing unit with heat through a glycol circuit) and adequate heating in the bathroom floor, also for hot water in the house. The washing machines and dishwashers are linked to the hot domestic water in all buildings (Fahlén, Olsson, and Kilersjö, 2015).

HVAC SYSTEM

The energy required for both space heating and household hot water in the residential district is provided totally from onsite renewable resources. Heat is produced from two various forms of solar thermal reservoirs: 570 m2 flat plate collectors (situated on substations and roofs) and 108 m2 ejected tube collectors (installed on the boiler) in a 250 kW centre of a wood pellet boiler (backed by an oil boiler). The target is approximately 40 per cent of annual energy usage will generate from solar thermal reservoirs for household hot water and space heating (Fahlén, Olsson, and Kilersjö, 2015).

In order to deliver heat from the production unit to single-family houses, the district-heating system is operated. This district-heating system is made up of two primary and secondary systems. The primary system is considered a teleheating with both deliver and return pipes which are supplies heat from the generator and also from evacuated tube collector transmit to four substations via the system. Solar heat produces from collectors which

are situated on substations. Heat is transferred to the secondary system through the stations, that is a domestic hot water loop supplying for a passive household with both hot water and heat (Fahlén, Olsson, and Kilersjö, 2015).

APARTMENT BUILDINGS - VÄRNAMO, OXTORGET, SWEDEN, 2006

The case study is going through 5 rental apartments that have been built in a developing city called Värnamo In Sweden. These 40 Apartments has been designed and constructed meeting passive house standardizations. This decision has been made based on the fact that the maintenance of the apartments during its life cycle in comparison to the cost of the construction is less than a normal apartment; so they came up with a concept of passive housing for these dwellings. The extra cost of construction of passive houses will pay off by cutting costs on maintenance over the years of the building's life cycle (Janson,2008).

The primary needs In the application that was represented to the Swedish Energy Agency for funding by the planning group:

The U-Value for Base floor is 0.09 W/m2K , for The exterior walls 0.10 W/m2K, For windows 0.85 W/m2K, for the entrance door 0.6 W/m2K and for the roof 0.08 W/m2K (Janson,2008).

For the Acoustics the walls should meet the Swedish class B standards; means that the highest sound level of interior spaces like bedrooms and living rooms can not be more than 26 dB(A). for the kitchen, the highest possible is 35 dB(A) and the highest possible outside noise can be 26 dB(A) in rooms and for the kitchens 31 DB(A) (SS 02 52 67 utgåva 3, 2004).

The household appliances should meet the energy class A++, there should be drainage for heat exchanger and the efficiency of air heat exchanger must be 85 per cent (Janson,2008).

DESIGN

The building is designed to be two, 2-storey buildings and three 2.5 storey buildings. The number of bedrooms in each apartment varies from 2 to 5 and some of the apartments have balconies or

a patio. The height of the interior space ceilings is 2.5 meters that work with the natural daylight in the apartments (Janson,2008).

Materials

The material that has been used for each element of the building are listed below:

- Flooring: Bathrooms: plastic matt
  Hallways: rubber carpet
  Other interior spaces in the apartment: parquet

- Walls: Indoor walls: paint/wallpaper preferably white because it meets the energy class A++ (Janson,2008).

Building envelope	U-value [W/M2k]
Ground floor (excl.foundation)	**0.09**
Exterior walls	**0.095**
Roof	**0.07**
Window, average	**0.94**
Door	**0.60**

Table 3.4 Depicts the U-value for each element

HVAC SYSTEM

The ventilation system in each apartment works separately. The air is warmed up by the heat that is conducted by electric heating batteries. The capacity of batteries differs related to the apartment's size. As was mentioned before in the text the heat exchanger's efficiency is 85 per cent that leaves less noise when it works. There needs to be a 58W power supply for each fan and there are two fans in every heat exchanger unit that works none-stop during day and night to blow five different levels of flow (Janson,2008).

WATER SYSTEM

The hot water producing starts from the solar collectors on the roof of each apartment. The area of solar collectors is 25 m2. The 50 per cent of the energy provided by solar technology and the rest of energy that is needed for warming up the water comes from electric batteries in the accumulator tank (Janson,2008).

In the case of not using the solar collectors two water heaters warm up the water to 65 degrees and then it mixes with the cold water before going to the taps. The system starts working when the sensors on the collectors show 3-4 degrees higher than the temperature on the hot water tank (Janson,2008).

The temperature of cold water should be kept between 5-9 degrees because it will cool the floors and walls (Janson,2008).

All the pipes are well-insulated so that the temperature of both cold and hot water would not change when the water runs into the pipe. Because of the high expenses, the plan of recovering heat from sewage water has been cancelled (Janson,2008).

WINDOWS

There was some problem with the planned U value for the windows that was 0.85 W/m2K: No Swedish company produces that type of windows so they had to increase the number of fixed windows and change the required U value for the operable windows to 0.94 W/m2K (Janson,2008). Also, the required airtightness had been changed from 0.2 l/s m2 to 0.4 l/s m2 because the contractor could not accomplish it (Janson,2008).

EXTERIOR WALLS

The Wooden frame structures mainly shape the exterior walls and was positioned on the construction site. The layers of the wall from outside to inside are consisting of: Façade material, wooden studs and mineral wool that has plastic foil on the studs and gypsum board and polystyrene. The role of the plastic foil is to prevent the plastic panels from getting moisture while poisoning pipes and electrical pieces of equipment (Janson,2008).

The plastic foils are sealed so it can accomplish the needed airtightness. Besides, double-sided adhesive tape was used in the connection of walls between the roof and foundation to test the airtightness.To keep the joints between walls and foundation dry, a metal sheet was used to conjunct wooden walls to the concrete slabs (Janson,2008).

The same problem with the windows existed with doors; doors with required U value could not be found in the market so they had to use their door design by a company (Janson,2008).

ECONOMY

The final costs of the project exceeded from the calculated costs and one the main reasons were the wage for the design team because the decision for making this project as a passive housing has been made after the first design and all the drawing should be revised again for the passive design that cost extra 200,000 -300,000 SEK. Although the was a 1 650 000 SEK funding by the government to help the project financially. Here is the list of calculated costs and additional costs (Janson,2008):

- Calculated costs for the client: SEK 50,243,000
- Purchased cost for the client: SEK 52,300,000
- Final costs for the client: SEK 55,700,000
- Total costs for the contractor: SEK 36,700,000
- Design costs: SEK 1,000,000

ECONOMIC ASPECT OF PASSIVE HOUSES

Promotion the Construction of Passive Houses (Feasibility)

Nowadays, people start to look in the direction of sustainable houses which consumes less energy and save the budget. However, this demand is not much. Architects and engineers need to change their approach towards construction methodologies. A passive house is one of the best approaches to construction where occupants can save their money.

If construction industries consider the possibilities to build a passive house, then there are technologies and methodologies which is already done in this sector. Above mentioned methodologies prove that there are quite feasible to build passive houses, though, there are challenges such as initial high cost, lack of awareness, technology transfer and patent right issues.

EDUCATION

There are examples of a passive house in a different climatic region but still, the construction industry should construct a more passive house to take care of occupant health as well as the environment. The construction sector needs more skilled personnel and awareness among users and the only solution to all these issues are education. Industries need to organize a more competition, seminar, conference and research on this area to develop and support innovation for energy and money saving passive houses.

INITIAL COST OF PASSIVE HOUSING

How much does it cost to build a passive house? It is not an easy question to answer, because the cost of such construction depends on what goes into the final product. Usually, it is a belief that a passive house requires high initial cost though, researchers are still working on this field to minimize it. As this sector is moving forward, construction experts and scholars are developing new technologies and materials to reduce cost. Sample projects for exhibition could be the possibly right way to understand the cost and benefit of passive housing.

Mostly, passive buildings are residential, and the trend of passive philosophy is increasing on the other type of buildings such as commercial, institutional and industrial. Therefore, builders and developers have a huge scope on such projects and can create new standards. The key point on certification of passive projects is the tools for the performance of a building. (Freeman, 2017)

Every building has its requirements, space uses and material qualities. Hence, cost rely on several issues and that is why the final cost of a building depends on what type of project is and what choice of person or client has. Use of materials and their finishes, appliances installed in passive houses and how many these are in numbers also affect the cost because it is not just one-time installation but maintenance or replacement would also take place.

The value for construction which depends upon resource

availability, skilled labour cost, government policies (for example carbon subsidies for developing nations) will not be fixed from one country to another country. Climate also plays an important role in this concept: sometimes the design of a building based on climate become the key factor of the initial cost for that specific project. In Finland, the implementation of insulation for the facade and renovation of a building is common. The cost for these renovations is more expensive than the building of new construction.

In most of the cases, the initial cost of passive projects range is around 7 to 15 per cent higher than usual according to the contractor´s experience, but again this issue is still under consideration. A logical approach would be to calculate the cost of a passive house not by how much money do builders invest rather how much return possible during the (Freeman, 2017)

FIVE FACTORS OF PASSIVE HOUSE COST TO CONSIDER

To invest in an asset: Initial cost of the project should not exceed more than 15 per cent of overall cost according to Freeman, otherwise, return on investment would take more time. A good asset has a good return on investment in the perspective of energy consumption, maintenance cost and productivity till their life cycle. (Freeman, 2017)

Installation of Prefabrication: Cast in situ is a more expensive approach if prefabrication is possible, it helps to reduce the construction time and brings perfection in finishes with the help of quality measures. (Freeman, 2017)

Building supply cost transparency: Since the passive design is often used in the market, so, the prices of passive components are flexible, competitive and variety of range in quality is available; that means transparency in the supply of building materials. There is various equipment like ventilator, glazing windows, window frame, Valve, solar panels which are also available in an online platform and easy to get through passive house companies (Freeman, 2017)

Operating costs: Traditional building consumes more energy than a passive one (around 90 percentage more). The prime focus of the passive house is to reduce energy and optimum use of natural resources. Therefore, the total cost of operation for energy tends to be zero and thus, it reduces the operating cost. The initial expenditure on assets based on the long-life cycle is useful for eliminating the replacement possibility and regular expense on maintenance, thus, save the operating cost.

Reduced insurance cost: Those insurance companies who are aware of passive housing concept and understand the benefits and durability of buildings, have more probability to insure in lower cost. As it is at lower risk side because of environment friendly and long-life cycle components used in passive buildings. In this perspective, several other insurance companies provide insurance at a reasonable rate. (Freeman, 2017)

A COMPARISON OF CONVENTIONAL HOUSING AND PASSIVE HOUSING

Based on the above case studies, true values related to cost analysis of the passive house and the conventional house would be feasible. In the following tables, there is a comparison of passive and non-passive house. A cost estimation of an apartment building in Sweden compared with a conventional building (2006).

Apartment Buildings - Värnamo, Oxtorget, Sweden, 2006

Items	Passive (€)	Conventional (€)	Notes
Design cost	69,15,000	36,88,000	extra 23,05,000*
Construction cost	33,83,74,000	24,42,74,600	
Door (extra)	23,05,000	-	As/passive
Ventilation(additional)	2,95,000	-	As/passive
Airtightness	6,91,500	-	As/passive
Appliances(additional)	14,93,600	-	As/passive
Total	35,00,74,100	24,79,62,600	

Table: 4.1 Cost comparison for the passive house in Sweden. Reference: Author, (Janson, 2008)

Another example from the UK shown in the following table4.3 provides some transparency in this respect. This is just a construction cost comparison in the UK as per their regulations. Authors are taking just construction cost to give a glimpse of how cost-wise construction of these two different buildings takes place. The passive house as an example is taken here is the Larch and Lime houses in Ebbw Vale. (Nick Newman, 2010)

The Larch and Lime houses in Ebbw Vale, Wales

Items	Passive (€)	Conventional (€)	Notes
Substructure	8,300	6,710	As/passive
Superstructure	62,000	50,400	As/passive
Building services	16,700	20,300	As/passive
Ventilation	7,200	1,200	As/passive
Total	94,200	79,400	

*At first it was planned for conventional Project

Table: 4.2, Cost comparison for the passive house in the UK. (Nick Newman, 2010)

It shows the difference in capital investment for passive against conventional houses in the UK. As the author mentioned above, the initial cost for passive houses is varied in a different region or builder or design. It is tough to estimate exactly how much initial cost is required for passive; however, it seems around 20-25 per cent from conventional projects at the same built-up area. These figures depend on various factors such as the location of the plot, building type, material sources, technologies, the economy of countries etc.

OVERALL AND RUNNING COST OF PASSIVE HOUSE, A CASE STUDY

A detached house in Germany with a floor area 149 m² is taken for running cost estimation and recovery of initial costs. (Passipedia, 2019)

Expenditure and savings for a Passive House (149 m²)

- Comparison for the first few years -

Additional investment* compared with a Normal house: € 15 000

additional repayment in the first year (bank): + € 945/year (At an interest rate of 4.7 per cent and 1.6 per cent repayment rate)
Reduced cost liability due to a low-interest loan (first year): - € 880/year
(KfW ESH40/Passivehouse)
With energy savings of 11000 kWh/a for heating:
Savings in heating energy costs with 65 cents/litre heating oil: - € 715/year

Extra costs for electricity for ventilation with 18 cents/kWh: + € 65/year

Output: reduction of the cost liability in the first few years: € 585/year

* Beispiel: based on before 2010 experience, the investment can now be lower. (Cblagojevic, 2020)

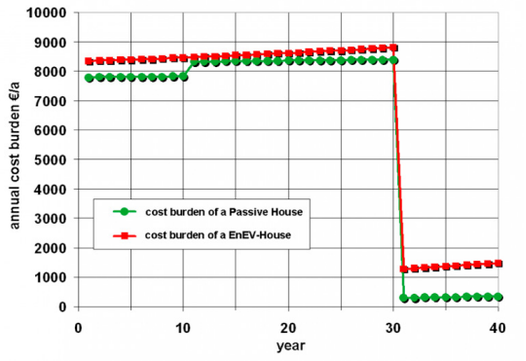


Figure 4.1: Cost liability trend of a normal house (red) and a Passive House (green).
(Cblagojevic, 2020) © Passipedia / Passive House Institute

As per shown in calculations and figure 4.1 (Passipedia, 2019), annual cost pressure is lower and after 30 years loan will be paid off and later profit due to saving on energy consumption would be possible. Therefore, the overall cost for the passive building could be summarized as less than the cost of a conventional one in the long run.

PASSIVE HOUSE STANDARDS

THE PHI STANDARD

The Passive House Institute (PHI) dates back to 1996 in Germany, where it has been a vital driver to the development and promotion of the passive house concept and techniques. Its standards and guidelines cover the techniques and building physics of new-build-housing (Passive House Institute, n.d.).

The standard formulated by PHI is a voluntary standard for building performance and primarily focuses on reducing the demand for heating in a building instead of pursuing green energy supply solutions to cover the demand. The standard offers a detailed design tool called Passivhaus Planning Package (PHPP), which is used by the designer to predict and calculate the energy consumption of the building. The PHPP program helps the designer to predict the building envelope or energy performance as the designer provide the necessary information such as the thickness of the insulation, the size of windows, to the PHPP program (Pullen, 2018).

The PHPP program does not consider the desired construction method but does give certain requirements such as very thick insulation, triple glazed windows with insulated frames and a high requirement for airtightness. The PHI standard target goal for a building to fulfil the standards of becoming a Passive house are set to 15kWh/m2/yr. (Pullen, 2018).

The idea of the PHI Standard is, that the building should be able to heat itself without or with minimum heat supply simply by the passive solar heating and the heating and usage of the building itself.

ISSUES RELATING TO THE PHI STANDARDS AND CERTIFICATION

The PHI standards can be difficult to adhere to, as the rules must be somewhat strictly followed otherwise the building can lose its status as a passive house. It is, for example, important to understand how to operate the building, how to heat it, when

to open the windows for natural ventilation or turning up the ventilation system, as these all have an impact on the energy consumption of the building and will thus affect the overall target of the standards. This means, that the Passive House buildings, are not as easily adapted to our liking and customization as conventional buildings, where one may do as he or she pleases. (Pullen, 2018)

It might also be worth considering the original conditions when the Standards were first published, the use and technology of renewable energy was not, as it is today, as well as the research and awareness of sustainable materials and reducing the carbon emission of building materials (Pullen, 2018).

Thus, reducing the heating demand is a well-sounding solution for both environment and homeowner, it is worth considering if focusing exclusively on reducing heating demand is the optimal solution or whether other factors and practices should be considered as well (Pullen, 2018).

THE ENERPHIT STANDARD

Retrofitting a building is an optimisation of an existing buildings energy performance. It typically aims to considerably reduce the buildings energy consumption by for example improving its insulating layer. A retrofit is therefore not only about implementing more sustainable energy supply sources but improving the thermal ability of the materials (Testa, 2018).

However, it can be difficult to live up to the demands outlined in the PHI Standards when dealing with an existing building as many of the factors for achieving the standards are already determined such as orientation and geometry.

Thus, the EnerPHit Standard aims to enable the building owner to set a target for how and how much should be achieved, when retrofitting a building, as it can also be difficult to determine exactly what and how this should be accomplished (Testa, 2018).

The EnerPHit Standard provides, similarly to the PHI Standard for new homes, a guideline and target goals for existing buildings with tough but achievable parameters.

The target goals for achieving the EnerPHit standard is instead of a PHI requirement of a U value 0,15kWh/m2/yr. It is changed to 25kWh/m2/yr. Similarly, the airtightness performance requirement is changed from 0,6m3/hr to 1,0m3/hr. So even though it is not entirely as strict as the PHI standard for new buildings, it will still perform a great improvement to the energy consumption of the existing building and thus the EnerPHit standard also recognises the issues connected to renovation and retrofitting of an existing building (Testa, 2018).

Again, a thick layer of insulation is in focus and a necessary parameter to meet the demands in the standard. Other elements such as triple-glazed windows and external doors are also repeated here as in the PHI standard for new buildings. And finally, a mechanical ventilation system with heat recovery also called a MVHR system (Testa, 2018).

Another parameter to pay attention to, both in the PHI and in the EnerPHit standard, is the careful planning and installations of windows and doors etc. to ensure the airtightness of the building (Testa, 2018).

However, most renovations also come with some difficulties, whether it is aesthetics or building physics or both. It is important to address the possibility of increased difficulty when retrofitting according to the EnerPHit standard, as there is likely possibility of cold bridges which must be tended as well as the issues with moisture and mould if the insulation is placed incorrectly for example when dealing with internal insulation (Testa, 2018).

In this case, opting for certification of the building according to the EnerPHit standard is a great benefit, as it provides quality assurance for the way the retrofitting has been carried out and thereby minimised later issues that might appear (Testa, 2018).

COMPONENT DATABASE

The PHI holds a digital component database, where certified systems and materials are stored. Everything from the opaque building envelope to the transparent building envelope, to the

building services, are found in the database.

This digital database also promotes and assists designers and planners who desire to achieve the standards of either PHI or EnerPHit and makes these techniques and knowledge available and easily accessible to the individual.

The component database can be found through the following website: https://database.passivehouse.com/en/components/

NEAR PASSIVE HOUSE ACHIEVEMENT

According to an Eco-expert Tim Pullen, approximately 35% of the extra cost attributed to building a passive house according to the PHI standards are spent on achieving the glazing requirement, as mentioned before, windows and doors must be of high quality, airtight and have triple glazing. An additional 30% is used for meeting the required airtightness (Pullen, 2018).

He argues, that the local climate in Germany, for which the PHI standard is developed for, are not necessarily as efficient or necessary in another climate where the weather might not be as cold and thus, additional and unnecessary strict requirements and standards might be unnecessarily costly (Pullen, 2018).

Another thing he points out while mentioning the good of the standards is that ignoring some of the strict rules and standards will still have a high impact on the energy consumption of the building. For example, by ignoring the high requirements of the windows and airtightness could reduce the extra costs of building a passive house with approximately 50% (Pullen, 2018).

TRAIN-TO-NZEB & FIT-TO-NZEB

The Train-to-NZEB is an EU financed research and educational project, which aims to deliver high-quality training on energy efficiency within the construction industry. The project aims to increase knowledge and the skills through practical and demonstrational training as well as thorough consulting to enable and promote the design of “Nearly Zero-Energy Buildings (NZEB). The training and research are based upon the Passive House concept with the support of Renewable Energy Sources (RES). The training and research is also aimed at non-specialists, such as

authorities, NGO’s and media (Train-to-NZEB, n.d.).

The Project partners include five European countries: Turkey, Czech Republic, Bulgaria and Romania and Ukraine and with the expertise and knowledge from Germany (PHI) and Irelands Passive House Academy and Limerick Institute of Technology, the project expects to promote and increase the desire for designing and building NZEB and also enhance the market demand for such solutions (Train-to-NZEB, n.d.).

The Fit-to-NZEB project is as the Train-to-NZEB also an EU financed educational and research program. But the Fit-to-NZEB focuses mainly on education and training in how renovation and retrofitting an existing building is achieved. The Fit-to-NZEB is aiming to increase the interest and demand for more training in the energy efficiency and deep energy retrofit of a building as well as through education and promotion increase the pace at which the existing building stock is energy renovated (Fit-to-NZEB, n.d.).

The Fit-to-NZEB project includes seven European countries: Romania, Greece, Austria, Czech Republic, Ireland, Italy and Bulgaria and includes several universities and institutes in the partner countries (Fit-to-NZEB, n.d.).

The goal with both Train-to-NZEB and Fit-to-NZEB is to increase the demand and interest for high-quality energy buildings and renovations as well as educating and sharing the knowledge of available techniques and solutions from other countries and cases, this way helps to reduce the energy consumption within the building industry (Fit-to-NZEB, n.d.).

AFFORDABLE ZERO ENERGY BUILDINGS (AZEB)

The AZEB project, financed by the EU Horizon 2020 initiative, sets out to identify, research and educate individuals in the construction industry, to how zero energy buildings can be reached affordably. The project has been initiated in the wake of the EU directive on May 19. 2010 on the energy performance of buildings to find an affordable method and solution to how NZEBs can be achieved and thereby also encourage and promote the interest in the subject (AZEB, n.d.).

The AZEB project has developed a common methodology for the design and construction of cost-efficient Nearly Zero Energy Buildings. Thus, along with the EU recognises the concept of the Passive House, but also finds, that achieving a true Passive House, will be difficult and perhaps the wrong approach to how to solve the energy consumption in the building industry. Therefore, it focuses on the NZEB, as it will still have a great impact and is more realistic to achieve, both for the union and for the construction companies and homeowners.

T

he Methodology developed by the AZEB project includes 17 steps for reducing costs of NZEBs. These steps are spread out on four sections where cost reductions can be achieved: Initiation, Design, Construction and Use and Maintenance (DNA in de Bouw, 2019).

The methodology can also be further boiled down to three key points on how Affordable NZEBs can successfully be achieved.

- Quality assurance
- Procurement
- Integrated project delivery

According to the methodology, Affordable NZEBs can be achieved by either one of the above-mentioned key points, or by any of them in combination with the other. Each key point holds a number of the 17 steps and are thoroughly described and explained in the AZEB Methodology report. Ultimately the methodology proposes the steps 1-6, deeming them critical for the achievement of Affordable NZEBs. These steps are as follows (DNA in de Bouw, 2019):

- Identify relevant contextual aspects
- Set balanced requirements
- Standardize costing practices
- Install a quality assurance process
- Conceive and select alternatives
- Define practices for procurement and guarantees

The first of the above-mentioned steps include activities such as formulating project goals, identifying relevant stakeholders, and identifying relevant risks and opportunities for the project (DNA in de Bouw, 2019).

The second step of the above-mentioned steps includes interviewing the client, identifying the needs and wishes of all stakeholders, developing an initial specification of requirements in a standardized format, whereby making it possible for stakeholders to track certain design or building specifics to their origins. Finally, being able to discuss any requirements and clarifications with relevant stakeholders (DNA in de Bouw, 2019).

In order to accurately estimate and access the cost of the NZEB, the stakeholders in the project must calculate and report the costs in a standardized way to clarify the actual lifecycle cost. Therefore, it is essential, that the stakeholders agree and implement definitions of building elements and costing parameters used in the project and agreements on how costing is practised in contractual agreements (DNA in de Bouw, 2019).

The fourth step requires you to implement quality assurance from early on in the project. Once the project goals have been established, a validation and verification plan should be developed, to control and validate the solutions and control whether they fulfil client demands. It is also important, that a quality assurance system is set up so that quality documentation and control is carried out in a standardised way. Quality assurance should be implemented in each of the project's phases (DNA in de Bouw, 2019).

The fifth step asks you to be creative and look for alternative building characteristics to achieve the client wishes and demands. Boundaries and a framework can be drawn from this and simple questions such as orientation and location of the project, whether it should be multi- or single storey etc. This also enables you to select the best alternatives for an Affordable NZEB (DNA in de Bouw, 2019).

The final of the six steps intends to assure efficient collaboration by thoroughly and carefully decide on the right tendering and contracting processes for the project and which guarantees to be made. This step intends to also enhance project management and thus reduce costs (DNA in de Bouw, 2019).

LOCAL AND EU LEGISLATION

EU DIRECTIVE

The EU ruled Directive 2010/31/EU of the European Parliament and of the council 19 May 2010 on the energy performance of buildings. The aim of the directive is to cost-effectively reduce the energy consumption of the construction industry. It demands that all member states adjust their energy performance of buildings requirements to a maximum as long as it will still be cost-effective (EU Directive, 2010).

The directive also sets out definitions for when and what is demanded to follow the directive. Since January 2019, it has been mandatory, that all new buildings occupied and owned by the public authorities are NZEBs. From January 2021, the same will apply for all new buildings in the EU, with special exceptions described in the directive (EU Directive, 2010).

The directive is focusing on the reduction of energy consumption by following the concept of NZEB and extensive implementation of RES. Another focus of the directive is the economic feasibility of the conversion to NZEBs. The directive rules, that the conversions must be economically feasible hence an exception from the directive may apply if a project is not economically feasible in a specific situation (EU Directive, 2010).

THE DANISH BUILDING REGULATIONS 2018 (BR18)

The current Danish Building Regulations (BR18) demands high requirements in the energy performance of buildings constructed in Denmark. There are thus no specific rules or benefits gained directly from Passive Housing nor NZEBs. Yet the Danes use their Building regulations as a whip for enforcing the high energy demands and quality within the construction industry (BR18, 2020).

The Danish approach is a way for the government to adjust the construction industry to implement higher energy requirements and solutions by over each revision of the building regulations slowly adjusting the demands and thus giving the industry time to adjust instead of facing it with a sudden conversion.

This being said, the requirements for the yearly heating demand of a building per m2 is still twice as high as the PHI Standard. The regulatory requirement for dwellings is 30,0 kWh/m2/yr. which is also a fairly low energy demand for a building. Similarly, the minimum requirements for exterior walls and basement walls is a U value of 0,30 W/m2K (BR18, 2020).

It can also be argued, that adjusting the demands for passive housing and determining the most effective method of achieving minimum heating demand should be adjusted to the local climate. Tim Pullen mentions, The PHI Standards are roughly 25 years old and new and other solutions have emerged showing, that low energy housing can be achieved in more ways and thus might not be the most efficient way of reducing the energy consumption in the construction industry (Pullen, 2018).

CHALLENGES WHEN CONSTRUCTING PASSIVE HOUSES

In the discussion of passive housing, there are lots of objectives that are meant to be achieved under special circumstances. There are some challenges on the way of achieving passive house goals. Regarding prior information in the text challenges can be categorized into three criteria:

- Techniques
- Principals
- Costs

TECHNIQUES

Accomplishing all the passive house characteristic such as thermal insulation, airtightness, thermal bridge, windows, and ventilation needs professional installation techniques and specialists. For instance, in existing houses, the application of insulation on the historical facades is challenging since it has to meet common circumstances in Europe, or the thermal barrier installation on the existing building can become a high-cost alternative (Passive House Institute, 2015).

Another challenging characteristic to accomplish is airtight-

ness. Little imperfection in the air tightening execution part may lead to a malfunction in the project (Blagojevic, 2015). According to Feist (2015), one of the stages that affect air tightening in construction is electrical cables and plumbing pipelines that pass through the slabs and walls, because installing these systems makes penetrations that increases the air tightening. The installation of these systems should be carefully analysed in order to decrease the penetrations.

The installation issues also attribute to the windows. The installation of windows should be done so professionally to avoid weakening the envelopment of the building (Burrel, 2015). The installation process requires up-to-date building service workers that have the knowledge to execute passive housing design principals. This matter brings us another challenge to accomplish the passive house concept (Burell,2014).

PRINCIPLES

There are some difficulties with the rules and regulations for passive housing. For instance, there are specified U-value for windows and other openings that might not be available in the market. They need to be imported from other countries or the designers should change their designs according to the new conditions. Achieving the required characters need companies with the knowledge and experience and as it was mentioned in the prior case study some of the required values might need to be changed because there are no companies that cannot accomplish these (Janson,2008).

COSTS

The initial cost of the passive house can be more than the traditional house and these costs can differ according to the conditions such as the climate and weather. (Tobias,2017)

The fact is the benefits of passive housing outweigh its challenges during the time so the passive house can be counted as an investment (freeman,2015)

CONCLUSION

Our generation is faced with finding a solution for one of the most urgent issues the world is facing today; climate change. The reason behind global warming and carbon emissions is the increasement in global energy consumption. Therefore, the solution for the climate change problem is decreasing the amount of energy consumption on a worldwide scale. The construction industry is responsible for 40 per cent of energy consumption and 36 per cent CO2 emissions in the EU. One-third of modern energy consumption is being used for heating buildings. To reduce this high percentage of carbon emissions, we need to rethink how we construct our buildings.

The solution to this problem is constructing energy-efficient, sustainable buildings that consume less energy. Several green assessment standards have been created to evaluate the energy performance of buildings and thereby to encourage sustainable building construction. One of the leading energy-efficient standards at present is the passive house standard. A building that has been certified as a passive house is one of the most energy-efficient buildings in the world.

A passive house is sustainable, energy-efficient provides a high-level of comfort to its residents while being affordable. The carbon footprint of a passive house is close to zero and renewable energy sources can be used to produce energy for the house. They reduce environmental pollution, increase indoor air quality and improve ventilation which is beneficial for the health of its residents. This report studies the techniques used to achieve passive house standards in Europe, presents case studies and explores the affordability and government policies that are in place regarding passive houses.

Passive houses do not compromise on the thermal comfort of the people who live in them to achieve high energy efficiency standards. On the contrary, the practice has shown that the indoor climate of a passive house is more comfortable than a conventional house. This is due to the effective techniques that are being used when constructing passive houses. The Passive House Institute (PHI) in Germany is the creator of passive house

concepts and techniques. The fundamental principles used in a passive house to make it energy-efficient are;

• Super-insulated building envelope: Passive houses do not depend on a central heating system. They are well insulated and require a minimum amount of space heating. The house is heated by the body heat of its residents and solar energy that warms up the house and traps the heat energy. As a result, the house is a large sealed box and it uses 90 per cent less heating energy compared to a conventional house.

• Airtight: There should be zero air leaks in a passive house and th

e airflow within a building is all controlled. This ensures that the heating and cooling demand of the house is decreased to a minimum during winter and summer seasons. An airtight prevents moist or humid air from entering the building envelope and thus affecting the indoor air quality, mould and structural damage.

• Energy-efficient windows: Window system of a passive house must be twice as efficient as conventional windows and their predisposition throughout the house must be arranged to offer the maximum of natural sunlight during all seasons. Passive houses use triple-glazed windows where the gap between the glass panes are filled with noble gases such as Argon or Krypton instead of air. This ensures high efficiency against heat transition.

• Ventilation strategy: Tenants of passive houses enjoy high-quality air because of the used central ventilation system. It exchanges polluted air from inside for fresh cold air from the outside. The cold air is heated by the escaping warm air before entering the house by a heat exchanger. This provides superior air quality and comfortable indoor temperature.

• Thermal Bridge Free Design: Since the main reason for the heat transmission of buildings is thermal bridges, a passive house must ensure that there are zero thermal bridges. This ensures that heat doesn't escape or enter the building during the winter and summer seasons.

A successful passive house brings all 5 of these elements together. The key benefits for its residents are high-level comfort, excellent health conditions and enhancement of fresh air quality. The main feature of a passive house is the way it heats the building. Passive houses are not heated using a central heating system. This factor alone helps to save a vast amount of energy compared to a conventional house.

Two case studies have been used to compare the construction of a passive house versus a conventional house. The first case study is the residential area Valda Heberg in Sweden where 26 single-family houses that have been certified by passive housing standard have been constructed. The second one is apartment buildings in Värnamo, Oxtorget, Sweden that have been constructed to meet passive house standards.

A common belief regarding sustainable building construction is that it is more expensive than traditional buildings. The truth is that the financial cost of a passive house depends entirely on the investor. A passive house could be quite modest, or it could be built using the best quality materials, have high-end finishes and consist of luxury appliances. Since passive house standards can be achieved in any type of building starting from single-family houses to large commercial buildings, there's room for an enormous amount of flexibility on the cost depending on the required quality of the result. Research is undergoing to develop new construction materials that cost less and thereby further encourage sustainable building construction.

It is important to remember that the initial higher cost in a passive house is a return of investment over time as a passive house immensely cuts down operational costs and saves money in the long run. Some facts to consider when investing in a passive house are:

• Passive houses are an investment. There's a return on investment (ROI) over the life cycle of the building in the form of energy savings and reduced operational and maintenance costs.

• Reduced construction time. Passive houses are constructed of prefabricated building components and therefore reduce construction time and labour costs.

- Transparent building supply cost. Passive house building components are becoming increasingly accessible and their prices are transparent which means more savings.

- Reduced operating costs. Passive houses use up to 90% less energy than conventional buildings.

- Reduced insurance cost: Insurance companies lower the risk profile of passive houses because of the benefits of their design.

For the purpose of studying the initial construction cost difference between a passive house and a conventional house, several cost analyses were conducted. The first cost analysis was done on the case study used for this report: apartment buildings in Värnamo, Oxtorget, Sweden, followed by examining the initial investment in several passive houses throughout the EU. It is estimated that the initial investment in a passive house can be 20-25% higher than in a conventional house. However, the annual cost burden is lower and after 30 years loan will be paid off. Later, a profit could be made by saving on energy consumption. Therefore, it can be concluded that the overall cost of a passive building is less than the cost of a conventional one.

The PHI offers a digital design tool called Passivhaus Planning Package (PHPP) which can be used to predict and calculate the energy consumption of a building. It provides necessary information such as the thickness of the insulation, the size of windows to the building designer. The PHI standard target goal for a new building to fulfil the standards of becoming a Passive house are set to 15kWh/m2/yr. The main criteria for achieving the requirements of a Passive house according to PHI standards of a new building are listed below. If these requirements are not strictly followed, a building can lose its passive house status.

- Low heating demand of less than 15kWh/m2/yr.
- Exterior walls must limit its thermal transmittance to a U-value of less than 0,15W/m2.
- So must the thermal transmittance in doors and windows be limited to a U-value of less than 0,8W/m2.
- Airtightness must be limited to less than 0,6m3/hr at 50 Pa.
- Finally, there must be more than 80% heat recovery from the ventilation exhaust air.

The PHI offers standard called EnerPHit to optimize the energy performance of existing buildings by retrofitting. Similar to PHI Standard for new homes, EnerPHit Standard provides guidelines and target goals for existing buildings with tough but achievable parameters. Therefore, the target U value goals for achieving the EnerPHit standard is 25kWh/m2/yr instead of 15kWh/m2/yr. So even though it is not entirely as strict as the PHI standard for new buildings, it will be a great improvement to the energy consumption of existing buildings.

The passive house concept has paved the way for many EU financed educational and research projects which aim to deliver high-quality training on construction of energy-efficient buildings. Train-to-NZEB project is designed to increase the knowledge and skills for the construction of new buildings and Fit-to-NZEB project is focused on training and educating about how to renovate existing buildings. The AZEB project researches about how zero energy buildings can be reached affordably.

The EU ruled Directive 2010/31/EU of the European Parliament and the council in 2010 on the energy performance of buildings. It aims to cost-effectively reduce the energy consumption of the construction industry. It also sets out definitions for when and what is demanded to follow in the directive. Since January 2019, it has been mandatory, that all new buildings occupied and owned by the public authorities are NZEBs. From January 2021, the same will apply for all new buildings in the EU, with special exceptions. Many EU countries have initiated government policies and regulations to promote the construction of passive houses.

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LIST OF FIGURES

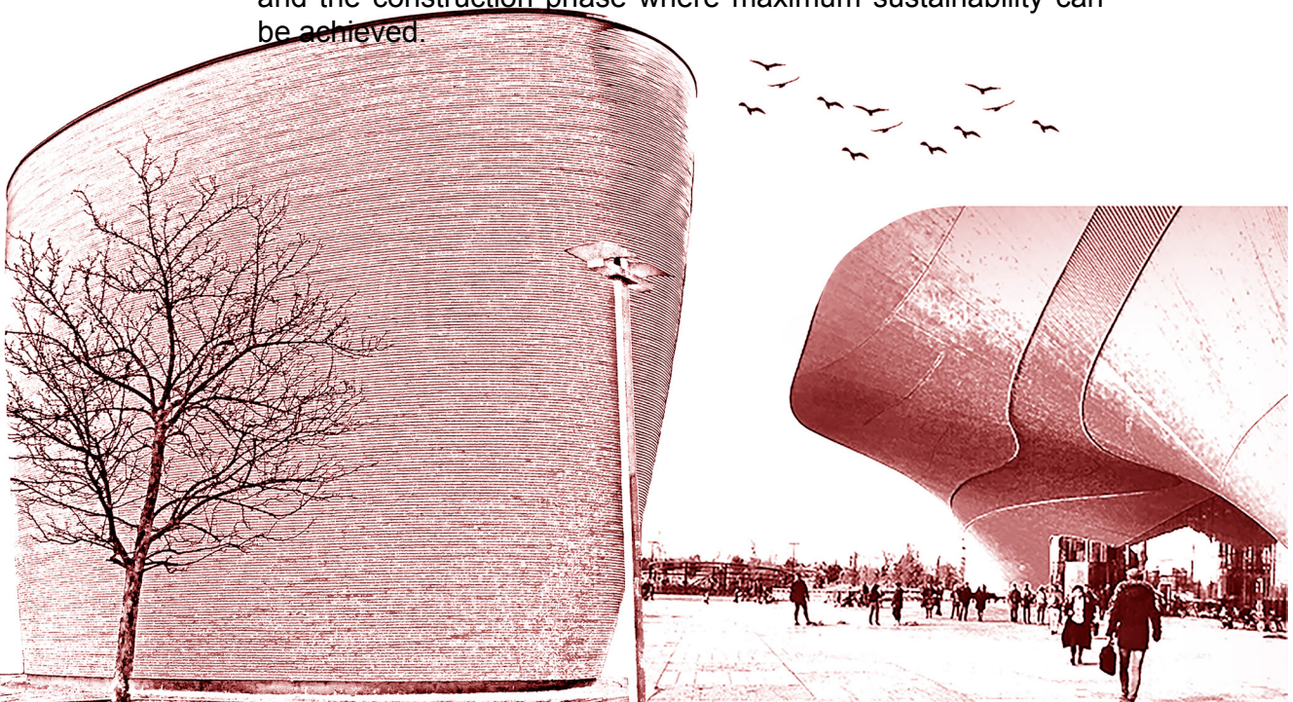
List of Tables

Elnaz Taghipourararaste, Fatemeh Daneshvartarigh, Awotimiro Temitope Julius, Mahharaj Thiruvadi, Udham Singh, Shantanu Chauhan

2. SUSTAINABLE DESIGN

ABSTRACT

Sustainable construction is the need of the hour as more natural resources are being utilized, and eventually thrown away which creates crisis for the future generations. Major effect can be brought to sustainability if proper planning and strategy are utilized in the design phase of the construction. Sustainable design uses research and planning to monitor the amount of resources available, consumed, and needed for any construction activity. Techniques such as ancient sustainability methodology, collapse mitigation, sustainability in documentation, automation in optimization of structures, and 3-D Printing are discussed as approaches to impart sustainability at an early stage of the construction/conceptualization. This chapter discusses these approaches to maintain a balance between the preconstruction and the construction phase where maximum sustainability can be achieved.



INTRODUCTION

Sustainability in construction is the need of the hour as more resources are being consumed without a plan to replenish the natural resources. The resources thus consumed, utilized, and eventually thrown out are not returned to the environment and this causes a chocking effect on the planet and all its dependents. Major changes can be brought about to sustainability if proper plans and strategies are utilized in the design phase of the construction. Sustainable design uses research and planning to monitor the amount of resources available, consumed, and needed for any construction activity.

Sustainability in architecture and construction is part of a wider discussion that has a significant impact on our lives. The aim is to reduce the negative environmental impact of buildings by improving balance and efficiency in the utilization of materials, energy, and space (Fergus, 2007). A sustainable approach is to understand the interactions that exist among environmental, social, and economic aspects to understand the consequences of our actions better. According to the World Commission on Environment and Development of UN “Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainable development is a paradigm that is changing not only physical structures but also the workings of the companies and organizations that populate the built environment, as well as the hearts and minds of the individuals who inhabit it (Kibert, 2016).

Arid or semi-arid climates account for about 36% of the earth's surface and imposes a large cooling energy load on the world (A.A Al-Temeemi, 2004). Over time people have found some architectural motifs to make their habitats tolerable in these areas. When there was no access to modern cooling and heating equipment, the engineers were obliged to trust natural energy to make a comfortable interior environment (Roaf, 1982). Some lessons can be learned from the past and taken into account to provide comfort and minimize the impact of construction on the surrounding environment.

Another dimension to sustainability is the utilization of the

building to its full life cycle by avoiding damage and eventual collapse of the structure. Low-quality control during construction in developing countries contributes to the random collapse of buildings and, to major catastrophe as a result of only moderate seismic activity. Therefore, due to poor construction procedures, millions of people live in millions of new buildings constructed in developing cities around the world are at risk of even mild earthquakes (Fernandez R.F. 2014). Low quality of construction is reported to be the main cause of the collapse of buildings around the world. Since 2006 at least 25 buildings in Nigeria have spontaneously collapsed; 229 deaths have been identified; many unidentified people have died and more than 400 have been injured. Meanwhile, each project has a fundamental goal of delivering work at approved time, cost and efficiency to achieve full sustainability. Each building project is sustainable if it can overcome the threats that prevent it from fulfilling its goals. It is therefore an enormous hazard for a building to collapse during construction; it is riskier when it is inhabited. Building collapse creates a bad industry view; it wastes human and financial resources; creates anxiety in the minds of investors and the building's occupants. Hence, mitigating measures to reduce the occurrence of structure collapse in Nigeria are to be known as well as their causes.

An important yet ignored process in the design phase is the documentation. Construction processes begin and end with the documentation. Plans, construction methodology, site execution details, quality assurance, operation, as-built construction information, etc. are to be well documented to ensure clarity throughout the project lifecycle. Documentation during different phases of the construction such as tendering document during the design phase, progress report during construction, and handover details during commissioning, play a vital role in the completion of the project within timeline and budget, thereby influencing the resources and indirectly affecting the sustainability

The booming advancement in technology has challenged the construction industry to adopt and advance accordingly which can optimize the construction process effectively and efficiently. Also, the environmental aspect and sustainability have been identified as the most important long-term vision to minimize the impact of construction on the environment and the natural resources. According to (Udomsap & Hallinger, 2020), the four

main sectors for obtaining sustainability are social sustainability in construction management, recycling and waste reduction, sustainable construction management and alternative materials for sustainable construction. The industry is hugely dependent on the economic aspect, so the initial phase designing must be done in a way so that the money required for the project is minimized without compromising the quality and safety of the structure.

The management of the construction process can be obtained by introducing BIM (Building Information Modelling) in the construction process at all stages. BIM has become a new tool to put all the available information at a place in a way that all the professionals working on a project can access all the information they require in a much efficient and faster way. BIM framework can be developed to optimize the structure in terms of cost, carbon and steel reinforcement with the use of various metaheuristic methods.

The designing phase of any project is very crucial in deciding the feasibility of the project. There have been many attempts to date to introduce automation in structural engineering design. Most of the past researches have been done on the optimization of steel structures and the research done on concrete structures are mostly on fixed structural layout system (Adeli & Sarma, 2006). The introduction of automation in structural engineering reduces the human error in designing, the time required for the designing phase, precise solutions, and easing the complexity of the big structures. The further subsections will be providing some insight into the optimization process for cost optimization, carbon footprint optimization and steel reinforcement with some researched examples and how the process is dependent on various factors.

Additive manufacture of 3D printing is a method to manufacture an object from a digital model (Ming Xia, Jay Sanjayan, 2016). This method is gaining popularity because of its efficiency and less wastage of material. With the help of automation, the product can be developed without any human interference. Apart from that, a small size complex geometry can be developed easily that increases the efficiency of the manufacturing industry (C.

Buchanan, L. Gardner, 2019). Because of this, the automobile, food, airline, and biotechnology industries already adopted this technology (Peng Wu, JunWang, XiangyuWang, 2016). Methods such as Powder Bed Fusion (PBF), Directed Energy Deposition (DED), Electrochemical Additive Manufacturing (ECAM), etc. are already being used by these industries to create an object (C. Buchanan, L. Gardner, 2019). But this situation is completely different for the construction industry.

The construction industry is so labor-intensive, inefficient, slow, hazardous, wasteful, and emission causing and corruption prone as well as often over budget. Even though the construction industry has lots of negatives in it, this industry is still not trying to adapt to new technology. This industry still wishes to stick to conventional methods that have been in use for a long period (Khoshnevis, 2004). Because of that reason this industry is facing lots of criticism around the globe. But by adopting automation, the above-mentioned problems of this industry can be minimized as shelter is one of the basic human needs.

As per Maslow's hierarchy of needs, human needs are categorized into 5 segments. Those five segments are self-actualization, esteem, love and belonging, safety needs and psychological needs. He arranged these five things in a hierarchy order. He has given most priority to the psychological need and in that need, the main things are breathing, food, water, shelter, clothing, reproduction (Saul McLeod, 2018).

As in psychological needs, shelter is one of the basic human needs. Therefore, conventional methods need to be replaced by automation so that this industry also takes advantage of automation and be efficient. So that the criticism can be minimized, and automation can give the construction industry a new dimension and direction. 3D printing and additive manufacturing can revolutionize the construction industry because of less labor-intensive, less wastage and by giving efficient results with less time.

ANCIENT SUSTAINABLE ARCHITECTURAL METHODS IN HOT ARID REGIONS AND THEIR FUTURE

The chapter is organized in the following sections: Section 2 identifies methods and materials, Section 3 is a literature review on hot and arid climates to identify the relation between energy efficiency and vernacular architecture focusing on-site location, the density of buildings, orientation and building envelope, Section 4 illustrates a number of contemporary buildings equipped with vernacular architecture that helps improve energy efficiency in the current context, Section 5 discusses the findings; Section 6 carries out the summary of report and recommendations.

METHODS AND MATERIAL

The literature review has been carried out with the specific aim of (a) exploring architectural motifs regarding sustainability considerations in hot arid climates, and (b) investigating the feasibility of applying them in contemporary projects. The methodology involved a review of the properties' design and construction materials.

In this study, the research method is descriptive/analytic with an applicable purpose. For collecting data, thesis, articles and books are used by library methods.

LITERATURE REVIEW ON HOT AND ARID CLIMATES

People in hot and dry regions try to create and find significant methods based on this region to build their houses in harmony with nature. Incredibly, these arrangements have controlled the abusive climatic conditions and even made some valuable and good natural motifs. For the most part, structures in this district have been intelligently incorporated with nature. This area has a few rainy days in a year, so it is exceptionally dry and hot. Along these lines, the fundamental motivation behind the structure in this area is cooling. In figure 1 there are some details of important spaces of buildings in this area (Eiraji, J. et al., 2011).

Historically people modified their houses to reduce the need for external energy inputs which resulted in practical, cost-effective and energy-efficient solutions. These solutions are ignored in the modern architecture as a result of easy access to fossil energy sources. Current environmental crises urge human

beings to add measures to minimize energy consumption (S.S. Chandel, et al., 2016).

A hot arid climate is one of the extreme weather conditions which requires a considerable amount of energy to provide thermal comfort.

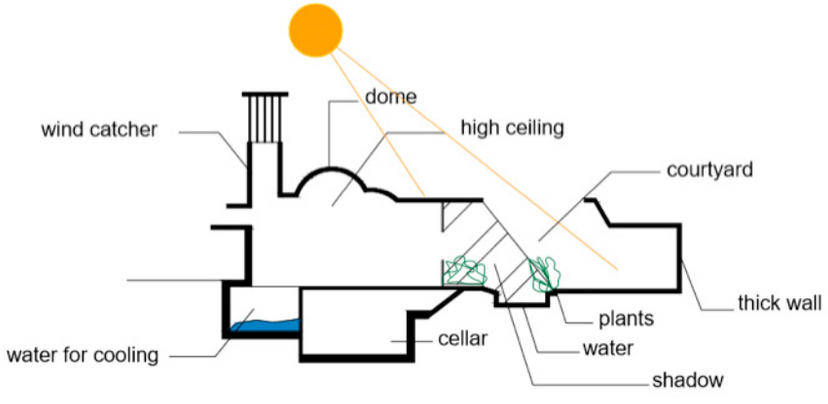


Figure 1 Main parts of building in hot and dry region

CLIMATIC CONDITION

Areas with high temperatures ranging from 40 – 50 degrees Celsius during summer with variations during day and night and seasonal are called arid climate regions. Low humidity, cold winds, sandstorms, along with enhanced radiation intensity due to reflection from the ground are observed during winter (Paul Gut, et al., 2018).

SPECIFIC ARCHITECTURE AND CONSTRUCTION METHODS

Managing comfortable ambient temperature inside the building during the daytime is important in hot and arid regions. High degrees of cooling have been achieved in the classical building by including natural cooling systems in their house design (A.A. Golneshan, et al., 1990).

SITE LOCATION

The positioning of settlements leads to micro-climate improvement to provide more comfort. “The topographical altitude, the geomorphology, the suitable orientation regarding sun exposure and prevailing winds must be considered” (Paul Gut, et al., 2018). The northern slope would be preferable in hot and arid zones as it would have minimum direct radiation. Provisions for air circulation are given at higher elevation, above valley level, on hilltops, and slopes. Air circulation is provided at higher elevations; above the valley level, on slopes and top of hills (A. Bouchair, et al., 2013). The city of Taos Pueblo as an example of hot and arid vernacular settlements in New Mexico located in the slope.

DENSITY OF BUILDINGS

The density of buildings plays an important role in providing thermal comfort in the urban areas in total. Energy consumption of buildings is also affected by the urban form. Step village and courtyard are two forms that are employed to provide microclimate in hot and dry regions.

STEPPED VILLAGE

Utilization and strict regulations of land are considered important for the sustainability and health of all ecosystems. Compact form of settlement contributes to efficient utilization of land which when compared to the widespread form of settlements in modern cities, has many environmental, economic and social advantages (G. Broadbent, et al., 2008). Crucial reasons for construction in hot-arid zones are compactness and shade to reduce sun-exposure in summer (Paul Gut, et al., 2018). Figure 2 illustrates an example of a compact Stepped village in the north-east of Iran. In Taos Pueblo, in New Mexico the roofs of the lower level buildings provide terraces for the above units by stepping back rooms. The rooms in centre of the structure were used for storage of grain and the living quarters are on the top and outside (Roth, 2016).

Figure 2 Qalebālā Semnan Province Iran

CENTRAL COURTYARD

In traditional architecture, there was a courtyard in the heart of the building for having better air transportation. Temperature decrease and ventilation create by opening the windows to the courtyard in each space. additionally, the consistent placement of empty and full spaces with different intervals causes the circulation of the wind using the properties of the shadow and the sun. The courtyard's confinement causes this open space to operate as a ventilator or interior space and leads to the extraction of hot weather. The courtyard is the central core, a space with geometrical order, introverted, independent, vital and open to the sky. The dimensions of the courtyard are based on the scale of the land and its dimensions, and in coordination with the number and types of the rooms that are built around it (Ranjbar A, et al., 2010). This method has been used in Iran, Spain, Jordan and China.

ORIENTATION

Building orientation was one of the important issues in constructing vernacular houses in hot and dry areas of Iran. The orientation was based on the quality of solar radiation and wind flows (Pirnia, 1992). The architects of traditional buildings set sections like three-door, five-door and seven-door in the north-west and north-east orientations for cold seasons (M. Kazemi, et al., 2014). Comparing the Taos in New Mexico and Ghadames in Libya the same attitude toward building orientation appears in Figure 2. The inhabitants of these areas, many years ago have decided to rotate the building to control the amount of sunlight shining to the windows and openings (M.A Ealiwa, et al., 2001).

Abufayed et al. who have studied the vernacular architecture of Ghadames declared that the city was oriented roughly in an NW – SE direction (A. Abufayed, et al., 2005).

(A) (B) (C)

Figure 3 (A) Yazd, Iran (B) Taos, New Mexico (C) Ghadames, Libya

BUILDING ENVELOPE

The envelope of the building should create a comfortable condition through a thermal time-lag. To reduce the amount of heat penetration, the size and position of opening on the envelope is extremely important (A. Bouchair, et al., 2013). The building envelope can be studied in the following categories:

WALLS AND ROOFS

In regions with large diurnal temperature ranges and night temperatures below comfort level, a large thermal capacity with an appropriate time lag should be possessed by walls and roofs to balance temperature variations. During the hot season, walls of daytime living areas should be made of heat-storing locally available materials, such as stones, mud and lime; walls of rooms for nighttime use should have a light heat capacity. This reduces the fluctuation of internal temperature. East and west walls should preferably be shaded. High reflective qualities are desirable for both thermal and solar radiation (Paul Gut, et al., 2018) (A. Bouchair, et al., 2013). Sun-dried mud bricks of thickness two feet (60 cm) at the bottom to one foot (30 cm) at the top make up clusters of houses in pueblo. A new coat of adobe plaster is used during the village ceremony (Roth, 2016).

Adobe plaster and a thick layer of mud laid over mats of branches form a layer above the cedar logs, the entirety making up the roof (Roth, 2016). This system of roofing is suitable for the harsh weather of the region, for the thick structure, whether of

stone or adobe. It absorbs the midday heat and then during the night slowly suffuses heat to the rooms within, so that the internal temperature remains relatively constant over a range of about ten degrees Fahrenheit, hovering around the upper seventies, while the outside temperature varies over more than forty degrees. Drafts were originally kept to a minimum by the low narrow doors and fixed selenite windows (Roth, 2016).

Usage of domes and arches is another method for reducing the warmth especially in the hot and dry region. This form was built by natural materials, so it is a practical choice for reducing the heat. The shape of the roofs which is convex spherical is suitable for flowing the heat radiation and cooling process during the night. Additionally, some part of the dome is under the shadow of other part and it helps to reduce the temperature during the day.

As the buildings' roofs receive the most amount of solar energy in comparison with the other sides of the building, some times in the hot regions of Iran, the height of the roofs' parapets reach 2 meters so that by creating the maximum amount of shadow for the roof, the heat radiation can be minimized (V. Qobadian, 1999). It causes the air with a higher temperature to move upward and the air will enter from the openable and a lower level and this leads to the ventilation of air (F. Mehdizade Seraj, 2013). Domes and arches had been used in Iran, Hellenistic, Roman, and China.

SABAT

Building in the dry and hot region is secluded from the road and has high and thick walls. So, in the daytime, outer walls of houses create narrow zones in the street and practical and comfortable zones in the yards, thus, in this way, a lot of warm places in winter and cool places in summer were created easily. One of the attractive arrangements of urban designing in the old area of the hot and dry region is roofed path and yard entry which is called SABAT. The sabat is designed by traditional architects to provide shadow during the day and keeping people safe from sunlight direct radiation. Persian architects built some protruded rooms for houses above the paths, so commuting was possible

under these protrusions. Sabat can balance the temperature and people in these ways are under the shadow in a suitable path. There are many integrated entrances of buildings for providing an improved sense of neighborhood using sabats (D. Watson, 1983).

OPENINGS

The function of opening in a building is to provide access, light, natural ventilation and energy absorption (Cremers, 2016). In arid regions maximum shading is ensured by considering the direct sun angle and by adjusting and minimizing the shutter size (Paul Gut, et al., 2018). In Taos Pueblo, low and small doors are used to access the ground level and few levels above while a ladder through a hole is used to access the roof (Roth, 2016). Qalebālā in Semnan Province (Iran) Figure 3 indicates the same characteristic.

Figure 4 Qalebālā Semnan Province Iran

USE OF MATERIALS

Using local and natural materials during the work for reducing the expenditure of energy is a wise decision because it also can reduce initial energy plus cost, specifically portage cost. There is some practical material in this region which only needs man’s efforts for use in construction. These materials take up warmth from the environment and sun and in the night when the sun goes down make this warmth available during the hot days. Addi-

tionally, heat remains in the walls for about 8 hours and then transfer it into the inner environment gradually. In the cold seasons the retained heat in the walls works like an isolation barrier, and the inner environment is warm when outside it is too cold. Such buildings build by environmental materials close to their location have the least damage to their environment. Moreover, these materials return to the earth without any pollution after building the life cycle.

WOOD

In the hot dry regions, using materials with low heat mass is better because they do not store heat in themselves. Excessive heat is the most important predicament in this region, so it is not right to store the heat for the night. The wood transports the heat very slowly and the heat absorbed during the day stays on the surface of the wood and by the cool wind in the night, the wood loses its heat and consequently the wood is used in the roof, doors, and windows. Thus, wood is the best type of material in these regions (V. Qobadian, 1999).

THATCH

Thatch was used for interior and exterior walls. This is a practical cover for protecting the inner environment from too much heat of summer and coldness of winter. Thatch is hollowness, so it has very low conductivity. Thatch prevents cracking and intense heat couldn't transfer to the inside so create a comfortable environment for people during the hot summers and cold winters (H. Qayour, et al., 1999).

BRICKS

Bricks are perfect insulators against coldness and heat because of their thickness and their covers. Although, thick walls in the courtyard have a high heat capacity to absorb the coldness in the night and released this coldness during the day. Hence, changing in the heat becomes a minimum because of the thickness of these brick walls (H. Zamarshidi, 2012).

S

UMMER AND WINTER AREA

The high-temperature difference in the cold and hot seasons in this region caused architects to build varied parts in buildings. Thus, buildings had two main parts, summer area, and winter area so people should move in different seasons to different parts of their house. In most cities of this region, these parts can be seen. In summer most of the summer area is in the shadow and front of the summer area, winter area is situated and during the winter have access to the warmth of sunlight. Such kind of houses called four-season houses and have a yard in the center which connected the winter area and summer area to each other this outstanding attribute of architecture protects people from displeasing climatic conditions (M. Tavassoli, 1982).

WINDCATCHER

Iranian traditional architecture has a wide range of solutions in sustainability based on nature. Thus, natural ventilation is one of the most significant of these solutions. The Windcatcher wind tower has a natural structure for cooling and makes a comfortable environment for people (Bahadori, 1985). The wind is the main parameter in the wind tower system, comes through several holes from the top and goes through many openings in the bottom. These holes and opening adjust the air circulation in different parts of the building. The windcatcher system is based on wind conditions and solar radiation. Warm air sucked by upper inside parts and cool air flows from bottom opening into the building at night. During the day, internal and external walls of the windcatcher absorb a lot of temperature and replace this warmth with coldness during the night. Hence, it causes a temperature balance in the houses (I. Meir, et al., 2003). In Figures 4 and 5 function of windcatcher in day and night is shown.

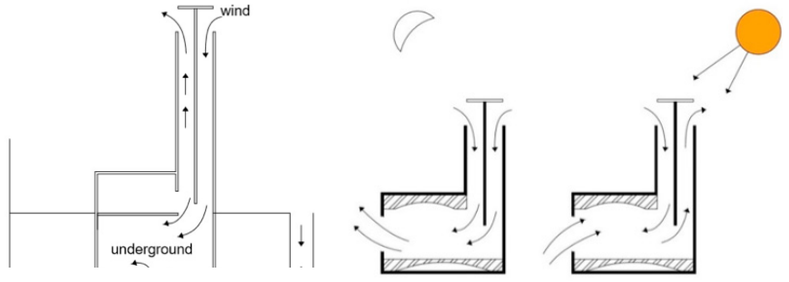


Figure 5 wind catcher function in day and nigh

In this way, the building benefits from natural energy and it works like a contemporary cooling system without any cost. Windcatchers remain present in Iran and can also be found in traditional Persian-influenced architecture throughout West Asia, including in the Arab states of the Persian Gulf, Pakistan, and Afghanistan (A. Azami, 2005).

AQUEDUCTS (QANATS)

Providing water in the desert is the most important challenge. So, people without any modern technology or pumping had to bring the water to their cities. They found a passive system called QANAT. They dug a mother-well far from the city and more than 100 meters deep to reach the water. Additionally, they dug other wells with minimum possible gradient toward the city. There are more than a thousand wells that were connected by QANAT and by the slope of the ground could bring the water close to the town (A. Behnia, 1988). And this function is shown in figure 6.

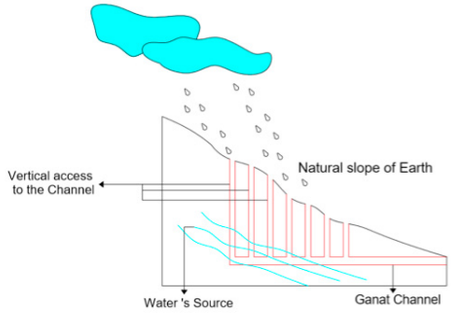


Figure 6 the function of Qanat

Although these days qanats are replaced by new deep wells there are many cities in the hot and dry region like Kashan, Yazd, Kerman, Naein, Shiraz, and Isfahan that still use qanats and many buildings, shopping centers, schools and mosques are connected to qanats by rivers and lagoons (B. Ahmadkhani Maleki, 2011).

CASE STUDIES

Modern houses whose principal building elements are derived from vernacular architecture can be traditional or modern and have no characteristic of outward appearance. Examples of sustainable architecture of recent century are shown here:

SHARIFIHA HOUSE

The 1630 m² building is designed by Alireza Taghaboni in 2009 (Figure 7).

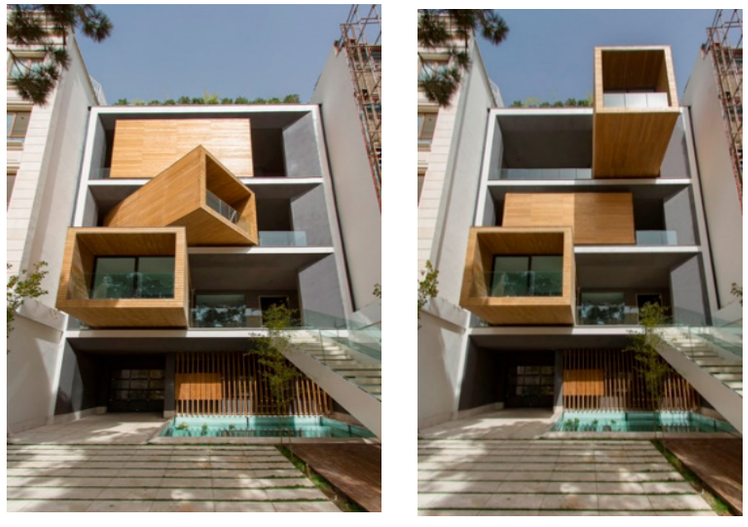


Figure 7 Sharifiha house, Tehran, Iran

It is a seven-story house having three rooms that can be turned 90 degrees, which enables its inhabitants to encounter different spatial organizations. The utilitarian dispersion in the house

can be clarified as the two storm cellar floors for sports facilities, the ground floor for a parking spot and the servants' rooms, the first and second floors for general activities and the third and fourth floors for the family's private life. The aim of sustainable traditional methods in architecture and construction and how we can utilize these methods in today's construction. Some methods have these traditional concepts in the contemporary examples.

This house comprises of three significant parts: the fixed part (rooms at the front and at the back) a focal void between them to give the light access when the rooms at the front are closed, and the portable part. In request to associate the rooms at the front and back, a path has been given all around the focal aatrium on all levels. Also, to permit visual contact between various rooms and floors, some inner balconies and windows are situated around the atrium (figure 8).

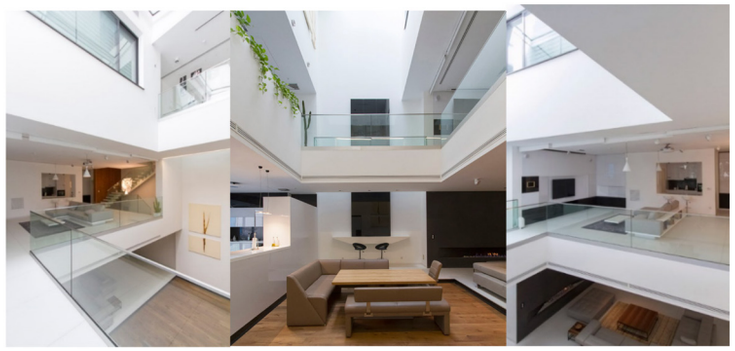


Figure 8 Atrium

In this building, the rotating rooms create wide terraces in the summertime, and in wintertime create a close area to keep the house warmer with minimal opening and nonappearance of those wide summer porches. Flexibility is one of the most important amenities of this house and as consistently there is a plausibility of having seasonal, distinctive utilitarian or lighting situations as is shown in figure 9.

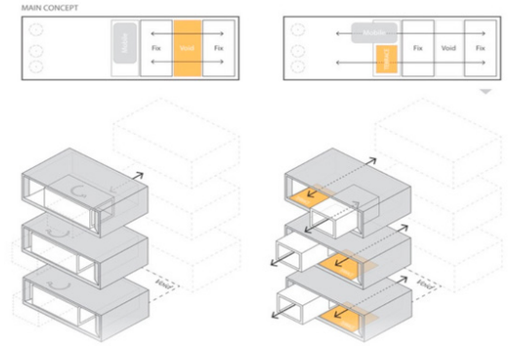


Figure 9 main concept

GALLINA CANYON, NEW MEXICO, USA

The Residence and studio are placed in a two-story building and is constructed of local sun-dried and unestablished adobes. This building is an example of an environment-conscious design. It distributes hot air to the colder rooms on the north side of the building through passive solar heating by combining the direct solar gain with a thermal chimney. The photovoltaic system provides electricity, and rainwater is harvested from the roofs for gardening purposes (Minke, 2006).

MITIGATING MEASURES TO BUILDING COLLAPSE IN NIGERIA.

BUILDING FAILURE

Building is all about solidity; but most consumers are more interested in the esthetics. Since architects are responsible for design; quantity surveyors are also responsible for the cost of building, and engineers for the structural permanence or failure. There's a chance of failure even if it’s a small building. Therefore, it is dangerous when engineers are not engaged during the construction and design phase. Project collapse begins with inadequate planning. The appropriate person's engagement at the appropriate time would enable proper planning and ensuring the effective implementation and sustainability of projects. Unless the correct rationale is given as to who approves the plans, construct, oversees and issues definitive approval during buil-

ding; there may be a recurring problem of building collapse.

The level of construction collapse can be compared to a level of divergence of a structure from its "as-built" condition, that represents in most instances the appropriate guideline within the community, locality, state or country. (Chendo, I.G & Obi, N. I. 2015). This divergence from the above argument may be initiated by some causes, such as the selfishness of the contractor and inadequate monitoring by the consultant or even both. The impact of the collapse of the building is the resulting consequence of impediment to the focus on construction procedure. The collapse of building either entire or partial collapse of any of its elements leads to the failure of the building to achieve its expected purpose of security, health or permanence. Often, no reliable data is provided by the quality assurance methods used in the construction sector.

The author's previous work showed a lack of data for most of the country's construction activities, particularly the privately-owned project. Capital development authorities grant approvals to build designs with no financial documents (knowing the value) of the intended structure. Nigeria has several structures that are so poorly built in major cities such as Ibadan, Lagos, Enugu, Kano, Onitsha and Kaduna; thus, they run the risk of collapse if nothing is done urgently to curb that situation. Collaboration between the federal government and construction professionals in Nigeria should be established immediately to rectify key high-rise buildings throughout key metropolises to lower the chance of further collapse.

Nigeria has increased the superiority of reinforcement on the market, although the problem of low-quality concrete, which is one of the key reasons for the collapse of building in the country, is yet to be overcome. Most concrete mixing is carried out manually, especially in most private projects, with no supervision. That act results in a poor mixing ratio and low concrete content. On public infrastructure projects, some of the Total Quality Management set up to certify quality concrete output is by sampling and crushing it within 7 days, 14 days and 28 days, this is hardly done. The test may pass even though the concrete remains poor. Event shows that nearly all samples are taken for testing after being properly notified; therefore, a proper sample mix is

prepared by the contractor and taken in the presence of consultants and then return to their usual way of mixing concrete. In a developed country most concrete is mixed and supplied by a ready-mix contractor using automated dispensing stations and drum-mixer trucks (pumping machine) in a developed country. In most Nigerian construction sites, mixing is poorly done and with inadequate aggregates and water causes bad concreting. It preceded the assumption; that the building materials engineering properties mostly concrete used in Nigeria, is grossly below the least standard (Afolayan J. 2014). He included that "despite the shortage, incompetent hands are hired to manage construction projects at different stages resulting in poor quality control.”

SOME CASES OF BUILDING COLLAPSE IN NIGERIA

Recently, not less than 20 collapses within the country were reported each with many causalities and injuries that are too obvious to forget. The horrible aspect is such that the incidents continued to occur and spread throughout the country. The Uyo project might be one of the latest but not the final unless significant measures have been undertaken for the necessary modifications (S. Shitanda 2011). Based on his prediction; in 2016, Oko town in the state of Anambra reported two building collapse incidents. In an event, when a three-floor building collapsed in Nwagu village, no less than seven people died (Punch newspaper 2017). Another masterstroke is the collapse on 25 July 2017 of four-story residential buildings under construction at Lagos.

An approximate sum of eleven million and seven hundred and sixty-six thousand Euro only for the selected collapsed building is shown in table 1. This represents a huge setback to the country’s gross domestic product (GDP). Adapted from Ayeni and Adedeji (2015) Clients or building construction promoters have three requirements of their buildings. These are: (i) that they are constructed within cost (budget), (ii) that they are constructed within time (schedule) and (iii) that they are constructed to acceptable quality (standard). Corruption and greed are the major debacles of these requirements.

Identified building collapse factors in Nigeria

The causes of the collapse of buildings can be classified as;

I. That caused by man's impact
II. That owing to natural forces (force majeur)

Table 1. Cases of capital collapse in Nigeria.

Occurrence	Type of project	Year	Location
Guest house synagogue site	6 - story structure	2014	Lagos State
Residential building	5 - story structure	2016	Lekki garden horizons, Lagos
Residential building (3yrs after completion)	4-story building with 36 blocks of flats	18th July, 2006	Lagos state
Residential building	4 - story structure	2010	Abuja (Garki)
Educational facility (3yrs after completion)	2-story building	2013 (September)	Jos
Residential building	3-story building	2013 (July)	Lagos (Ebute-metta)
Residential building site	2-story building	2013 (May)	Abia State
Bank of industry	21 - story building	2006 (March)	Lagos State
Residential building	3-story building	2013 (July)	Kaduna State
Residential building	2-story building	27th July, 2017	Lagos State
Residential Building (uncompleted)	3-story building	29th May 2017	Lagos State
Residential building	4-story building	13th June 2017	Anambra State (Oko)
Residential building	4-story building	25th July, 2017	Lagos State

Guesthouse (under construction for Synagogue)	Deaths 116 Injured 100 Under investigation	456,510,800	Church and contractor claimed that unknown aircraft flew over the bldg..
Residential Building (uncompleted)	Deaths 34, several injured.	343,360,000	Client/developer
Residential building (3yrs after completion)	Deaths 28, Injured 50	415, 798, 000	Quack contractor
Residential Building site	Deaths 23, Injured 7	273,220,000	Quack contractor
Educational facility (3yrs after completion)	Deaths 10, Injured 20	182,934,800	Designers and contractor structural defects
Residential building	Deaths 7, few injured	214,544,000	Client/occupant lack of maintenance
Residential building	Deaths 7, few injured		Designers and contractor structural defects
Bank of industry	Deaths 2, Injured 23	1,774,990,000	Natural disaster heavy (downpour & windstorm)
Residential building	Many deaths and injuries	198,645,500	Clients lack of maintenance
Residential building	Deaths 2, injured 1	230,868,000	Lack of maintenance
Residential building	Deaths 2, many injured	297,564,000	Construction error
Residential building site	Deaths 3, injured 1	338,140,215	Substandard materials
Residential building site	Deaths 5, injured 13		Extra floor added

Table 1. Cases of capital collapse in Nigeria.

In a study on structural instability and the collapse of buildings made at the end of a two-day seminar in August 1996, construction professionals summarized that major causes of the collapse

of building includes the following:

i. DESIGN ERROR: This does not only mean computational errors, but failure to understand the loads of the structure can lead to misguided theories, reliance on unreliable results, ignorance of the repetitive impulsive stress effect, and inappropriate material options or knowing their elements. The designer is liable for these errors formed on the drawing board.

ii. CONSTRUCTION ERROR: This was the main reason for structural failure; the contractor is as well guilty. That is if supervision happened to be lenient (i.e. not disciplined, careful enough about job, rules or mode of conduct). This involves using salty sand for concreting, replacing standard steel with inferior types; even inappropriate tightening of the nuts, unnecessary use of the drill pin to shape holes, poor welding and further construction workers ' activities that are well known.

iii. LACK OF MAINTENANCE CULTURE: While constructing a building, it is important to act on the above steps, but once completed, most property owners appear to be tentative in the maintenance area. This negligent attitude can be problematic for all those who occupy the property as it gradually dilapidates until the day it finally breaks down. It would be enough to conclude that anything created by man must always be revised to preserve its quality.

iv. USE OF SUBSTANDARD MATERIALS: Poor supervision, greediness, and corruption have enabled the use of below-standard materials during construction work in Nigeria. Adulterated cement, dirty water, mud sand; below-standard reinforcement is one of the major materials known for the construction industry in Nigeria. Many contractors deliberately use the inferior materials to reduce costs. It is hoped that some regulatory professional bodies such as COREN and SON (the standard organization of Nigeria) will engage in on-site evaluation rather than the usual office inspection to evaluate the quality of materials used. The quantity surveyors should also ensure the right materials are being used before valuing contractors.

v. CARRYING EXCESSIVE LOADS: When the load of a building exceeds its designed capacity, it tends to collapse (Ede, A.N 2010). This is like expecting a baby to bear a big bag: "Such

baby won't be capable to hold back the burden." The introduction of more weight while constructing puts heavyweights on the foundation. That's only when the foundations and materials are solid enough for that which it was first intended for. Therefore, when a building was built for 2-story shops and then converted into 3-story shops, the house will strain due to the weight because of the added floors.

vi. POOR SOIL INVESTIGATION: All construction points; Building strength should be examined (Ede, A.N 2010).

vii. ADVANCEMENT OF QUACKERY: The contribution of quacks have done the industry a great deal of harm. The square hole accommodates the round pegs which exposes the industry to increased risks. Qualified engineers are neglected as the construction environment is dominated by politicians, lawyers, religious leaders, doctors, businessmen and all sorts of people. "You come across bricklayers, also technicians who call themselves engineers". This implies that, In Nigeria, it is normal for most contracts to be awarded first to businessmen fronting on behalf of politicians. This practice is that the contractor receives the project and sells it to inexperienced engineers well-known to him without the usual contractual processes and without testing the competence of the engineer. Such an effect is a poor result that could cause a collapse in the building (Chendo, I.G & Obi, N. I).

viii. POOR SUPERVISION: Each construction stage needs supervision and monitoring of expertise to reduces collapse chances. The most critical part of the building as mentioned above is the foundation. And as well, the column bearing the slabs etc. The roof therefore should not be too bulky to boost supporting components. There was an opinion that any aspect of the work phase is very essential in the life of the structure as an error can have an extending impact in the construction process at any point (Ede, A.N 2010).

ix. NATURAL INCIDENCE: A longer time heavy downpour can mainly affect a freshly poured concrete and thus weaken the strength. In March 2006, storm and cloudburst were identified to be the reason for the collapse of 21 story buildings belonging to

the Lagos Island Bank of Industry, which resulted in the deaths of 2 people and 23 others injured. Flood, earthquakes, movement of the earth and severe wind are some types of natural incidents that could contribute to the collapse of the building. Some of these incidents of construction collapse initiated by natural disasters in Nigeria were stated by Arayela, O and Adam J.J (2001).

The previous report showed that structural failure was the primary cause of the building collapse, tailed by poor workmanship and supervision, using inferior materials, negligence that could be related to lack of construction practices, supervisory skills and defective design. More factors include thunderstorm / natural disaster, overloading, conversion and neglect of authorized designs. This evidence shows that countless construction failures occur due to human inactivity or activity.

Preventive Measures/Strategies for Building Collapse

In Nigeria, there are some defined strategies to curb the collapse of buildings.

1. Occupants must be involved in the culture of maintenance and risk to improve the value and life span of the building.

2. Necessary advice on environmental and impact changes should be sought from experts.

3. Undergo soil test. In building construction, mobilization of registered geotechnical engineers is quite necessary. Those specialists assess the soil's bearing capacity. It allows all consultants to assess the building weight the soil can sustain.

4. Using the correct design and construction of foundations. The licensed structural engineer must design a suitable building foundation using the test results of the geotechnical engineers to justify its design. The structural engineer may also advise on the construction methods at each point, from start to finish.

5. Hiring a professional building contractor. The engagement of a professional contractor is very critical for the construction. You need to evaluate the types and number of instruments and equipment, whether a foreign or local contractor. The client will provide the contractor with All-Risk Insurance (an architect can be contacted for expert advice and more information). While using local contractors, you must ensure these local building

contractors can do the job. By inspecting their previous jobs, referring to their former clients, examining their employees, including numbers of trained and unskilled staff.

6. Follow the recommendations of Consultants. Comply with work designs and instructions mainly by architect and structural engineer to prevent buildings collapse. Do not replace specific materials by non-recommended ' poor quality ' ones.

7. Compliance with statutory construction guidelines. In your geographical area you must comply with the building laws. These regulations cover welfare, protection and efficiency in built environments. Notable breaches include invasion of setbacks and building beyond the permitted number of locally imposed floors. Abide by the National Building Code to prevent collapse, outbreak of fire or demolition.

8. The expertise of qualified structural engineers has to be used if the original structure of a building is modified, most notably in multi-story buildings.

9. Also, the experts must be actively involved in construction, valuation and planning. An example, structural engineers must make certain designs after soil surveys; generate a calculation sheet before design and be active until the end. After visiting the site, the Architect will plan the foundation level and building height and operate closely with the structural engineers.

10. Quantity surveyors should prepare bills of quantities free of slight errors and avoid the measurement of drawings lacking the engineer’s approval.

11. By imbibing the maintenance culture, Nigerians will minimize exposure levels of structures to risk, by seeking professional advice when modifying the shape and function of structures and recommend soil and material testing as opined by Afolayan J. (2014). He as well stressed the necessity to create national codes and construct on the established engineering element of the building items available in Nigeria. In short, each project should be under the watch of an engineer to prevent more hazards. The country's construction industry stakeholders need to work synergistically to help the industry grow. Not realizing the

economic contribution made by the industry is found to be another risk.

DOCUMENTATION AND SUSTAINABILITY

Construction documents serve as a record for data and knowledge, guidelines and specifications, and references for future work and analysis. Sustainability of a project can be verified or measured by analysis of the documents particularly the green building techniques adopted during the conceptualization and construction, choice of materials used, tests on quality, and certifications acquired post completion of the project.

CHALLENGES IN DOCUMENTATION

Large amounts of documentation are generated during the entire life cycle of a building. Typical problems in documentation are inaccessibility, incorrect data, outdated versions, etc. These problems are common in any country, but the intensity varies with the complexity as well as the size of the project. For example, errors in design documents could result in large scale rework, and mistakes in a tender document could result in losses for the contractor. As human errors are unavoidable in most of the situations, documents must be verified by an external party at the earlier stages of construction.

OBJECTIVES OF THE REPORT

The objective of this report is to answer the following research questions: What are the current challenges in the construction documentation? What can be done to improve the situation? What is the effect of improper documentation on efficient resource utilization and sustainability? To answer these questions, this report explores the current literature on construction documentation and sustainability. This report is based on findings from 2 what Cooper (1989) called a theoretical review. The paper explores the literature on how the construction industry, problems in the documentation, and sustainability are interrelated and how changes in documentation can impact sustainability. (Cooper, 1989)

CURRENT CHALLENGES IN CONSTRUCTION

Construction documents must be precise and error-free to ensure safe and quality construction. The fact that a large amount of information is processed during construction work, added with time pressure increases the chances of errors in the document. Listed below are the most common errors that plague construction work.

- Inaccuracy and human error
- Information redundancy
- Difficulty in accessibility
- Version confusion (BC, 1976)

Inaccuracies in data leads to construction errors at the site, budget overruns, and delay in project completion. For example, it has been observed that in transport infrastructure projects there exists a large degree of inaccuracy between the actual demand and construction cost estimation. (JF, 1988)

CASE STUDIES

CASE 1: DESIGN DOCUMENT SURVEY BY NIKKEI CONSTRUCTION

A case for example is the inaccuracies and defects in design and documents in the Japanese construction industry. According to independent analysis, design and documentation are the most important influencers of cost and any decision made during the design phase would impact the end cost of the project. (BC, 1976) (JF, 1988) (NN, 1991). A survey conducted by Nikkei Construction involving 79 Japanese contractors showed that 44% of respondents often experienced design documents problems. (Andi, 2003). Designers and contractors' perceptions of the achievement of design document quality were assessed. The quality was evaluated from several attributes indicating the quality of the documentation (Andi, 2003). Table 2. Below show the attributes on construction document quality.

Attributes of Documentation quality
Completeness – drawings and documents provide all the information required
Clarity – drawings and other documents are easily read and interpreted
Consistency – drawings and other drawings are consistent
Accuracy – drawings and other documents are free from errors and omissions
Standardization – use of standard details and specification in drawings and other documents
Relevance – trade specifications and details are specific, relevant and appropriate to the project
Timeliness – drawings and other documents are supplied when required, to avoid delays
Certainty – drawings and other documents do not require changes or amendments
Coordination – drawings and other documents are thoroughly coordinated between design disciplines
Conformity – drawings and other documents indicate the requirements of performance standards and statutory regulations
Representation – drawings and other documents correctly represent the geographical, topography conditions, including the existing utilities and structures.

CASE 2: AS-BUILT CONSTRUCTION DOCUMENT

On-site data collection and documentation play a greater role in tracking progress and ensuring sustainability. Inaccuracies here will lead to poor construction quality and rework. Inefficient practices in documenting as-built information such as redundancy in data storage, manual methods, and paper-based documenting results in increased time consumption, confusion, and cost overruns. The study of McCullough for example, reported that 30-50% of field supervisors time is spent on recording and analysing field data. 9 (Tarek Hegazy, 2012) 10 (McCullouch, 1997)

Effective documentation could improve efficiency in resource utilization and therefore improve sustainability. Daily progress reports, labour reports, work schedules, quality conformance regulations and quality assurance reports, equipment maintenance reports, material handling and storage procedure, etc play an important role in the analysis, operation, and maintenance of the project.

CASE 3: DOCUMENTATION IN LARGE SCALE CONSTRUCTION

Large-scale construction projects are characterized by expansive sums of documentation. Over the years experienced designers have reported an increase in the documentation which raises the question as to how it affects the quality of construction. Project member's responses to time constraint, an increase in pressure, and an increase in workload has led to an increase in documentation. This can be observed through the E.g. of increase in the production and circulation of general documents as opposed to specific specifications. Cooperation between multiple organizations and the parallel work to cope with the increase in workload also serves as a good example that contributes to the situation. The combination of information overload and time pressure has led to the partial failure of documentation as an information processing instrument. The phenomenon labelled defensive documentation has also been observed where documentation serves to redistribute work and responsibility among the project members. A common model of engineering documentation shows the influence of external factors such as time pressure and incentive mechanism on an individual's response. (Ingrid Anette Wulff, 2000)

Two offshore projects have been investigated to see how the situation is coped. Offshore development projects are technically complex and mobilises many resources and organizations. A major risk involved in the processing of hydrocarbons is an explosion which requires sophisticated management systems, voluminous procedure handbooks and specifications to manage. Public regulations such as health, safety, and environment (HSE), quality control and quality assurance certification, an arbitration agreement with contractors, etc have also contributed to the bureaucracy. Although these documentations have been developed to ensure compliance with rules, there exists the risk of information overload. (Ingrid Anette Wulff, 2000) "According to Allen, the term 'information explosion' was coined in the early 1960's" (Allen, 1984). According to Simon, " the first generation of management information systems failed because they aimed to provide more information, not taking into account that attention rather than information was the scarce factor" (Simon, 1996) (Ingrid Anette Wulff, 2000). Another factor in large-scale engineering documentation is the failure to recognise and represent Human Factors (HF) which are often communicated better through other channels. They are given the least importance as they have been soft documentation. (Wulff, 1999) (Ingrid Anette Wulff, 2000)

CASE 4: DOCUMENTATION IN CONSTRUCTION MANAGEMENT

Documentation in construction management displays the necessary planning and process required in any project. These documents be continuously updated and processed to manage any addition, deletion, revision, or changes in the construction project's scope (C. Ibbs, 2001). Changes in the documentation, scope, etc which are hard to predict brings with its alteration of the projects initial cost, timeline, and performance. The difficulty in predicting changes is since every project is unique and the responsibility of predicting these changes lies with the project manager (A.S.Hanna, 2004). Minimizing conflicts and implementation of countermeasures is achieved through earlier discovery of problems in the construction (Kartam, 1996). The process of implementing changes in design and planning is complex and takes a long time, the impact of which can be observed as the result (M. Whelton, 2002). It was discovered that the direct cost incurred due to post-contract design changes amounts to about 5.1% - 7.6% of the total project cost (I.D.Cox, 2004) and about 50% of work had been delayed due to changes (H.G.Ballard, 2000) (Maria Kozlovska, 2016).

Documentation during the planning phase presents a significant amount of information that must be managed at the earliest (S. Xu, 2014). Construction management documentation serves as an important source of information to the investors, designers, contractors, and other stakeholders. Inefficiency in terms of construction quality and recurring overruns in time and cost are linked with poor collaboration among the multiple organizations (H.G.Ballard, 2000). Evaluation of construction documentation against time, budget, and quality control is as important as the management of information flow throughout the building life cycle (P. Mesaros, 2014). The site manager handles and evaluates the construction schedules' ability to meet the deadline, the budget's ability to fund the project at the right time, and the quality control plan to ensure the highest standards of construction. Constant monitoring and updating is an essential work during the execution phase (M.Juszczyk, 2014) (E. Radziszewska-Zielina, 2014) (A. Lesniak, 2014). Information and procedures required to ensure safe and healthy construction environment can be found with the plan for occupational safety and health (OSH) (Hulinova, 2014) (Maria Kozlovska, 2016) [29] Since construction documentation is a complex system, planning is required to complete the project. It can be concluded that the focus is primarily on the planning phase of the construction and precise and constantly updated documentation is required to ensure that the project is completed within the time, budget and quality. (Maria Kozlovska, 2016)

IMPACT ON SUSTAINABILITY

Academics and professionals in the fields of architecture, engineering, and construction are increasingly showing interest in the sustainable development of construction projects, in conformity with the gradual degradation of the natural resources and environment due to human activity (United Natins Environment p, 2018). Sustainability is the harmony between the development activity of the society while conserving the natural environment (Du pisani, 2006). It is important to create a system that connects sustainability with production and consumption to ensure the conservation of natural resources without inhibiting the social demands for products and services (Manzini, 2000). It should focus on reducing the environmental, social, and economic impact during construction, operation, and demolition in short throughout the life cycle of the structure (Torres, n.d.). As documentation is one of the most important systems to ensure communication of sustainability goals, it is important to know the relation between sustainability, documentation in the construction industry, and the impact of documentation on sustainability practices (David Carvajal-Arango, 2018).

Documentation takes a crucial role in the development of specifications, contracts, procurements, storage and processing of data, and as an important tool for communication and arbitration. Improper documentation with poor standards and insufficient data could delay the development of the project. Documents in different phases describe different usage.

As discussed in case 1, one of the major problems plaguing construction documents is inaccuracy. "Discrepancies in documentation could result in rework, delays, cost overruns, changes, accidents, disputes and loss of profit" (Andi, 2003). Rework

being a common result of inaccuracy results in the consumption of more resources to complete the same project which could otherwise be completed with fewer resources. This inefficiency in resource utilization harms sustainability as the growth in production and services is not balanced with environmental resource conservation. Other factors such as information redundancy and over documentation affects sustainability in a different way such that, the increase in documentation by itself increases the consumption of resources such as paper, ink, electricity for printing, wear and tear of machines, etc. but the core problem of excessive documentation is that the necessary information drowns in the unnecessary documents (Wulff, 1999). Excessive documentation results in loss of time in picking out necessary information as well as a reduction in the work efficiency of people. This in turn extends the project timeline and budget, resulting in unsustainable practice.

The construction industry is a significant contributor to the generation of wastes. It is observed that about 1 – 10% of by weight of the purchased construction materials are wasted (B.A.G Bossink, 1996). Moreover, the cost of transportation of the generated waste, cutting and embankments required to dispose of the waste, obtaining bigger landfills to compensate for the waste generated all contribute to unsustainability. Document discrepancies such as lack of guidelines in the disposal of toxic, chemical, and medical wastes, treatment of urban waste before dumping results in environmental pollution and poses a risk of health hazard for the poor. Unethical practices in the development of contractual agreements could result in the redistribution of liabilities to another member or loss to the contractor. Another example to be observed is the exploitation of workers by lack of basic income and benefits provisions in the contractual agreements for the construction workers, which results in poor and undignified living conditions. This indirectly leads to poverty.

RECOMMENDATIONS

By adopting the latest technology and communications, collaboration and coordination among organizations could greatly improve. Using inter-organizational systems in the collection, retrieval, processing and storage of data will help achieve greater control over the decision-making process. An integrated database management system can be developed by collecting and organising data from various sources of the project. Thus, performance improvement can be ensured. By classifying texts in accordance with their project components documents such as meeting minutes, change orders, specifications, etc could be better organized and retrieved when required (Carlos H. Caldas, et al., 2002).

In countries where buildings operational for the next 50 years exist, facility management becomes the most important task. As-built documents for assessing building performance, repairs and decommissioning become prime value for facility managers (A. Akcamete, 2009) (C. Eastman, 2008) (M.P. Gallaher, n.d.). Changes occurring during construction and during handover can be integrated into as-built documents using BIM (M.P. Gallaher, n.d.). One promising approach to as-built documentation is 3D geometric modelling and digitization of data using BIM (C. Eastman, 2008). By spending time early in the development phase over documentation can be reduced. This is done by eliminating the incentive-consequence corresponding principle and adopting the time pressure principle. (Stichcombe, 1985)

AUTOMATION CONCEPT IN OPTIMIZING STRUCTURES

STEEL REINFORCEMENT OPTIMIZATION

The construction industry is one of the consistent growing industries in the world which has a direct impact on the economy, sustainability, employment rate, material manufacturing and consumption of a country. Technology booms year after year have challenged the construction industry to integrate manpower with technological innovation to develop the best approach for construction. Current statistics show that steel reinforcement uses 44 % of total steel used in the building and infrastructure industry and 22% of the total steel produced (www.worldsteel.org, n.d.). Therefore, the optimization of steel is one way to minimize the cost of any project. Current trends exhibit that most of our steel reinforcement calculations are done manually or by structural analysis software such as RFEM, SCIA, ETABS, etc. These software and manual calculations work on satisfying safety criteria with less focus on optimization of the structural elements such

as beams and slabs. Therefore, we must develop a framework on how we can implement the optimizing strategy using BIM and hybrid Genetic algorithm (Cheng & Mangal, 2017). We can work on increasing the efficiency of the steel reinforcement satisfying the minimum requirements given by the codes.

PROBLEM AND INDUSTRIAL CONTEXT

The current way of analysing the required steel quantity gives an insight into the issues we are facing in the current market and some of them are listed below:

- Hand calculations are harder as the size and complexity of the structure increases.
- The time required for analysing big structures manually is huge which adds to the increase in project cost.
- Structural analysis software such as ETABS, RFEM, SCIA calculates the steel provided according to the codes focusing mainly on safety and missing out on the practicality of steel placement on the site.
- The complexity of automation requiring competence knowledge of professionals.
- Lack of systematic coordination between various professions in the construction industry.

The above-mentioned issues can be dealt with the help of BIM framework. Therefore, the following example will depict and compare the above points with the implementation of automation in designing structural members (Beam) using BIM (Building Information Modelling), structural analysis software and genetic algorithm (GA).

EXAMPLE OF A BEAM

The steel reinforcement is an essential part of any Reinforced structure and must be calculated for each structural member according to design codes. Therefore, optimization of the steel reinforcement calculations using the concept of automation is a very innovative and essential process in today's time to attain sustainability. The idea is to study automation framework using BIM (Building Information Modelling) for optimizing steel (using GA-Genetic Algorithm) considering all the variables and realistic

site installation challenges for best results. The provided steel reinforcement for the beam is calculated from structural analysis results which are performed manually, with structural analysis software RFEM and with automated optimization framework. The calculated results for steel reinforcement are observed and studied for consumption differences among all the different ways. The efficiency of all these three systems is compared with the lens of sustainability, cost-effectiveness and climate effects and how automation has a huge impact to provide the best efficiency.

The simple beam is analysed and compared for required steel reinforcement results using structural analysis software RFEM, hand calculations and the automation technique using BIM and GA. The line diagram of the beam model is shown below:

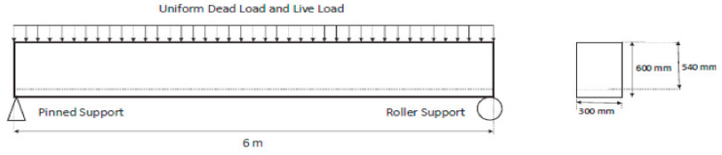


Figure 10 Line diagram of the beam

To optimize the steel reinforcement, the BIM framework is developed which has four different phases as can be seen from the diagram below:

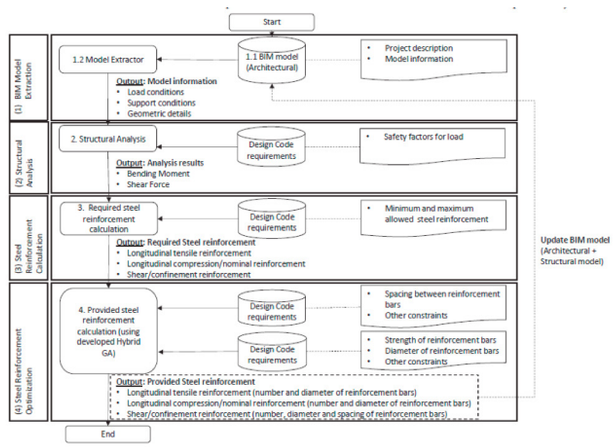


Figure 11 BIM Framework

The architectural model is extracted with geometrical data to run the structural analysis of the model giving us all the internal forces required for steel reinforcement design. The optimization is done with the help of modified version (Cheng & Mangal, 2017) of a genetic algorithm developed by (Goldberg, 1989) which includes penalty function (considers site installation problems such as bar size, number of links and different diameters in one beam) and objective functions given below:

Obj_fun (As, As', Asv) = As + As' + ∑(Asv)

Where (As) is Area of tensile reinforcement
(As') is Area of compression reinforcement
(Asv) is Cross-sectional shear area of links at the neutral axis at a section

The GA optimization is explained for the figure given below where the required area of steel reinforcement is minimized using three processes i.e. Generation, Crossover and Mutation. The area of required steel reinforcement for the below-mentioned example is 932 mm2 and the optimization process is carried out to finally provide 935 mm2 which is the most optimized solution compared to other methods using software and hand calculations

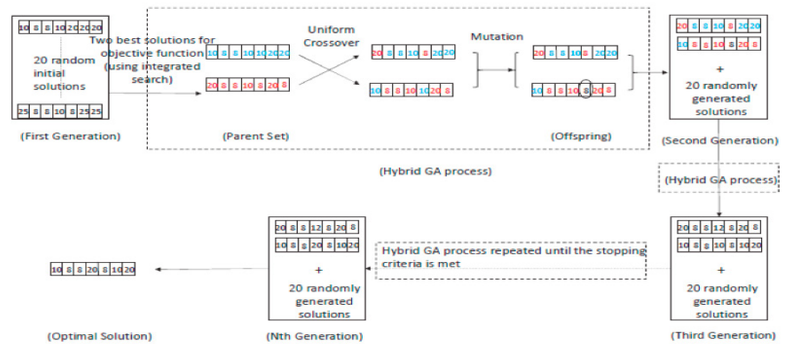


Figure 12 Hybrid GA

The calculations for required steel reinforcement is done using ETABS, RSAP, RFEM (using British Standard-BS8110, German Standard and Finnish Standards), Hand-calculations (using BS8110 and Eurocodes 1&2), automation using BIM and GA. The calculated results are as follow

Table 3: Results from different calculation methods (Cheng & Mangal, 2017) (Dlubal Software s.r.o, n.d.)

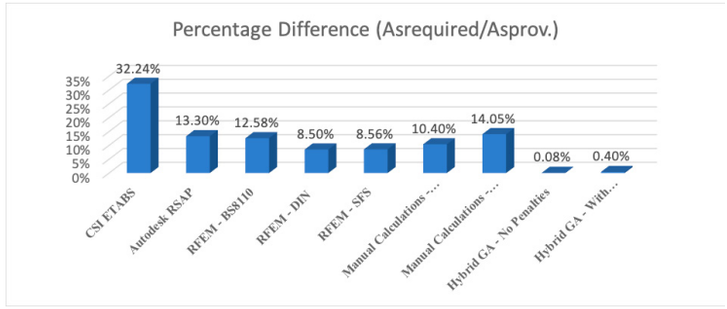


Figure 13 Result Comparison

The comparison of calculation with different software, hand calculation and by automation shown below clearly indicates that the efficiency of provided steel reinforcement by automation concept using BIM and GA is far superior and gives an efficiency of 0.4%. There is a huge amount of steel that can be saved by automation.

RELATION TO SUSTAINABILITY

The steel used for reinforcement is around 388.21 million tonnes of the total steel produced which is 1730 million tonnes in 2017 and amounts to 22 % (World Steel Association, n.d.). Now, bearing in mind each tonne of steel-producing 1.83 tonnes of Co2 emissi on, it's fair to say that steel used for reinforcement purposes in 2017 contributed 710.43 million tonnes of total Co2

emissions which were 35.6 billion tonnes (35,600 million tonnes) in 2017 (Roser, 2011). The contribution of steel reinforcement to the factors affecting environment and energy consumption is big so there is an urgent need that we work on efficiently using the steel for reinforcement purposes. The positives of the above example in terms of sustainability can be summarised in a few important points as follows (Cheng & Mangal, 2017) (Goldberg, 1989):

Reduction in Co2 emission with reducing consumption.

Wastage is exponentially decreased.

The energy required for raw steel production will be less.

Digitalisation can be increased on the construction site using BIM (Brathen & Moum, 2016) which will be reducing paper documentation required.

Penalty function considered improves ease of installing steel on-site by ironworkers.

Optimization contributes to the United Nations sustainable development goals.

Less paper documentation required using automation by BIM.

To sum up, the automation concept using BIM and GA was studied by performing calculations of steel reinforcement of a simple beam using software RFEM from Dlubal (Dlubal Software, 1987) complying to British standards(BS:2005), German standards (DIN:2015), Finnish standards (SFS:2007) and manual calculations using excel complying to British standards (BS8110) and Eurocodes 1 and 2 (EC 1&2). The results obtained from these calculations were then compared to the results of ETABS, RSAP and Automation.

The observation from analysing results agrees with the results obtained by (Cheng & Mangal, 2017) in terms of automated calculations being the most efficient from all calculations performed. Saving steel means saving energy to manufacture, reduce co2 emissions in the process and saving a lot of project material cost, minimizing the probability of errors which in turn saves catastrophic alterations, reducing the time required for calculation.

COST AND CARBON OPTIMIZATION

The construction and real estate industry is heavily driven by

the cost of a project which is a summation of all the processes from scratch to the finishing of the project i.e. property purchasing or leasing, surveying and geotechnical analysis, planning of the project, architectural designing, structural designing, construction phase, etc. The cost can be minimized in all the phases of the project depending on various aspects. One of the phases is structural engineering where an efficient design can lead to saving lots of money.

There has been an evolution of technology and the construction industry in parallel where we can develop the design with the help of software rather than manual calculations that has reduced the time to a great extent and reduced the errors significantly. Nonetheless, the growing need to sustain for our coming generations had motivated us to find more efficient solutions for designing. One such method to achieve a high level of efficiency is by using computing the problem using computer programming. The challenge with this approach is how to design a complex structure that is designed in real life and how can they be optimized effectively.

EXAMPLES

The difference in cost calculations for a structure by manual and semi-automated approach is compared by (Haider, Khan, Nazir, & Humayon, 2019). The cost of the structure is calculated manually by using the centre line method of estimation which is done by calculating the quantities of the different materials and then multiplying it by the current market price to get the total cost. The same model is developed in the BIM-based software such as Revit and the quantity take-off are collected for all the materials. It has been found that the total difference in estimation between manual and BIM-based semi-automated software (Revit) was around 4.8%. The saved cost can be utilized in different tasks involved in the project. Also, the total cost of the planning phase in Europe is around 3% of the total cost of the project which can easily be saved. Therefore, it’s a big amount of money saved by just switching from manual to the semi-automated approach.

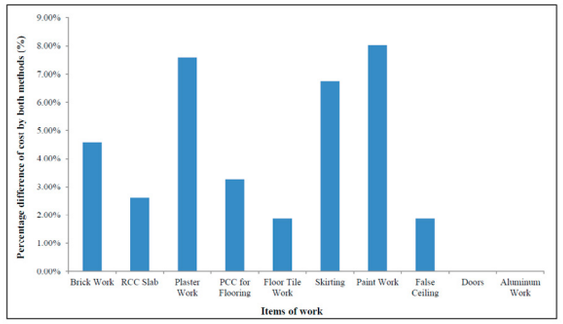


Figure 14 Cost difference by manual estimation and Revit

One of the biggest contributors to the cost in a structure is a slab which is also the most complicated to design among all the other structural elements. Automatic Optimizing slab using different heuristic methods can lead to a big difference in cost estimations as depicted by the (Sahab, Ashour, & Toropov, 2004) (Olawale, Tijani, Kareem, Ogungbire, & Alabi) corresponding to British standard(BS8110). The cost is optimized fully by BIM framework and Heuristic methods for searching the most optimized solutions. The results of the optimization given by (Sahab, Ashour, & Toropov, 2004) for a flat slab showing the difference in cost per m2 are as follows:

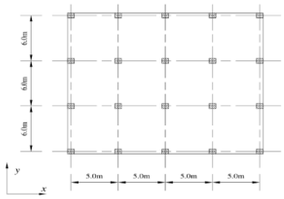


Figure 15 Plan layout of the slab

Design Method	Total Cost of floors (£/m²)	Total Cost of columns (£/m²)	Total approximate Cost of foundation (£/m²)	Total Cost (£/m²)
Optimum design	38.411	5.944	5.2	49.556
Conventional design	39.811	5.756	5.411	50.978
Cost saving (%)	3.5	-3.3	3.9	2.8

Figure 16 Cost estimation by conventional and optimized design

Another very important analysis of a model using the Genetic Algorithm done by (Eleftheriadis, Duffour, Greening, James, & Mumovic, 2017) which depicts the optimisation difference of a structural model showing best possible option from a point of view of cost and carbon. The research paper also indicates that there are different sizes of structural elements for cost-optimized and carbon optimized solutions which gives choice to the designer to choose the model best suited for what they prefer to optimize the most. The floor plan for the model, input data for optimization and the final selected sizes by (Eleftheriadis, Duffour, Greening, James, & Mumovic, 2017) are as follows:

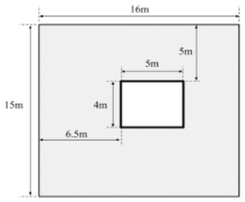


Figure 17 Floor Plan

Gene	Type	Options	Designs
1	Slab Thickness	5	(225,250,275,300,325) mm
2	Column B	4	(250,300,350,400) mm
3	Column H	4	(250,300,350,400) mm
4	Bay X	4*	{(5x6x5), (6x5x5), (8x8), (5x5x6)} m
5	Bay Y	4*	{(5x5x5), (8x7), (7.5x7.5), (7x8)} m
6	Bars per column B	3	(3,4,5) Number of bars
7	Bars per column H	3	(3,4,5) Number of bars
	Total Combinations	11,520	
* As generated by the computational component: The Number of options depends on the details of the inputs. In this case, values for the bays between 5m to 9m with 0.5m increments are used.			

Figure 18 Input data for GA

	Carbon Optimum	Cost Optimum
Slab Thickness	225 mm	250 mm
Column B	250 mm	250 mm
Column H	250 mm	250 mm
Bays X	(6x5x5) m	(5x6x5) m
Bays Y	(5x5x5) m	(8x7) m
Columns Reinforcement	8 Bars per column	8 Bars per column
Total number of columns	12 (5xØ16, 7xØ12)	10 (1xØ20, 3xØ16, 6xØ12)
Slab Reinforcement Rates	101 Kg/m³	98 Kg/m³

Figure 19 Result of Optimization

The important result of the research (Eleftheriadis, Duffour, Greening, James, & Mumovic, 2017) is that the cost-optimized solution is 3% cheaper than the carbon optimized solution. Also, in contrast, the cost-optimized solution has 7% more carbon

emission. Therefore, the results in Figure 10 clearly states that we must choose one option depending on our priority which can be either saving cost or reducing carbon in the structure.

3D PRINTING IN CONSTRUCTION

3-D printing is an additive manufacturing process where products are built on a layer-by-layer basis, through a series of cross-sectional slices (Berman, 2012). In the construction industry, the 3-D printing technology is in its initial stage. But in the past few years, many experiments have been conducted to explore the potential of 3-D printing into construction. In additive manufacturing a digital model is being used to fabricate 3D structure (Ming Xia, Jay Sanjayan, 2016). The development of this technology can make so many differences in the construction industry. For the construction industry, several techniques are developed. Some of them belong to concrete or cement printing and some of them related to metal printing.

CONTOUR CRAFTING

This printing technique is like the Fused deposition modeling (FDM) method. In which cementitious material emits in layers from a nozzle fixed on a gantry to print a structure. The maximum particle size allowed in this type of printing is 2mm to 3mm. The shape of the extrusion can be circular, oval and rectangular and the rate of extrusion is from 50mm/s to 500mm/s (Ming Xia, Jay Sanjayan, 2016).

Contour crafting is a layered fabrication technology that requires computer technology to create a smooth surface with accuracy (Behrokh Khoshnevis & Rosanne Dutton, 1998). The main advantage of this technology is speed, safety, and better surface quality. Just like other fabrication techniques such as rapid prototyping, stereolithography, and solid free-form fabrication, CC also requires a computer-controlled process to deposit the material (Paul Bosscher, Robert L. Williams II, L. Sebastian Bryson, Daniel Castro-Lacouture, 2007). It deposits one layer of the material at a time. But unlike other fabrication technology, this CC is designed for construction purposes only. CC is the first viable additive manufacturing process for building construction (Ali Kazemian, Xiao Yuan, Evan Cochran, Behrokh Khoshnevis, 2017). The most significant benefits of CC are better surface quality, higher fabrication speed and a wider range of materials (Khoshnevis, 2004).

The main characteristic of CC is the use of two trowels, that act as two surfaces to create a smooth and accurate surface of an object. The application of CC in construction can be seen in the following image, where a gantry system carrying the nozzles at the construction site. A single house or group of houses can be built in a single run. The prototype CC machine has work envelope dimensions of 5m x 8m x 3m, corresponding to 120m2 printing zone (Ali Kazemian, Xiao Yuan, Evan Cochran, Behrokh Khoshnevis, 2017).

CONCRETE PRINTING

concrete printing is another type of 3D printing, which is like Contour crafting. This is a machine designed in Loughborough University by Sungwoo Lim. This printing system is a prototype of a 5.4m (L) x 4.4m (W) x 5.4m (H). The different kinds of processes in this printing are Data preparation, Material Preparation, Delivering and printing. During the data preparation, the 3D CAD model is drawn, then being converted to STL file format, after than slices with required layer depth, a path for the printing is being decided for each layer and then G-code printing file is being created (Sungwoo Lim, Richard Buswell, Thanh Le, Rene Wackrow, Simon Austin, Alistair Gibb, and Tony Thorpe, 2011).

For Material preparation, the mixture of Cement and Gypsum has been used. Since this process requires a high degree of precision, therefore high-performance material has been developed. The density of this concrete was 2300 kg/m3. Approximately less than 20% of strength has been reduced because of the creation of voids between layers. Therefore, the mix of 100-110 MPA, has resulted in the component strength of 80-88 MPS strength. To maintain the strength, the material is being fed on small batches with a flow rate of 1.4kg/min with a nozzle diameter of 9mm (Sungwoo Lim, Richard Buswell, Thanh Le, Rene Wackrow, Simon Austin, Alistair Gibb, and Tony Thorpe, 2011).

Figure 20 The printing frame of Concrete Printing

MESH MOULDING (ANOTHER TYPE OF 3D PRINTING FOR REINFORCEMENT)

This technique is one of the possibilities that can replace conventional steel reinforcement construction. By using a robot, it can print thermoplastic polymer in 3D space. During printing, it allows a higher level of control that results in a wireframe in a free space that can be seen in the picture below. The density of the mesh can determine according to the type of force and application of force (Figure 24c). After that concrete can be inserted in this framework and smoothen the surface manually (Figure 24b). by using this method, a considerable amount of time can be reduced for the fabrication of complex geometry epically for large scale applications (Norman Hack, Willi Viktor Lauer, 2014).

Figure 21 Mesh Moulding

PWDER BED FUSION (PBF)

In this process, the powdered material is being placed on the bed and then being fused with the help of either by laser or electron beam. In the manufacturing industry, this method is being used just because this method is best suitable for small parts with complex geometry. In PBF metals, a combination of metals, polymers, a combination of polymer and metal can be used. And the maximum size that can be achieved through PBF is 250mm (S. W. Williams, F. Martina, A. C. Addison, J. Ding, G. Pardal & P. Colegrove, 2016).

DIRECTED ENERGY DEPOSITION (DED)

In this technique, the metallic powder or wire is being fed at the focal point of the laser or electron beam which results in the molten state of the material that can be deposited. Wire and arc additive manufacturing (WAAM) is one of the DED techniques that uses arc welding tools and wire to build material. In WAAM the deposition rate of the material is 4-9 kg/h with the surface roughness of 0.5mm. This process is the cheapest additive manufacturing process as compared to other 3D printing processes (S. W. Williams, F. Martina, A. C. Addison, J. Ding, G. Pardal & P. Colegrove, 2016).

EXAMPLES OF 3D PRINTING IN CONSTRUCTION

WINSUN HOUSES AND OFFICES

Winsun, a Chinese organization first started exploring 3D printing in construction. In 2016, It manufactured different components of a building by using sand, cement, reinforced glass fibre, etc. with a 150 x 10 x 6.6m machine. Then they assemble all the components on the site. A two-story building of 1100 m2 was being built in just three days (one day in the factory and two days on the site) with three workers. They built all the components of the building in China than shipped them to Dubai. This 3D construction resulted in 80% reduced construction costs, 60% lower labor costs and produced 60% less waste than a comparable conventional office building (Dubai Future Foundation, 2016).

CASTILLA-LA MANCHA 3S BRIDGE:

This bridge is recognised as the first 3D bridge and it was constructed by the Institute of Advanced Architecture of Catalonia. It has a span of 12m and having a width of 1.75m and It took 2 months to complete the bridge. Fused Concrete powder with polypropylene reinforcement was used as material for the construction of this bridge. This bridge was completed in the year 2016 (IAAC, 2017).

GEMERT BICYCLE BRIDGE:

The 8m long and 3.5m wide bridge is the first 3D printed prestressed bridge. This is a bicycle bridge in Gemert, Netherlands. With additive manufacturing technology, a 1cm layer of concrete was laid down (Clarke C. Royal BAM group use 3D printer to make concrete bicycle bridge with TU Eindhoven, 2017). This bridge was built in different segments and combined at the site. This bridge was completed in the year 2017 (Eindhoven University of Technology, 2017).

THE MX3D BRIDGE:

This bridge has a width of 2.5m and a span of 10m and this bridge was built by using the method Wire and Arch Manufacturing (WAAM). This is the first metal bridge constructed by 3D printing technology. This bridge was first displayed Dutch Design Week 2018. Now it is located at Amsterdam, Netherlands (Anderson Goehrke S. 3D printed steel pedestrian bridge will soon span an Amsterdam canal, 2015).

Advantages of 3D printing over conventional construction

- Design Flexibility: - It allows the designer to design the structures which cannot be achieved by the conventional construction method.
- Reduced Waste: - 3-D printing takes an exact amount of material, which the object needs. That results in less wastage at the construction site.
- Reduced Manpower: - As this is fully automated technology: therefore, it requires very little manpower as compared to conventional construction (Peng Wu, JunWang, XiangyuWang, 2016).
- Less time taking: - As compared to conventional construction it takes less time, for a one-story building it takes less than 24 hours (Peng Wu, JunWang, XiangyuWang, 2016).

FUTURE POSSIBILITY (3D PRINTING CONSTRUCTION ON LUNAR SURFACE)

As the human race is evolving, the need for research in outer space is obvious. The research in space can discover lots of things such as black holes, and discoveries of other planets can resolve the problems of resources which human may face in the future. Therefore, exploration in space is necessary. Till now, human space mission on other planets or satellite was done only once by NASA in 1969, That mission was Apollo 11 on the Moon (Redmond, 2008). But now NASA and SpaceX are trying to reach on planet MARS to working on colonizing the Moon and MARS for research and other discoveries (Dunbar, 2019). For this reason, there is a requirement of a shelter or research center in which humans can live.

3D printing technology can be used on the surfaces outside Earth for the shelter of humans. Because when a human will take the first step to the surface outside Earth, they would need quick construction. They would need shelter within a few hours. By using conventional construction, this is not possible. Apart from that, the conventional construction needs lots of material and labor. Which may increase the cost of overall space projects significantly. The inclusion of automation into construction can solve this issue, and the solution is the introduction of 3D printing technology to Lunar or Martian construction. Even though this technology is in the initial stage, especially in the construction sector. But it can resolve lots of problems of construction on another planet (Giovanni Cesaretti, Enrico Dini, Xavier De Kestelier, ValentinaColla, Laurent Pambaguian, 2014).

Researchers have already developed a concrete made of Lunar regolith (Soft soil on the Moon surface). In which sulfur would act as a binding material rather than water. As water cannot be found in the liquid form at the atmospheric pressure of

the Moon. They have tested 3D printer which can work on vacuum by using the lunar regolith. This kind of technology not only can provide the quick construction, but also can solve issues on Earth and on the surfaces outside Earth (Giovanni Cesaretti, Enrico Dini, Xavier De Kestelier, ValentinaColla, Laurent Pambaguian, 2014).

CONCLUSION

It is time to think about what humanity has done to nature for a long time. As a response to the new paradigm of sustainable development, energy consumption and the human footprint on the environment must be reduced. The essence of sustainability could be observed in the vernacular architecture which emphasizes an eco-friendly building. Achieving a balance between population growth and the environment through sustainable practices is necessary to ensure society's continual survival.

Traditional architecture in the hot and dry region was based on sustainability to create a balance between buildings and nature. Traditional architects paid careful attention to natural energy sources like water, wind, and sun and delivered comfort to people's life. They understood that buildings are connected to their environment, so they built them as a part of nature. Buildings in these regions were built by excellent sustainable methods absorbing the heat from the sun that releases during the cold hours of the day and cooling during the hot hours through natural ventilation and water.

This paper attempts to regain the value of traditional construction in the hot and dry region also to familiarize individuals with the benefits of traditional architecture in the world and urge them to think about practical, easy and cheap ways of construction.

The impact of a collapse in Nigeria's buildings is enormous. Huge financial investment is wasted in every incidence. Capital wasted outcomes due to low GDP allocation and negated economic growth in the country. For most recorded cases human lives are often lost which are unquantifiable. The factors found, such as the use of unauthorized materials; the faulty model and construction performed by quacks, etc., are the reasons for building collapse in Nigeria as determined by several studies. The major drawback to the country is the rate of collapse of buildings which renders the industry extremely volatile and unreliable. Investment and material loss, psychological distress and threat to the reputation of the country are amongst the effects that building collapse has on the development of citizens and economic growth.

Nevertheless, policymakers should institutionalize suitable planning, supervision and control of construction work to ensure that all buildings are designed, specified and properly planned. Building professionals should uphold their reputation, professional conduct and work in compliance with best practice procedures established in the formal form of contract building.

Through the case studies it was analysed that the documentation in construction business and sustainability are connected and changes in documentation will affect the construction project which in turn will affect sustainability. By adopting the latest technology in communications and by making changes to the principles with which documents are handled the project can be kept in check within the scheduled timeline and budget.

In a nutshell, the fully automated structural engineer designing indicated much-optimized solutions for a structure than achieved by semi-automation and manual calculations. The optimization can be done concentrating on one of the three different aspects which are steel reinforcement optimization, cost optimization and carbon optimization. Also, interestingly the selection of a structural model can be very different when it comes to these three optimization techniques. Therefore, the industry should be focused on choosing the most important and efficient structure which benefits the company, clients and the society in terms of sustainability.

The need to save resources in the current scenario is of utmost importance and the industry should be trying all the possible ways to achieve it and opting automation is one of the perks of booming technology. It is contributing to the sustainability we are contemplating for in a long run to save the natural resources we have excessively consumed using best possible techniques and innovations perfectly aligning with the quote “We cannot solve our problems with the same thinking we used when we created

them” by Albert Einstein.

The construction industry is still facing lots of negative issues. Wastage of material, time over-runs, and corruption are common issues in this industry. Apart from that deaths are also common in a construction site. Additionally, this industry is considered as the least efficient industry because of not adopting new technology. The problems, which humans were facing in the past: those were somewhat resolved by using Building information modelling and by using 3D drawings such as visualization of the structure, any interference of the structural object with each other, etc. It solved the problem for people who are working in offices in the construction industry such as structural designers, architects, planners, etc. But the problems on construction sites are still the same.

By using the 3D printer, it can give a completely new dimension to the construction industry. Like it did with the other industry such as an automobile. 2 decades before, no one has imagined a vehicle with Artificial intelligence (AI). But the case is completely different. At present everyone wants to have a car or automobile with AI. As it gave a new dimension to that industry and gave lots of scope for discovery.

The construction industry also needs this kind of revolution. Contour crafting and concrete printing are being developed up to a decent level, and structures have already built by these methods. But these methods need more development in terms of how these methods can be used with reinforcement. A method can be developed in which concrete and metal can be printed at the same time at the same location. By using this kind of method reinforced structure can be achieved. Mesh moulding is a method in reinforcement that can be provided, but in that methods, the concrete supposed to be poured manually.

By adopting 3D printing, not only it can solve the construction issues on Earth. it can give a new direction for the construction outside Earth. with the development of this technology, 3D printing can be used for different construction materials at different conditions (such as a vacuum or different atmospheric pressure). As humans will take steps on the other surface, they would need quick construction with the material available on that surface.

Only by using 3D printing, it can be possible. Otherwise with the help of Other technology, it will take lots of capital and time which is not feasible.

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TABLE OF FIGURES

Mohammad Mohammadi, Siu Kong Lau, Youngeun Kim,
Ahmed Ghoneim, Saurabh Dwivedi, Caroline-Julia Mastalerz, Maris Klose

3. SUSTAINABLE URBAN PLANNING

ABSTRACT

This chapter aims to discover major aspects of sustainable urban planning which plays an important role in sustainability today. It is necessary to address and meet various environmental, social and economic needs so that sustainable development of urban planning can be achieved. Therefore, various fields of urban planning such as urban regeneration, waterfront regeneration, waste management, renewable energy management and social aspects need to be focussed. Based on the results of this chapter, sustainable urban planning requires support and collaboration from governments, citizens and the private sector. They should have a clear understanding of sustainable urban planning, adopt innovative sustainable policies and make goals that take into account long-term social, economic and environmental impacts. If sustainable goals are set and practices are applied correctly, sustainable urban planning will make everyone's lives better.

INTRODUCTION

When humans became able to watch the earth from space with the help of satellites, they observed the damages that their development had done to their planet (Rogers, 1997).

The world's urban population increased ten-fold from 200 million to more than 2 billion only in 40 years between 1960 and 2000. Cities turned into giant units of consumerism because of dramatic growth in the migration of people from rural areas. The demand increased and as a result people consumed more than before. This led to more waste and pollution. Nations felt the need to re-consider the relationship between humans and the environment (Rogers, 1997).

The United Nations Conference on Human Environment was held in Stock-holm (1972) to provide an opportunity to talk about the environmental damag-es that were caused by human activities and how to reduce them. This action was accompanied by another conference in the late twentieth century, which aimed to help world countries to discuss the kind of development that could help them to reduce the destructive effects of human activities (Rogers, 1997).

The Brutland Commission in 1987 announced the publication of "Our Com-mon Future", which was about a new definition of development; sustainable development:

A development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This idea was a change of approach from an intellectual way of thinking to a more rational way and was also a practical answer to the problems of that time (Rogers, 1997).

One of the most important aspects of sustainable development is sustainable urban development. Sustainable urban development arguments started to form after 1990 and opened new horizons for engineers, academic scholars, and architects (Cohen, 2017). This theory addresses issues such as prevent-ing urban pollution, not supporting destructive developments and trying to re-duce poverty in the society. Sustainable cities can be defined as compact, eco-friendly and appealing cities that provide equal

opportunities for people from different levels of society to reach prosperity (Cohen, 2017).

All over the world countries started planning to achieve more sustainable cities. The following examples are giving an insight into various areas in different countries where concepts and strategies for sustainable urban planning have already been developed. At the same time, they identify areas where sustain-able urban planning is still urgently needed.

Some good cases for sustainable urban planning can be found already in Europe. Helsinki, the capital of Finland, struggles like all big cities to provide suf-ficient building sites within the city. This is a problem because more and more people are moving into big cities, without having enough space for them. Con-sequently, they started to redevelop brownfields to satisfy the rising housing demand. With this idea, they are good examples for the rest of the world, es-pecially to the big cities where more space is urgently needed.

Another good example of sustainable urban planning can be found in Sweden and Germany. Both countries carried out very good strategies for the reduction of plastic waste. Because plastic waste has turned out to be an increasing danger for our environment. There is a great extinction of species, especially in the oceans, due to plastic. This is the reason why many countries all over the world started to rethink their plastic waste management. Germany and es-pecially Sweden are having a leading position in redeveloping their plastic waste management. They became pioneers in this field for other countries.

But not only Europe is active in sustainable urban planning. The whole world started more or less to rethink urban planning. An international example is the revitalisation of waterfronts in South Korea. In previous years these areas were mostly used as an industrial area. Many industrial complexes and of course the harbour were located near the water. Over the years these areas became more attractive and developed to an aesthetic place for the pleasant life of ur-ban residents.

Even the most rural places in Egypt are used for sustainable

technologies. They can take many advantages of their deserts and offshore regions for solar energy and wind power. Apart from this, they want to develop offshore wind much more to reach their sustainable energy targets in 2020 and 2030. Some of these developments can also be seen in some parts of Europe. This is for sure not easy for Europe. A big disadvantage is certainly the poor geographical location. Egypt is much better located for producing renewable energy.

But not every country and every big city have good sustainable urban planning strategies. Iran still has to catch up. Not only the state but also the population need to be more interested in sustainability. At the moment Iran has an urban planning system which is not aligned to any sustainability goals. And most of the Iranian population do not support their government to develop those strategies. A quick rethink is needed here.

Even Germany has to rethink some of their strategies. Concerning plastic waste management, they are a kind of pioneer for other countries. But when it comes to considering demographic changes in Germany, they have a big gap in their actions. Because the demographic change shows that the population in Germany will become much older in a very short time. In 2060 around 28 % of the population will be over 67 years old. For this case, Germany needs many more accommodations for older people. They already feel the changes right now, but still have reacted slowly.

Sustainable urban planning is especially a problem in developing countries, like for example India. The amount of plastic waste is huge in this country and they just started to realise the problem and the impact on the environment. By now they haven't a good strategy for the whole country to reduce plastic waste. In addition, they have also economic barriers because they simply lack some money. Even if European countries have more money at their disposal, developing countries need to have a closer look at the strategies of Sweden and Germany and should ask for financial support. It could be helpful for India to develop its own practices and strategies for a long-term reduction of plastic waste.

Not every country plans ahead at the moment. But with the

rapid change in our environment, many countries are rethinking their strategies now. In some countries and cities, it is already more established than in others. For develop-ing countries, it is still hard to find good strategies because they often don't know how and where to start. But this is not only a problem in develo-ping countries. Besides, Iran is for example still at the beginning of sustainable urban planning.

This chapter should give the reader an overview of different projects which are already happening in the world. In addition, it should provide ideas on how to implement sustainable urban planning. Especially for countries where it has not yet been estab-lished in a satisfying way. It is already a start, that many countries are developing strategies for sustainable urban planning. But it can only make a difference to the environment when all countries work sufficiently on it.

AN INVESTIGATION OF DIFFERENT ASPECTS OF URBAN PLANNING IN IRAN

A CASE STUDY OF IRAN

The first international conference on the human environme-nt was held in Stockholm in 1972 to provide an opportunity for nations to talk about the de-structive consequences of human activities on earth's environment (A. Ha-kiminejad, 2018). In this conference, professor Firoz (known as the father of sustaina-bility studies in Iran) talked about the fundamental concepts of responsibility for natural resource usage and environment care. The rational use of natural resources was the phrase he used. In 1992, Iran's government established a National Committee for sustainable development. Sustainable ur-ban development means shifting from fixed goals to process-based approach-es (Emami, 2012).

This sub-chapter starts with an introduction to Iran's general information. Fur-thermore, Iran's government perception of sustainable urban development and some of the actions that it did will be explained. It will continue by investigating challenges in the way of reaching sustainable urban development in Iran.

INFORMATION ABOUT IRAN

Figure 2 1-Iran's location (worldmap.com, 2019)

A brief glimpse of Iran's condition in terms of its general, eco-nomic and cultural information will be provided in the following paragraphs.

Iran is the 18th largest country in the world with more than 1.63 million square kilometres and more than 80 million popu-lation (Iran National Statistics Cen-ter, 2016). Iran's economy is mainly based on oil export, agriculture, and ser-vice sectors. Due to sanctions imposed on Iran's oil export, the economy is facing numerous difficulties, which has led to a reduction in the bud-get of ur-ban sustainable development projects (A. Hakiminejad, 2018).

Iran's government perception and actions regarding sustai-nable urban development

Regarding the case of Iran, to understand the concept of sus-tainable urban development, it is vital to perceive the existing situation by carefully consider-ing the assessment policies that exist in Iran, and the actions that the govern-ment has done so far. Indicators play an important key role in the process of eva-luation of urban sustainability. Iran's department of environment in cooper-ation with other organizations developed the National Committee for sustaina-ble development. NCSD published nine sustainability assessment systems as shown in Table 2 1 (A. Hakiminejad, 2018).

	Iranian assessment systems	Source
1	Set of Indicators for Environmental Sustainability (SIES)	Iran Department of Environment
2	Urban Development Index	Tehran Municipality: Performance and Management Department of Assessment Improvement
3	The state of Environment (SoE) Report of Tehran (1998-2007)	Tehran Urban Planning & Research Centre
4	Iran State of Environment Report 2004(Iran SoE 2004)	Iran Department of Environment
5	Tehran Annual Air Quality Report (2015-2016)	Air Quality Control Company
6	Socio-Cultural Indicators for Tehran Neighbourhoods (SCTTN)	Socio-Cultural Deputy of Tehran Municipality
7	Evaluating the Quality of Tehran's Urban Environment (EQTUE)	University of Tehran, faculty of Environment
8	Urban Heart Tehran: Urban Health Equity Assessment and Response Tool	World Health Organisation, Tehran Urban Planning & research Centre (Tehran Municipality)
9	Environmental Performance Assessment	Tehran Municipality: Environmental and Sustainable Development Management Centre

Table 2 1- Iranian sustainability assessment systems (A. Hakiminejad, 2018)

URBAN DEVELOPMENT INDEX

There is a project named Urban Sustainable Development Index that was es-tablished by the department of performance assessment and management improvement in cooperation with Tehran's municipality. Twelve well-known experts are involved in this project. They published their first progress report in 2015. The main focus was on Tehran to find out what kinds of points of

view are mainly used by the urban management system of Tehran for sustainable urban development. This is the first indicator ever to be defined by Iran's gov-ernment to assess the urban sustainability level of the cities in Iran. This indi-cator has more than 400 variables within six headlines as shown in Table 2 2 (A. Hakiminejad, 2018).

Indicator	Sub-Indicator
Socio-cultural	Promoting Islamic-Iranian identity and strengthening revolutionary values Health Neighbourhood Management & local capacities Research Entrepreneurship and dealing with social pathology Physical Development
Traffic and transport	Public transport Traffic management Environmental pollutants Road safety Active transportation (non-motorised transport)
Urban services	Waste management Green space development Sustainable urban environment Organising pollutant businesses and industries Beautification and urban space management Supply of goods and service management Cemetery management
Safety and disaster management	Safety hazards Fire and rescue infrastructures
Architecture, planning and urban infrastructures	Fulfilment of urban development vision Lawfulness of physical development and image of the city Urban traffic infrastructure Surface water management

Table 2 2- Tehran Urban Development Index (A. Hakiminejad, 2018)

The Wastewater treatment plant in Shiraz and Ahvaz with the financial support of the World Bank

More than 70 % of Shiraz's and Ahvaz's wastewater was unt-

reated. This pro-ject benefited a population of more than three million. While the water system was developed and population coverage was total in Shiraz and Ahvaz, sew-erage coverage was very low, and there was a great need to develop wastewater treatment plants. These sewage treatment plants were established to cover the needs of people living in Shiraz and Ahvaz. This project improved environmental conditions and also public health. Also, it helped the irrigation systems in the surrounding area of the plants (World Bank, 2004).

Implementing City Development Strategy (CDS) plans

CDS is defined as the process of preparing a long-term vision of the city's fu-ture from shorter-term action plans that are drawn for priority sectors. The main applications of CDS are promoting sustainable growth of cities, and improving the quality of life for its residents. CDS seeks urban sustainable development through the continuous participation of the citizens. CDS has four main steps:

1- Analysing the current situation
2- Strategic and long-term visioning
3- Strategy formulation
4- Continuous monitoring and evaluation

Figure 2 2- CDS process (city-development.org, 2016)

CITY DEVELOPMENT STRATEGY IN IRAN

As a comprehensive planning method was unsuccessful in Iran due to the rap-id and improper growth of cities, city planners and governmental policymakers realized that the only way to improve the situation is using CDS as a powerful way to enhance existing unsustainable cities. As a result, Iran's government in cooperation with World Bank established an urban upgrading and housing reform program. The program aimed to start housing reforms, and to improve the quality of urban living. Three cities were chosen for conducting this pro-gram; Qazvin, Bandar Anzali, and Shahrud. This project started in 2005 with a budget of 85 million dollars loan from Word Bank to support the first CDS pro-ject in Iran, which started in 2007 and ended 2010 (Emami, 2012).

The Objective of Qazvin, Shahroud and Anzali CDS programs
The focus of Qazvin, Shahrud, and Anzali CDSs was on:

- Strengthening their economic competitiveness
- Poverty reduction
- Improving the condition of the city environment
- Infrastructure development
- Financial sustainability of development

The CDS plan could be verified as one of the few successful projects in the field of sustainable urban development in Iran. The cities chosen in this project are small, and it is needed that CDS projects to be implemented in large cities like Shiraz, Tehran, and Isfahan (A.Shahraki, 2014).

MEHR HOUSING PROJECT

DEFINITION OF MEHR HOUSING PROJECT

Iran, as a developing country, needs to construct more than 1.5 million hous-ing units every year to bring equality between supply and demand. One of the recommended ideas that were operated in other countries and was successful is Mass Housing. Briefly, it means construction of a huge number of houses to reduce the total cost, construction time, labour costs, providing

the opportunity of using different financial resources and diversity in urban planning. In this regard, Mehr Mass Housing Project was designed in 2007 to provide cheap housing units for low-income families and youth by eliminating the price of land and preventing the skyrocketing of housing prices. Other objectives of this project can be expressed as poverty reduction, boosting the economic growth and employment rate (G.Abbaszadeh, 2016).

FINANCING AND BUDGETING

Building more than 1.5 million housing units covers more than six million pop-ulation, meaning that it needs huge financing from the government. On this subject, the Mehr Housing Project is being constructed in collaboration with Central Bank, municipalities, Ministry of housing and national insurance (Sta-tistical Centre of Iran, 2016).

Administrative barriers in the way of developing the Mehr Housing Project

- Administrative bureaucracy

The process of getting loan credit from a bank for this project is complicated in Iran due to a lack experts who are familiar with stages of confirmation of construction financing to builders (G. Abbaszadeh, 2016).

- Lack of coordination between different organizations

Lack of integrated management system is one of the main barriers in the way of properly planning and construction of all projects, especially Mass Housing Projects. Mehr Housing Project involves versatile organizations, such as the Ministry of Housing and Urban Development, Housing Bank, national insurance. The precise role of each organization was not defined before the design and operation of the project, and this creates conflict and chaos (G. Abbaszadeh, 2016).

- Lack of technical monitoring

Construction supervisors should be present at the construction site to moni-tor every stage of the project. Due to the lack of presence of supervisors, most of the buildings were not constructed properly based on exact build-ing codes and regulations, and this led to reducing the strength of building against earthquakes and other natural disasters (G. Abbaszadeh, 2016).

ECONOMIC NEGATIVE IMPACTS

- The Increased cost of units

One of the main objectives of this project was to reduce the cost of housing units by providing free land for the people of the poor community, but two problems made achieving this goal impossible. The first one was that these houses were built in areas far from cities with no infrastructure, and provid-ing infrastructure costs were not taken into consideration when computing the overall price of housing units. The other problem is that contractors and builders considered huge profits for themselves, which led to increase in the price of housing units, and there is no supervisory body to control them (G. Abbaszadeh, 2016).

LOANS REPAYMENT

Applicants are mainly from low-income households and the amount of the first payment that they must pay to the bank is much more than what they can pay. This caused serious financial problems for the government and the applicants (G. Abbaszadeh, 2016).

SOCIAL NEGATIVE IMPACTS

- Being unsuccessful in recruiting target groups

Mass Housing Projects such as Mehr Project, which can be classified as socio-economic development programs, should provide a clear and ration-al definition of their target groups. Mehr Housing started claiming that its main objective is to help the top third low-income households while in reali-ty, low-income families withdrew from the program because of not being able to pay bank instalments and the difference between the price that when they signed the contract and the increased price (due to inflation) that the government asks them to pay (G.Abbaszadeh, 2016).

CLASS SEGREGATION

One of the other major social problems with this project is that it is only de-signed and constructed for poor and low-income classes and this is in con-tradiction with basic principles of sustainable urban development, which emphasizes on the inclusion

of different classes of society when planning and designing Mass Housing. If this is not considered, these projects will turn into ghettos. Unfortunately, only poor people live in these areas and this attracts new poor immigrants (G. Abbaszadeh, 2016).

• Lack of sense of belonging to the living area because of the lack of pub-lic open spaces

Projects such as Mehr Housing, which are mainly constructed in the sub-urbs as shown in Figure 2 3 and Figure 2 4, have a lack of green and rec-reational spaces, such as parks, playgrounds, gardens. Most of Mehr Housing units act only as dormitory settlements with low levels of social in-teraction and lack of sense of belonging to the living space, which all lead to serious social problems. The following table shows the percentage of public places in different provinces that Mehr Housing Project was operat-ed (G.Abbaszadeh, 2016).

No.	Province Name	Total area (ha)	Public land use area except for green space	
			ha	% of total
1	Gilan	229.4	28.9	12.6
2	East Azarbaijan	1951.1	205.7	10.5
3	Khuzestan	1535	129.9	8.5
4	Ardabil	235.4	42.1	17.9
5	North Khorasan	350	81.4	23.3
6	Bushehr	71	14.5	20.5
7	Zanjan	34.5	4.5	13
8	Kerman	440	66	15
9	Hamedan	67.1	20.9	31.1
10	Sistan	282	64.5	22.9
11	Qom	215	34.6	16.1
12	Hormozgan	610	128.7	21.1
13	Qazvin	592.5	132.1	22.3
14	Lorestan	259	61	23.6
15	Khorasan Razavi	1644.1	126.1	7.7
16	Tehran	1739	382	22
17	Kermanshah	372.5	45.8	12.3
18	Kohgiloyeh	72.79	5.67	7.8
19	Kurdistan	197.6	44.5	25.5
20	Semnan	213.2	31.8	14.9
21	Fars	10.2	.3	2.9
23	Markazi	395	55	13.9
	Total	11516	17.6	14.8

Table 2 3- Percentage of public places (G.Abbaszadeh, 2016, reproduced by author)

Description of the main challenges in the way of achieving urban sustainable development in Iran

Huge differences in the definitions and attitudes towards the concept of city in comparison to western countries

One of the main challenges in the way of achieving sustainable urban devel-opment in Iran is the difference in understanding the concept of a city in Iran in comparison with western countries. The word “city” is embedded in the culture and history of Iran for thousands of years ago but uniquely. The city was al-ways believed as a sacred concept for Iranian people. In Iranian mythical be-liefs, the city is considered to be a paradise that no one has the power of es-tablishing it. City, in its ideal form, is interpreted as light, which is something extremely holy in Iranian culture. On the contrary, in western countries, alt-hough the city was the place of residence of kings, it was mainly considered to be something materialistic and earthy, and the demand of people is more evi-dent in its formation rather than the mighty of divine power. This means that the city is designated as the market place. The city emerged to respond to the fi-nancial needs of non-urban and rural people for trade and business (Barati et al, 2015).

Max Weber’s point of view about the difference between cities in the west-ern world from other parts of the world and its relation to urban planning in Iran

Weber describes the distinctions between cities in the western world from oth-er cities as followed:

- Legitimate authority rests on rational foundations, not divine beliefs.
- The law is obeyed by everyone no matter their social class level.
- Social grouping is based on social class, not family or tribe.
- The power of the city rests on economic foundations, not military power (Economy and Society, Max Weber, 1986).

Therefore, a city in Iran is substantially different from its counterparts in the west and these differences led to different attitudes by the city officials and people. This made city affairs

less important in comparison to family affairs. As a result, Iranian citizens have been used to not take care of their responsibility for their cities. Dialectic of political concentration and decentralizati-on, political tyranny during history, invasions and destructions of the cities, lack of progress in achieving a citizenship culture, low influence of city people on city govern-ance, economic insecurity in aligning the public will and government man-agement for various reasons, they have all led to the necessity of the existence of a powerful force in the name of government, which highlights the govern-ment’s position in achieving urban sustainable development in Iran (Barati et al, 2015).

A GOVERNMENT THAT DOES NOT DECIDE BASED ON THE OPINIONS OF SCHOLARS

The role of government in achieving urban sustainable development in oil-rich countries like Iran is different from Western Europe and the United States. These countries’ governments do not hold themselves accountable for an-swering their citizens because of the high profits of selling oil. When a gov-ernment strives in any possible way to elevate or show the economic growth to increase its acceptance rate among people, it is far from reality to expect from it to pay attention to the consequences of its actions, and the main problem is that they leave instability as a legacy for future generations and governments. Our urban planning system, which is almost a part of the government body, is not exempt from this rule (Barati et al, 2015).

Projects such as “Mehr Housing” that had the aim of providing cheap housing for poor people turned to be a complete waste of national budget and energy because of improper planning and operation that were due to not listening to the opinions of scholars who warned about the destructive consequences of these mass housing projects. Most of these houses are constructed in places that are far from public facilities. Their tenants do not have access to schools, hospitals, parks in their area and as a result of not being demanded most of these projects were stopped and those of them that are constructed have low rates of residency. This money could be disbursed to pay attention to the reno-vation of worn-out built areas as the most unstable parts of the city especially in metropolises, which helps to have compact cities

that properly answer to the needs of their citizens and prevent from the waste of national time and capital. Also, lack of coordinated programs for the public transportation systems, all of them indicates the absence of a serious will and a proper strategy for achiev-ing sustainable urban development in the body of government (Barati et al, 2015).

Isolation and poor contact with advanced countries for planning and im-plementation of sustainable urban development plans due to illegal and unfair sanction imposed by the United States

Sustainability is a process that must be pursued at local, national and global levels by the help of the government to make it possible to occur. After the Is-lamic revolution in Iran in 1979, United States initiated to put sanctions on var-ious sectors of the Iranian government, and this caused various problems for different sectors of government and society including public and private plan-ning organizations. An important problem caused by these unfair and one-sided sanctions is that other countries have the fear of being punished by the US because of cooperating with Iran. Due to that projects such as Shams pro-ject, that aims to develop and prosper the eastern axis of the country by creating job opportunities and prevention of migration of rural people to the big cit-ies, have remained silent (Barati et al, 2015).

A planning system that is non-aligned with sustainability goals

The emergence of the crisis in the planning system of the country over the past decades due to the lack of successful plans and proportionality between the goals and the performance of the plans necessitated the need to change the various aspects of the plans. Therefore, the ministry of Housing and Urban Development recognized the necessity for reforming the country's urban de-velopment system and proposed this below-mentioned outline:

- Revision of the urban development of the country
- Revision of the laws and regulations of urban planning
- Revision of description of urban planning services

Planning in Iran is based on pre-defined plans with fixed frames that will be used for all the cities of the country without considering their unique geograph-ical and demographic characteristics. With this situation, it is completely evi-dent that Iran encounters many problems. This proves the point that the pro-cess of urban planning in Iran is not moving towards sustainable development goals (Barati et al, 2015).

NOT TAKING ADVANTAGE OF PEOPLE'S PARTICIPATION IN CITY ADMINISTRATION

Based on Agenda 21, the participation of all people and the efforts of govern-ments to promote and raise public awareness are vital for achieving sustainable development in any field, such as the field of construction and urban plan-ning. The concept of public participation means that people's needs and de-sires should be taken into consideration in the time of planning and operation. Dr.Parviz Piran, a prominent Iranian sociologist, points to the lack of willing-ness in public for cooperation with government institutions as one of the rea-sons for not being successful in planning and implementation of urban devel-opment plans. According to his theories, Iranian people tend to participate in informal areas, but they are not willing to take parts in formal areas, such as city management and urban planning. He states that this originates from the cultural and historical background of Iranian people (Barati et al, 2015).

Incompatibility of some of urban planning laws and regulations with sus-tainable urban development goals

Reviews of laws and regulations approved by the supreme council of urban development and architecture of Iran reveals that almost none of these rules are in contradiction with the concept of sustainable urban development. But the problem originates from the different understanding and consideration of laws to gain illegitimate profit. One of the laws that its legislation or how it is implemented is in contradiction to sustainable urban development is:

Zoning criteria and determination of building densities and land use in ur-ban development plans (Ministry of housing and urban development, 1987)

This act was a license given to the municipalities of big cities (especially Teh-ran) to sell construction congestion as an unstable income, which harms sus-tainable urban development, to earn income to provide city administration costs. Currently, more than 80 % of Tehran's municipality budget is supplied from selling construction congestion, which leads to an increase in the city administration expenses, imposing pressure on the ecosystem and increasing urban instability. As an example, over the past decade, more than 1.4 million parking spots were sold out for creating parking, but it can be observed that less than half of this number of parking spots are created. This means earning illegitimate and unstable income because if 1.4 million parking spots are in-tended to supply, more than 20 times of the income that was earned ten years ago from selling the spots have to be spent, and this means that the city is bankrupt (Barati et al, 2015).

LACK OF A COMPREHENSIVE LAND USE PLANNING DOCUMENT ON THE NATIONAL SCALE

Comprehensive land-use planning can be defined as rational use of land, which means the rational allocation of land to different activities to reach sus-tainable development in general, and especially urban sustainable develop-ment. The necessities of preparing and implementing experimental programs to reach sustainable urban development are:

- Imbalance in the use of land
- Organizing the settlement system
- Settlement network deployment
- Population policy (National organization of management and planning: 2003, 11-12)

RECOMMENDATIONS

Summary of challenges in the way of reaching sustainable urban devel-opment in Iran

To summarize, the barriers in the way of reaching sustainable urban planning and development in Iran are:

- Iranian people are reluctant to participate in formal areas such as help-ing their government. This lack of willingness originates from the inabil-ity of Iran's governments in responding properly to Iranian people's needs and desires during history
- Not taking advantage of people's participation in city administration by governments
- An urban planning system that is non-aligned with sustainability goals
- Iranian people consider city affairs less important in comparison to their family affairs
- The incompatibility of some of urban planning laws and regulations with sustainable urban development goals

RECOMMENDATIONS

This section provides an overview of the challenges that Iran is facing in the field of urban sustainability. Proposing exact and precise solutions for solving these problems is beyond the scope and power of just one research. But fol-lowing some recommendations are giving:

- Carrying out structural reforms in the body of an urban planning system
- Review of urban development laws and regulations on the national and local level
- Developing sustainable development bill as an upstream document
- Increase public awareness about urban sustainability topics using mass media and social networks
- Establishing a master's program in sustainable urban development in universities
- Implementing successful experiences of developed countries such as Finland by considering Iran's unique cultural characteristics
- Using public participation when planning urban development projects, such as Mehr mass housing
- Developing urban sustainability assessment frameworks as a powerful tool to diagnose the major problems that cities are encountering

BROWNFIELD REDEVELOPMENT IN HELSINKI

Urbanization is happening rapidly across the world. Half of the world's popula-tion, 3.5 billion, lives in cities and this number is projected to grow to 5 billion in the year 2030 (United Nations, 2019). Land scarcity is very much a city problem. Big cities like Hong Kong, New York, London are notoriously plagued with high property/rent prices (Global Property Guide, 2019). High rent/ property prices can be debilitating to a city in terms of youth's ability to live alone, entrepreneurship and just the general living standards. One case in point is Hong Kong's coffin homes (Taylor, 2017). This is not just the problem of a few big cities like Hong Kong, London, or Paris. As urbanization is set to continue, high rent/property prices are coming to every city in the world.

To satisfy the rising housing demand, cities need to find more land. However, for cities that cannot expand into the suburb/ nearby cities or cities like Helsinki, which are particularly keen on preserving their natural resources (i.e. green areas and bodies of waters), developing brownfield land is the way to go. As an alternative to reclamation and deforestation for land, developing brownfield land will help preserve the natural environment of the city. Also, brownfield redevelopment increases the land supply and combats high prices, which helps with the economic health of the city and the social wellbeing of its citi-zens.

In Helsinki, there are some good measures in brownfield redevelopment as a sustainable means of urban redevelopment, which sets a good example for the rest of the world. For this reason, this sub-chapter shows sustainable measures and innovations in redeveloping brownfield lands in Helsinki in terms of construction and urban planning. It investigates how sustainable brownfield redevelopment is as a form of land supply in Helsinki.

DEFINITION AND SCOPE

Brownfield lands have been previously been defined as "Real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or con-taminant" (DE SOUSA & GHOSHAL, 2012) especially in the US. The definition has since been expanded to include also previously developed land which

is now unused or underused, as opposed to Greenfield land, which is virgin land that has never been developed. This is the definition used by the UK. In Hong Kong brownfields also include previously agricultural land in rural areas that are currently occupied by various unsanctioned industrial operations (Our Hong Kong Foundation, 2016, p. 93). In this subchapter, there will be mainly the focus on the brownfield redevelopment in the traditional sense i.e. previ-ous landfill sites in Helsinki.

CASE STUDY: HELSINKI

Helsinki is the capital of Finland. It has a population of 650,000 people. To-gether with the Metropolitan area and the neighbouring municipalities, the Helsinki region has 1.5 million people which is almost 30 % of the country's population. Helsinki has a surface area of 715 km2, of which only 30 % is landmass and the rest are mainly seawater bodies. This makes Helsinki's population density 3,000/km2, which is quite sparse as far as capital cities go (City of Helsinki, n.d., p. 8).

Finland is well-known for its abundance of forests and Helsinki is no excep-tion. The city has about 25 % green spaces, most of which are forests, parks, landscape fields and meadows. As the capital of a country that enjoys a lot of nature, Helsinki has a lot of incentives to preserve its water bodies and green spaces. The city plans to "secure sufficient recreational and green zones" and to "develop maritime areas and urban nature networks." To achieve this, new nature reserves are proposed in the Nature Conservation Programme (2015-2024) (as shown in Figure 3 1). This will double the nature reserves of Helsin-ki, which is currently at 3 % land area and 1 % water area (City of Helsinki, n.d., pp. 46-47). To preserve the natural and green areas of the city further the need to prioritize the development of contaminated brownfield land is of high importance.

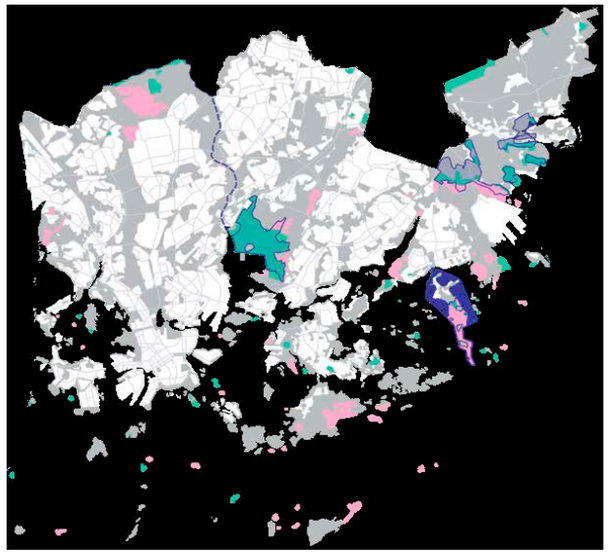

Figure 3 1- Nature reserves of Helsinki (City of Helsinki, n.d., p. 47)

OVERVIEW OF FORMER LANDFILL SITES AND CONTAMINATED LAND IN HELSINKI

In order to assess the extent of contamination in the land of Helsinki, the soil condition database was established by the Ministry of Environment. The data-base shows 878 areas in Helsinki where the soil is contaminated, assessed to be possibly contaminated and where the soil has been restored (City of Helsinki, n.d., p. 50). These data are also presented in the City Information Model for the public to access (see Appendix 1). This tool is useful in identify-ing where brownfield lands should be redeveloped first.

The two largest brownfield redevelopment projects are the project areas of Kalasatama and Jätkäsaari. Both of these areas have a history of having con-taminated soil and are being redeveloped into residential areas. Apart from that extensive soil restoration work is being carried out in Kivikontie and Hakaniemi. There is currently a project of restoration of the Vuosaari landfill and the city is planning on the restoration of the Iso-Huopalahti landfill (City of Helsinki, n.d., p. 50).

To restore the soil, the soil containing the harmful pollutant were excavated and transported away for processing or by isolating it on site. A total of 92,700 tonnes of contaminated soil was treated this way. Some of the excavated, con-taminated soil matter was utilised in landfilling at construction sites, mainly for the base structures of parks and in landfill sites (City of Helsinki, n.d., p. 50).

The recycling of the excavated material should be commended. According to the Environmental Report 2018 by the City of Helsinki, simply by using exca-vated soil with coordination in management, the city saved EUR 4.5 million and 840,000 litres of fuel and reduced by 2,093 tonnes of CO2 emissions. When the total amount of excavated earth and rock used in the public con-struction projects in 2018 is as large as 734,800 tonnes, it is not hard to imag-ine the reduction in logistics had brought about all these economic and envi-ronmental benefits. The report also quoted that the location for the largest amount of landmasses used is the restoration site at the previous Vuosaari landfill (City of Helsinki, n.d., p. 55), which just goes to show how much poten-tial in sustainability there is in redeveloping brownfield land when implement-ed correctlv and innovativelv.

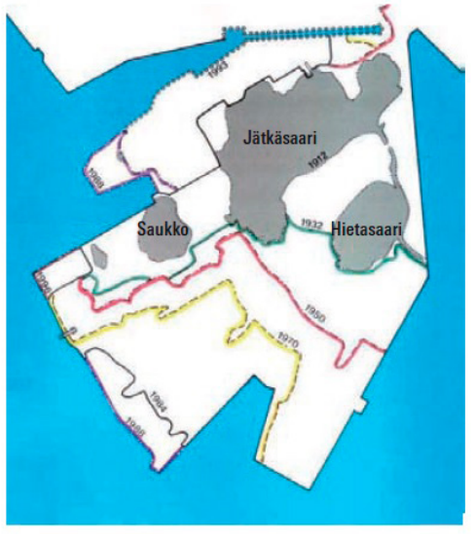

Figure 3 2- Map of Jätkäsaari (Kaupunkisuunnitteluvirasto, 2008)

REDEVELOPMENT OF JÄTKÄSAARI DUMPING SITE (HELSINKI, FINLAND)

Jätkäsaari is an Island/peninsula located in the south-west of the Helsinki city centre. It is being developed into the city centre's western extension. Jä-tkäsaari is projected to house 21,000 residents. Currently, it is already being inhabited by a small neighbourhood with its own community: schools, sports ground, a community centre, and library. The whole Jätkäsaari project is ex-pected to be completed by 2030. The redevelopment of Jätkäsaari is a suc-cessful case of brownfield redevelopment as the island was once used as a dumping site and the soil had been contaminated (City of Helsinki, Helsinki New Horizons, 2018).

SITE HISTORY

Jätkäsaari has its origin as a natural island in the 19th century. Back then Jä-tkäsaari consisted of four islands: Jätkäsaari, which was named Busholmen then, Hietasaari or Sandholmen, Uttern, or Sauko and the tiny Saukonkar. The island only hosted several permanent fishermen dwellings and some summer villas for the gentlemen of Helsinki.

In 1913, the area was constructed into a cargo harbour. All the original islands in the area were levelled and connected by reclamation for ports and industrial and storage purposes. Extensive land reclamation was carried out. The land area of Jätkäsaari expanded three times. The seabed was dredged to accom-modate large ocean-going vessels that needed deep water. This sets the ba-sis for the modern port operation. By 1928, the four islands were no longer dis-jointed, and they are was known as Jätkäsaari, which was by then connected to the mainland (City of Helsinki, Helsinki New Horizons, 2019) (City of Helsinki, New Helsinki, 2017). Today there is still reminiscence of the old uses of the island such as the western harbour area in Ruoholahti, Alko factory and warehouse buildings etc. (Kaupunkisuunnitteluvirasto, 2008).

Figure 3 3- Black hatch indicate heavily contaminated areas (Kaupunkisuunnitteluvirasto, 2008)

From 1930 to 1944, the city of Helsinki encouraged residents to bring waste for land reclamation on Jätkäsaari Island, in order to facilitate port expansion. The area was never designed to be an actual landfill site. Only non-conventional landfill materials were dumped in the area. Construction waste, spoiled vege-tables, ash and wastepaper and fill material for land reclamation were dumped here. As a result, several sites in the area are mildly contaminated (Hovi, 2013).

After a halt in development during the war, Jätkäsaari underwent reconstruc-tion in the 1950s. In the 60s the Western Harbour became the biggest harbour in Helsinki in terms of traffic. The Island saw even more expansion since the 70s. The Western Harbour traffic grew and grew until the 2000s, which saw the peak of the traffic when most operations started to move to Vuosaari. By 2008, the development of Jätkäsaari has come full circle as Jätkäsaari had been planned to become once again a residential area (City of Helsinki, New Helsinki, 2017).

Key Engineering Factors for the Redevelopment of Jätkäsaari

Given the previously mentioned history of the site, the buildability of Jätkäsaari is relatively poor over a large portion of the island. In this case, the focus will be on two main engineering challenges in the redevelopment of Jätkäsaari.

Firstly, there is the geotechnical challenge. Due to backfill and quarry em-bankments, the area was predominantly fill-land and was not suitable for building foundations. In some parts of the area, the natural soil layers and the rock surface are closer to the present surface, but the bearing soil layers are mainly deeper. A large amount of quarry has been used as the filling material. Part of the area has fine-grained soils beneath both quarry embankments and intermediate fillings. Piling as the foundation or deep compaction as soil im-provement was required (Kaupunkisuunnitteluvirasto, 2008).

The second challenge is the soil contamination problem. To ascertain the ex-tent of contamination, site investigation was carried out in 2008. Over 1,360 samples were taken from over 460 sites. The investigation concerned concen-trations of heavy metals, oil-based hydrocarbons, polycyclic aromatic hydro-carbons, and in certain locations, the presence of asbestos. The groundwater was also surveyed from 15 observation points, and sampling tubes and landfill gas were collected at 20 different points. It was concluded that the groundwa-ter was also contaminated as a result of the history of dumping (Kaupunkisuunnitteluvirasto, 2008).

Due to the way the land was reclaimed, land pollution is mainly spot-on. There were more contaminated areas along the shores of the former islands. The most extensive contaminated land is the old municipal waste dump located south of the bulk storage facility, which has also caused groundwater pollution. The waste was dumped on top of pliable layers of clay and the filling of the waste extends to a depth of 15 metres. Other contaminations include for ex-ample demolition debris from buildings. It was determined that buildings had to be provided with ventilation on the basement floor (Kaupunkisuunnitteluvirasto, 2008).

TRAFFIC

Trams are the main method of public transport on Jätkäsaari. Three tram lines were planned based on the planned number of residence and jobs in the ar-ea. The existing lines 6 and 8 were planned to be extended into the island. The Route 6 extension is called 6T and together with route 7, the lines service West Terminals T1 and T2. Besides, routes 8 and 9 connect Jätkäsaari

to Ru-oholahti and Kamppi. Most residents were planned within 300 metres of the nearest tram stop with the maximum distance being 400 metres. In addition to trams, cycling lanes were designed to be separate from the pedestrians and on both sides of the road. Bicycle, roller skates and wheelchairs, as well as strollers are allowed on the cycling lanes.

Figure 3 4- Tram and Bus on Jätkäsaari (Author)

The traffic generated by Jätkäsaari was estimated to be 30,000 vehicles per day after the island. In a simulation, it was found that Mechelininkatu, the road which connects the northeast side of Jätkäsaari to the mainland, will have double the traffic volume and that traffic from the north of Mechelininkatu was the most congested. The Crusell Bridge, which will connect the northeast of Jätkäsaari to the proposed Helsinki Central Tunnel (Helsingin keskustatun-neli), is expected to ease the congestion of Mechelininkatu (Kaupunkisuunnitteluvirasto, 2008).

SOIL REMEDIATION

To make the island suitable for redevelopment, soil remediation measures were taken in almost the whole area. To remediate land mildly polluted by metal, the surface was levelled up to the current profile by filling up and cover-ing the ground. For areas heavily contaminated with metals, which is at edge areas of the former landfill site, mass replacement and isolation were carried out (Kaupunkisuunnitteluvirasto, 2008).

For the area which was the original landfill, the amount of was-

te filling under-neath is substantial. As was mentioned previously the waste filling could be as deep as 15 metres underground. Replacing it all was deemed to be almost impossible from a civil engineering point of view. The waste area is retained and redeveloped into the sports park instead of the residential area, under which the landfill gas was allowed to continue to form and was collected. The harmful landfill water was prevented from flowing into the shore to reduce the risk of exposure (Kaupunkisuunnitteluvirasto, 2008).

THE RECONSTRUCTION

The redevelopment had a significant amount of reclamation in the existing sea area. Also, existing fine-grained soils at the site and the seabed were dredged and replaced with an aggregate that meets the quality requirements of the foundation. The ground elevation of the entire area was raised to provide the area with the required slope differences for drainage and to provide backfill for contaminated land. Ground elevation variation also increased comfort. Ap-proximately 2.0 Mm3 was dredged and about 4.5 Mm3 filled into the water area. Filling of the land area is about 1.4 Mm3 (City of Helsinki, Helsinki New Horizons, 2019) (Corporation, 2019).

The original municipal waste dump was isolated and preserved at its current location and a sports park was built on top of it. Slightly contaminated soil with inorganic materials was normally allowed under the building, with certain building restrictions. Green areas are reserved for the location of slightly con-taminated land from inorganic materials from construction activities. Contami-nated soils are insulated from green structures to prevent exposure of contam-inants in plants. The contaminated surface portions of the sediments represent about 9 % of all dredges (City of Helsinki, Helsinki New Horizons, 2019).

CURRENT STATUS AND SCHEDULE OF CONSTRUCTION

The district has begun its construction in 2010. Figure 3 5 shows the different parts of the district and their construction period. Currently, about half of the city has been built and it is estimated that the construction will complete by the end of the 2020s (City of Helsinki, Helsinki New Horizons, 2019).

It is planned that the 100-hectare district will provide 850,000 m² of housing which will house 21,000 residents. The district will be divided into 1) Jä-tkäsaarenkallio and Hietasaari, 2) Saukonpaasi, 3) Saukonlaituri, 4) Atlantinkaari, 5) Melkinlaituri and 6) Ahdinallas etc. The location of these sub-districts and their work dates can be found in Figure 3 5 (City of Helsinki, Helsinki New Horizons, 2019).

Figure 3 5- Construction periods of Jätkäsaari (City of Helsinki, Helsinki New Horizons, 2019)

HOW SUSTAINABLE IS THE REDEVELOPMENT OF BROWNFIELD SITES IN HELSINKI?

HELSINKI'S POLICY

Helsinki has done a great job in terms of sustainable development of the whole city in general. In the Helsinki City Plan 2017 published by the City of Helsinki, sustainable growth is first and foremost highlighted (City of Helsinki, Helsinki City Plan, 2017). In this plan, the concerns and rationale behind the decision of the city's planning are listed out and how residents, people who work and study in Helsinki, can participate are also explained. In addition to the City Plan, the City of Helsinki also publishes an Environmental Report eve-ry year which is where the information on brownfield redevelopment in Jä-tkäsaari and Kalasatama is featured in its own section. All these materials pre-sented are in easy-to-read forms and often infographics are used.

Besides, the city publishes interactive 3D maps of the whole city online so an-yone interested can access (See Appendix 1). All of Helsinki's urban planning maps are available online for access. It shows that not only is the city aware of the extent of the brownfield sites, but also promotes public engagement and feedback.

All these measures promote the participation of the public and make city de-velopment, including brownfield development, fall in line with social needs and public expectations and help with sustainable development. Having sus-tainability in mind during planning, also make the economic and environmen-tal savings possible as already discussed. These reasons explain to a large extent why the redevelopment of brownfield sites is a success in Helsinki.

THE PLANNING AND CONSTRUCTION OF JÄTKÄSAARI

The zoning review of Jätkäsaari has been announced as early as 2003 and the partial plan has been pinned up for public opinions in 2004. Public opin-ions were collected and summarized in the 2008 development report (Kaupunkisuunnitteluvirasto, 2008, p. 64). The collected opinion helps to un-derstand the social needs in Helsinki, which is a great measure of sustainabil-ity. With the social needs and public expectations in mind, good and timely planning was conducted. The end product is a well-functioning community, with a variety of facilities to give the residents a well-balanced life.

Figure 3 6- Model of Town in the Jätkäsaari Library and Info-centre (Author)

Another lesson to be learned from the Jätkäsaari redevelopment is that some-times the more economical way to deal with an engineering challenge is to avoid it altogether. On Jätkäsaari there are instances of contamination too dif-ficult to remove and are unsuitable for buildings, by simply building the sports ground and park on top of it the engineering challenge of removing 15 metres deep contaminated soil is avoided.

The final lesson by the Jätkäsaari is to use a mix of different land supply. The Jätkäsaari redevelopment is made up of different land types: Original Island, contaminated and reclaimed land. This ensures that the land is large enough for comprehensive planning. However, this is also the caveat of the success story of Jätkäsaari: it was unregulated dumping in the past that brought on the problem in the first place. Also, arguably one of the most controversial land supplies for Jätkäsaari: reclamation was all carried out in the 20th century. The last reclamation on the island was carried out in 1988 (Figure 3 2). Presuma-bly, reclamation projects will be harder to garner public support today due to increased awareness of environmental protection.

LIFE IN JÄTKÄSAARI

Jätkäsaari is still under construction. But residents, businesses and services have already started to move into the island. Whether the redevelopment of Jätkäsaari is a successful and sustainable development can best be evaluated by life in Jätkäsaari so far. In this section, a few aspects of life in Jätkäsaari are highlighted, namely residence, waste management, transportation and green area.

Figure 3 7- Residence in Jätkäsaari (Author)

SATISFYING RISING DEMAND FOR RESIDENCE

In the year 2018, the City of Helsinki gained 4,770 residents, and in all of Helsinki region, the population increased by 16,750. The highest increase was in Vantaa with 5,139. (City of Helsinki CITY EXECUTIVE OFFICE , 2019) The Jä-tkäsaari redevelop-ment will bring about the residence for 21,000 new resi-dents. This is larger than the annual gain in population in the whole Helsinki region. In 2018 the growth of Vantaa, and Espoo both surpasses that of Hel-sinki this might be attributed to that the housing in Helsinki is saturated and people have to live in either Vantaa or Espoo. With the new residences in Jä-tkäsaari, the growth of the Capital region can be more balanced.

WASTE MANAGEMENT

The waste collection system is a pipeline transport system called Rööri. Waste of the residents is sorted and collected in col-lection points, like the one shown in Figure 3 8. The underground pipe network transports the waste to their re-spective collection station. The waste is then transported onwards by trucks. (RÖÖ-RI, n.d.)

Figure 3 8- Waste Pipeline Rööri (Author)

The tube system reduces maintenance traffic significantly. This reduces car-bon emission by traffic and increases road sa-fety. Also, since there is no need for conventional waste bins, odours are eliminated for the better quality of life on the Island. Economically, the system requires a lower maintenance cost than conventional waste management, saving taxpayers money. (City of Helsinki, Helsinki New Horizons, 2019)

TRANSPORTATION

Jätkäsaari is accessible by trams 6T, 7, 8 and 9. Its closest metro station is Ru-oholahti and the island is connected with East Helsinki and Espoo. Apart from the public transport of trams, the traffic on Jätkäsaari relies heavily on a net-work of pedestrian and cycle paths throughout the island. Bicycle bridges and pedestri-an paths connect all the parks of the island. And the island is con-nect-ed by the cycling path called Baana to the mainland Helsinki and Töölö (City of Helsinki, Helsinki New Horizons, 2018).

Also, light traffic as a sustainable means of transportation, Jätkäsaari is a test-ing ground for intelligent traffic. New mobili-ty technologies such as smart junc-tions, smart car rides, cargo bike services (Forum Virium, 2020). These innova-tions in tran-sportation have the potential of increasing the residents' safety, improve the lives of the residents and increase the efficiency of traffic. They are also setting an example for the rest of Helsinki.

Figure 3 9- Tram 6T on Jätkäsaari (Author)

GREEN AREA AND SERVICES

The district will designate one-fifth of its total area to green area (20 hectares of land). The largest of the parks is the Hyvän-toivonpuisto or Good Hope Park, which will be the centrepiece of the whole district. The park will feature a lawn, a sports field and playgrounds for children, a waste collection station and a swim-ming hall (City of Helsinki, Helsinki New Horizons, 2019).

Figure 3 10- Park in Jätkäsaari (Author)

In addition to the facilities mentioned above, the district will also feature com-prehensive public services, such as elementary school, kindergartens and postal service. The area is also expe-cted to see an increase in commercial services. Currently, 90 % of the retail space has been leased (City of Helsinki, Helsinki New Horizons, 2019). All in all, Jätkäsaari will be a fully functional community and will seem to be a good place to live as construc-tion continues.

RECOMMENDATIONS

This sub-chapter gave an overview of some sustainable measures in the re-development of brownfield lands in Helsinki, in terms of construction and ur-ban planning. The most important recommendation urban designers can have in sustainable de-velopment is to have sustainability in mind. The government of the City of Helsinki demonstrates a good philosophy in urban de-velopment and awareness of sustainable redevelopment, which sets a good example for the governments of the world.

In the brownfield redevelopment of Jätkäsaari, planning and construction was carried out sustainably. The redevelopment of Jätkäsaari is installed with sus-tainable operations e.g. waste management and transportation. Residents live well-balanced lives with sufficient green area, local services and good pub-lic transportation. The take-away from this is that the planning should be done with the livelihood of the people who live or work there in mind. A well-balanced social life requires the services, green spaces, transportation etc. in the community.

In this subchapter, it was demonstrated that brownfield re-development can be used as a form of sustainable land supply when implemented correctly. A mix-ture of different types of lands should be used to satisfy the rising housing de-mands in cities: including virgin land, contaminated and reclaimed land. This is to ensure the new town is large enough to contain all essential functions of a well-balanced community.

However, this also comes with three caveats when trying to copy this model to other places: 1. it was unregulated dumping which made the land a brownfield land in the first place, which is in itself not a sustainable city policy; 2. reclama-tion was carried out in the 20th century, which can be more controversial as land supply today and harder to garner public support due to increa-sed awareness of environmental protection; and 3. as mentioned previously, the increase of residents in the City of Helsinki was only 4,770 residents in 2018, which is only a small fraction of its total, while other capitals see a much larger annual growth. Other cities must take these factors into account when trying to imple-ment the Helsinki model.

SUSTAINABLE URBAN WATERFRONT REGENERATION

Urban waterfront space has played an important role in urban development by being used as the location of coastal industrial complex and harbour in indus-trialization and urbanization process. However, urban regeneration of water-front has emerged as a hot topic, such as de-industrialization, population stagnation or decline, the suspension of urban expansion and the emergence of urbanization. The waterfront space is no longer a space for industrial devel-opment, but also an attractive place for the pleasant life of urban residents and has been used as a space that can improve the image of the city and econom-ic revival in aesthetic and environmental aspects. As such, the urban water-front is transformed into a hydrophilic space that performs new complex func-tions such as natural ecology, leisure and tourism. Waterfront regeneration through waterfront construction has emerged as a new means of urban regen-eration (Timur, 2013), (Smith & Garcia, 2012).

Recently, South Korean society has realized the importance of nature, signifi-cantly the value of waterfronts as citizens are experiencing psychological fa-tigue as a result of serious and rapid industrialization and urbanization chang-es. Policy projects undertaken by national and local governments in recent decades include large-scale projects related to river use and surrounding de-velopment; e.g. The Cheonggyecheon Restoration Project, and Han River Renaissance Project (Park, 2005).

Based on this background, this sub-chapter presents the principles of develop-ing a waterfront for sustainable urban regeneration. It also shows the sustain-able element of urban waterfront development and how the collaboration of waterfront developers and governance affects urban regeneration.

In the future, the selected waterfront development area will be used to estab-lish more specific ways to revitalize the utilization value of waterfront space considering the cultural, historical and geographical characteristics of the ar-ea, the desire of the residents and economic conditions.

WATERFRONT

The waterfront space in the city has the following characteristics: First, it has the characteristics of relieving the mental pressure of the residents and provid-ing physical open-ness such as granting the prospect right. Second, agricul-ture, forestry, fisheries and other service industries are relatively more active than in other regions. Third, it is a place that can exert relaxation functions such as leisure and recreation, enhances the emotion and quality of life of res-idents. Fourth, due to its simplicity, naturalness, quietness, liberation, open-ness, etc., it is a space that provides comfort to residents' lives. Fifth, land use is diverse, including water transport, fisheries, national defence, industrial lo-cation, urban development, tourism development, and has a unique culture that is open and mixed. It is also characterized by its historicity as urban de-velopment began with waterfront spaces such as rivers. As such, the water-front space in the city is rec-organized as an open and public space, a region with a natural environment that is difficult to access every day (Jeong, S. & Hwang, S., 2002).

URBAN WATERFRONT REGENERATION CASE STUDY

To clarify and analyse the urban waterfront cases selected in this subchapter, the UN-approved '10 Principles for a Sustainable Development of Urban Wa-terfront Areas' are used as an indicator of analysis (Moretti, 2008). The ten principles are reorganized into three major categories for case studies, and the characteristics of the principles are named after the points of each principle are proposed: development principles, design elements, development and governance (Jeong, G., 2011).

THE CHEONGGYECHEON RESTORATION PROJECT

Cheonggye stream runs 10.84 km long across the centre of Seoul. The water from the mountains surrounding Seoul meets Jungnang stream and flows from west to east, meets the Han River. It has served as a river in the city for hun-dreds of years, and it continues to be a waterfront space. However, in modern times (1950's), the massive refurbishment project has made the road it possi-ble for cars to run. Since then, as a centre of urban industry,

there are large and small shopping malls such as tool shops, lighting shops, shoe shops, clothing shops and bookstores on both sides of the road. The industrial devel-opment was simultaneously recognized as the biggest evil of urban develop-ment due to noise congestion and smoke. In 2003, the Cheonggye Stream, which has been covered for 40 years, was transformed into a water-flowing path by the restoration work. It is historically a continuation of restoration and development (Lee, 2006).

Figure 4 1- Transformation of the urban highway to the stream (Kim, 2015)

1) Development Principles

The most significant change in restoring Cheonggyecheon is the resto-ration of nature and ecology. The demolition of Cheonggye Highway, which covered the Cheonggye stream, improved the atmospheric envi-ronment as traffic volume entered the city decreased. As the water flowed through Cheonggye stream and winding paths along with the restored greenery and streams, the temperature dropped and the urban heat island phenomenon decreased, also fish and birds returned. It is estimated to have had a positive effect on improving the environment due to a decrease in the amount of traffic entering the city centre and the large increase in public transportation (Lee, 2006).

2) Design Elements

The water path of Cheonggyecheon contains the history and image of the city and the future. It consists of vegetation community, shelter, step-ping bridge, shoals, and nature study ground everywhere around the stream. It has become a cultural and leisure space of citizens who use urban rivers such as a wall of hopes drawn by 20,000 citizens, a fashion show and

concerts where citizens can participate. Also, the Seoul Lan-tern Festival which is sponsored by each overseas tourism agency is held every November in the Plaza and Cheonggye stream. On a limited level, restoring the traces of Cheonggyecheon's history makes it easier to experience and remember 600 years of Seoul (Lee, 2006).

3) Development and Governance

The Cheonggyecheon Restoration Project Headquarters began in 2002 and has been steadily strengthened by the Seoul Metropolitan Gov-ernment to reinforce the role of the headquarters of the project and so-lidify the role system of governance. The CRP Headquarters tried to maintain smooth parliamentary relations by enacting ordinances for the establishment of the Citizens' Committee and securing budgets. The Citizens' Committee consisted of about 30 citizen representatives from all walks of life, served as a deliberation and decision-making body. The CRP Support Research Group, a temporary organization, was or-ganized to provide basic data and ideas and to conduct research by holding various debates; seminars, international symposiums, etc. (Lee, 2006).

The City, Seoul, has succeeded in regenerating the waterfront space towards an ecological habitat by expanding 24-hour monitoring facilities and the rivers that were restored to improve water quality. When water quality is improved through the restoration of waterfront and the waterfront ecosystem is restored and citizens find the waterfront space, the ecological preservation zone, expe-rience facilities, culture and complex facilities that support the activities of the citizens are eco-friendly and the waterfront space is activated and promoted. The increase of vitality and the increase of the use population lead to the revi-talization of the shopping districts around the waterfront space, which pro-motes the reconstruction, remodelling and re-use of the surrounding re-siden-tial areas, thereby creating a virtuous cycle of urban regeneration (Lee, 2006).

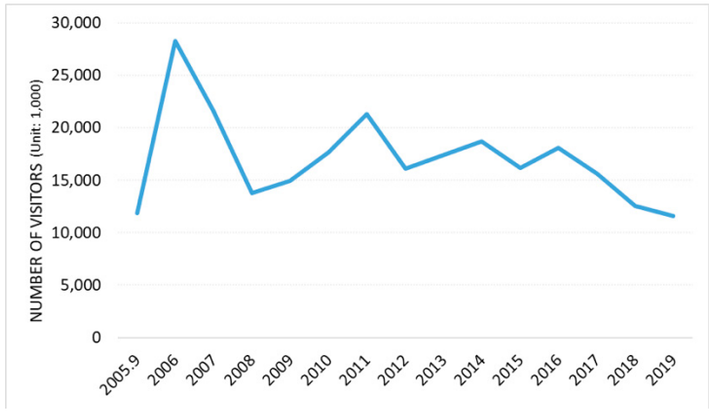

Figure 4 2- Number of Visitors since the sustainable development (Seoul City, 2019)

HAN RIVER RENAISSANCE PROJECT

The Han River is the fourth-longest river in South Korea. According to the Han River Renaissance project, the Han River in Seoul occupies a total area of 41.5 km and 40 km² from east to west. The width is from 600 to 1,200 metres. The Han River played a pivotal role in politics, economy, society and culture for more than 600 years in the capital city, Seoul (Jeong, S. & Hwang, S., 2002).

1) Development Principles

To activate water use and prevent water pollution accidents, monitoring is conducted and immediate response to changes in water quality. Dis-aster prevention precaution and rapid disaster recovery systems were established to change into a healthy river where life lives. The concrete non-environmental spaces and retaining walls, which hinder the Han River's waterside space, were converted to green lakes by up to 87 %, transforming them into green spaces (Seoul city, 2015).

Figure 4 3- Environmental changes from the concrete riverside to green spaces

a) → b) (Seoul city, 2015, p.49).

2) Design Elements

Factors that reduce access to the Han River's waterfront include roads, embankments, power plants, military facility protected areas and indus-trial areas. As a result, a free bicycle service system operated by the pri-vate sector was introduced, the pedestrian path was extended by short-ening the road of the Han River Bridge and the public transportation linkage system was used. A bus platform was installed on the bridge and a pedestrian bridge connected directly to the waterfront. Besides, the pedestrian walkway was installed on the Jamsu Bridge to provide the South-North side connection function, improve access to the citi-zens' park entrance, and experience the unique waterfront by walking across the Han River (Seoul city, 2015).

Seasonal and thematic festivals are operating to reinforce the percep-tion of the Han River, which is unique and full of fun. The festival sched-ule is fixed early and attracts seasonal visitors through advance publici-ty. Improvement and maintenance of convenience facilities such as eco-logical experience hall, education centre, library, camping ground, wa-ter playground, rafting and canoeing are being done. Performances, exhibitions and participation programs provide citizens with a variety of cultural enjoyments and opportunities (Seoul city, 2015).

3) Development and Governance

The Seoul Han River Renaissance Headquarters is in charge of project management, including budget planning and operated a Citizens Committee, including 26 related experts, carried out several projects in-cluding collecting opinions from city councils and related organizations, civic groups briefing session, discus-

sion and public relations for for-eigners (Seoul city, 2015).

FOUR RIVERS RESTORATION PROJECT

The Four Rivers Restoration Project refers to the four major rivers (Han River, Nakdong River, Geum River, Yeongsan River), Sumjin River Mainstream and major tributary rivers. Nakdong River is the place where most of these projects are made. The Nakdong River flows into the South Sea through the Yeong-nam region and is 521.5 km long and covers an area of 23,817 km². Originat-ing from Hambaeksan, Gangwon Province, the upper stream merges with var-ious tributaries around Andong and flows westward. The Four Rivers Restora-tion Project was conducted from 2009 to 2012 with a total budget of EUR 1.68 billion (Four Rivers Project Investigation and Evaluation Committee, 2014).

1) Development Principles

To prevent flooding and drought, the installation and construction of 570 million cubic metres of dredging, 16 mini-sized dams, 5 dams and 87 agricultural reservoirs in four rivers were carried out. In particular, dredging construction is less effective than planned, with a reduction of 130 million cubic metres compared to the existing plan, but survey re-sults show that the flood risk is solved or reduced in more than 90 % of the areas (Park, 2010).

However, the criteria and process for selecting the location of the river to resolve the water shortage could not be confirmed. In the Nakdong River area, there was a discrepancy between the water shortage area and the available water supply area secured by the Four Rivers Resto-ration Project (Park, 2010).

2) Design Elements

The Four Rivers Restoration Project was promoted as part of the project to create a new leisure space by utilizing rivers in connection with the main project. There are not enough outdoor leisure spaces available in South Korea, and the resources available are limited. Therefore, on the positive side, the creation of bicycle paths, waterside parks, sports facili-ties, riverside camping grounds and narratives newly created in the wa-terfront space by the Four Rivers Restoration Project will contribute to improving the quality of life for the people (Four Rivers Project Investi-gation and Evaluation Committee, 2014).

Due to the tight progress of the Four Rivers Restoration Project, there was a problem that the preliminary surveys were omitted or did not go through necessary procedures. This resulted in damage to 33 conser-vation areas (Four Rivers Project Investigation and Evaluation Commit-tee, 2014).

3) Development and Governance

The Ministry of Land, Transport and Maritime Affairs is mainly responsi-ble for revitalizing the Four Rivers and the public and private sectors have cooperated with the national agencies and local governments to increase the bidding points of local businesses; it consists of turnkey 20 % and general 40 %. However, the project has continuously received criticism and suspicions from opposition parties, civil society groups and the media even in the initial phase of implementation, content and ap-propriateness and is still ongoing (Four Rivers Project Investigation and Evaluation Committee, 2014).

RECOMMENDATIONS

In the ten principles adopted as the basis for comparative analysis, there have been cases where these principles have generally been well-established, while others have not been realized to the extent that they are somewhat insuf-ficient or struggled. Therefore, while paying attention to the ten principles for successful waterfront creation, the implications and practical lessons are drawn for Korea's waterfront in pursuit of urban and cultural regeneration through waterfront regeneration (Moretti, 2008).

- Speaking of hydrophilic space, it is no exaggeration to say that water quality and the environment are preconditions. All members of the ur-ban community should strive to uphold the principles of protection of the water environment for a long time.
- There are problems with laws and institutions related to waterfront redevelopment. To succeed in sustainable urban development, the current waterfront development process and operating system need to be improved.
- The main user of the waterfront is, after all, a citizen. Attracting people can work when the well-conserved natural and environmental elements are combined. Taking advantage of the long history of marine culture and the identity of the region, conti-

nuous spaces should be formed in connection with the city centre, and accessibility should be guaranteed for anyone to come and go.

- Finally, strong leadership in administration is needed early in the de-velopment of the waterfront. Each relevant department should build a cross-organized organization that works organically, derive a coopera-tive system between local governments and governments and pay at-tention to the promotion of international exchange.

This subchapter reviews the cases of urban and cultural regeneration through the development of waterfront spaces in South Korean cities by applying the ten principles for the development of sustainable waterfront approved by the United Nations and to derive implications and lessons with cause analysis.

The significance is that the evaluation was attempted by applying internation-ally approved indicators or criteria for the analysis and evaluation of real cas-es. Using the ten principles as the basis for comparative analysis, it was pos-sible to objectively evaluate and compare the cases and to prove the validity. The Ten Principles reflect aspects of social and environmental regeneration, but it was difficult to assess economic regeneration as one of the important aspects of urban regeneration.

SOLAR POWER AND WIND FOR SUSTAINABILITY

Since all eyes are turning now towards sustainability so it is required that peo-ple become aware of the importance of using clean energy sources in enhanc-ing the sustainability concept. The topic is also directly linked to the UN sus-tainable development goals, SDG 7 which refers to Affordable and Clean En-ergy. Being in line with the UN SDGs certainly adds value to this paper and also increases awareness regarding the clean energy sector.

This sub-chapter discusses recommendations for future projects in Egypt re-garding sustainable operations. Besides challenges will be mentioned, which need to be dealt with in an early stage concerning future projects in Egypt. This sub-chapter shows also if Egypt can hold an offshore wind project.

Also, the current situation in Europe will be highlighted regarding the recent developments and challenges facing the sustainable growth in the energy sector.

BACKGROUND

Sustainable Energy is an approach to energy aimed to serve the demand of today's people taking into consideration the future and the demands of people living at that time. All renewable energy sources like solar, wind, geothermal, hydro and tidal (Solar and Wind will be the area of focus in this sub-chapter) power are forms of sustainable energy. These sources have been existing for centuries and will keep existing as long as life on Earth is still possible.

For a country with Egypt's profile and specifically speaking about its size, pop-ulation and geographic location, it's important to monitor Egypt's progress to-wards sustainability with its three well-known aspects: Environment, Economy and Society. Focusing on the Environmental aspect, one can note that Egypt possesses hot sunny weather, high-speed winds and an extremely large piece of land thus making it a prime location for seven renewable energy resources. Therefore, Egypt must be dedicated to the widely spreading deployment of renewable energy technologies (Egypt Today Staff, 2019), (US Embassies abroad, 2019).

According to a report done in 2018 by the International Renewable Energy Agency (IRENA), Egypt has a total installed capacity of 3.7 gigawatts (GW) of renewables. Hydropower is included with 2.8 GW and Solar and Wind power amounted to 0.9 GW. As clarified in the ISES to 2035, the Egyptian govern-ment has set renewable energy targets of 20 % of the electricity mix by 2022 and 42 % by 2035 (Ennerray, 2018).

The latest projects relating to sustainable energy in Egypt will be shown in this subchapter. For solar power, Benban Solar Park was the case, while for the wind projects it was Gabal el Zeit wind farm. Those projects were studied in terms of four main headings: construction, effectiveness, maintenance and se-curity and finally the challenges faced by those projects. Moreover, the two cases were also compared to some global cases represented by the Moroc-can Noor Ouarzazate Complex and Hornsea One

project in the United King-dom.

Offshore wind could be an option for Egypt to upgrade its renewable energy capacity to meet its 2020 targets. Considering its outstanding location between the Red Sea and the Mediterranean Sea, Egypt is considered to be a candi-date to host an offshore project. In addition to its great need for renewable energy and the availability of wind data by which Egypt is the only country having a detailed wind atlas in the Middle East. (Mahdi & Bahaj, 2018).

SUSTAINABLE PROJECTS

SOLAR POWER PROJECTS

BENBAN SOLAR PARK – EGYPT

Egypt is now hosting a massive construction site which is soon to be the larg-est solar installation worldwide. Benban Solar Park is the name of the project which is mainly a PV (Photovoltaic) power station with a total planned capacity of 1.8 GW. The project will be located in the eastern region of the Sahara de-sert, Aswan, Egypt. (Nordrum, 2019).

Starting with an overview, the Park involves the construction and operation of 41 individual PV (Photovoltaic) panels which are generating electricity. The panels are located about 37.2 km² near the village of Benban in Aswan Gov-ernorate in Upper Egypt. Limited Infrastructure was also provided by the NREA. Starting with two access roads connecting the site to the nearest high-way and another road network on the Benban site itself.

Moreover, four states of the art electricity power stations were constructed to which the individual panels are to be connected. After their construction, sta-tions will be connected to a 220 kV High Voltage Overhead Line which is close to the site, approximately 12 km away. Also connecting to a near 500 kV line is a possibility in the future (New and Renewable Energy Authority, 2016).

NOOR COMPLEX – MOROCCO

Located in Ouarzazate, Morocco. The Noor-Ouarzazate complex is set to power a city of the size of Prague, Czech Republic or even twice the city size of Marrakesh. Morocco's aim of 42 % of its power to come from renewable sources (solar and wind) is not a dream anymore as its share now is 35 % and that's due to the complex.

The construction section was divided into three main phases, Phase I: (Noor Ouarzazate I) which involved the development of a 160 MW concentrated par-abolic trough solar thermal power plant (CSP) as well as the development of infrastructure that will be used among all project phases. Infrastructure in-cludes access roads, water and electricity supply, fence wall, telecommunica-tions, security. Thanks to the use of molten salt, the CSP power plant included also a thermal energy storage system that makes sure that at full capacity the operations continue for three hours without solar radiation (African Develop-ment Bank, 2012).

Phase II: (Noor Ouarzazate II) which was about the construction of two concen-trated solar thermal power plants with 350 MW total capacity, in which the power plants consisted of the CSP technology as well as the use of a Solar Tower. Phase III: (Noor Ouarzazate III) final phase of the complex consisted of a 70 MW photovoltaic (PV) power plant (African Development Bank, 2012).

WIND POWER PROJECTS

GABAL EL ZEIT WIND FARM – EGYPT

Gulf of Zeit is considered to be the largest wind complex in MENA (the Middle East and North Africa) region with 580 MW of installed capacity in total and about 3 TWh (Terawatt hour) in three years' production. Construction was di-vided into three phases, named Gulf of Zeit 1 (capacity of 240 MW), Gulf of Zeit 2 (capacity of 220 MW) and Gulf of Zeit 3 (capacity of 120 MW) (United Nations Partnerships for SDGs platform, n.d.).

A study was conducted regarding the Gulf of Zeit area in 2007.

This study di-vided the area into three zones. A red zone ranging almost 656 km² but due to bird migration activity, it is banned to set any wind turbines in that area. Then a yellow zone where the existing studies are not enough to decide on a project and more studies need to be conducted. The third zone is a green zone and this is where the wind farm was implemented generating 580 MW (United Na-tions Partnerships for SDGs platform, n.d.).

HORNSEA 1 PROJECT – UNITED KINGDOM

120 km away from Yorkshire coast, England. Upon its comple-tion in 2020, Hornsea One will be able to provide over one mil-lion UK homes with clean electricity. The project is claimed to be spanning an area greater than the Mal-dives or even Malta. Moreover, it's into the sea more than any other offshore wind farm. It's also claimed that the nine blades of the wind turbines of the Hornsea One cover a greater area than the London Eye observation wheel as they turn (Ziady, 2019).

Hornsea Project One extends to an area of 407 km² along with having 174 Siemens wind turbines with a capacity of 7 MW each. The world's longest high-voltage AC (Alternating Current) offshore wind export cable system is fea-tured in this wind farm including more than 900 km of cables. The shore and the natio-nal grid will enjoy the generated electricity transferred by these ca-bles. Depths of 20 metres to 40 metres were considered to be the selected depths for the project's execution (Power Tech, n.d.).

DISCUSSION

Solar projects appeared to be promising and that was shown in the great po-tential presented in Benban Solar Park as well as Noor Ouarzazate Solar Complex. Results showed the Benban Park will have a production capacity of almost 2000 MW aiding the Egyptian target of achieving 20 % of its energy mix through renewable energy as well as increasing this percentage to 42 % by 2030. Moreover, the Noor Ouarzazate complex is set to aid Morocco's targets with a production capacity of 580 MW in total. The complex will also aim to re-duce Morocco's dependence on imported energy or fossil fuels.

Projects also had some common challenges that need to be focused on:

1- Both projects did not have a proper water supply at the beginning of the construction processes

2- High risk of car accidents on the main roads leading to the site

Even though there were common factors between both proje-cts, there were also some differences regarding the construction techniques and the ways to make use of solar energy. These dif-ferences have made some impacts also on the costs of the pro-jects. Benban Park depended on the PV technology while CSP was the technology used in the complex Nour.

CSP appeared to be more expensive than PV but also more beneficial; be-cause simply CSP can work at day time as well as at night while PV can only work in the daytime. Also that CSP allows for Alternating current which is trans-ferred directly to the grid while PV produces Direct Current that needs to be changed to Alternating current at first.

However, the Noor Solar complex using mixed technologies seem to be a new promising technique by using PV and CSP technologies, the disadvantages of each technology will be mi-tigated as well as having combined advantages thanks to this hybrid solution. Lower cost planning results were the main im-pact of this solution as PV provides affordable production while the CSP opti-mizes the output by extending the thermal storage. The Phases in the complex were:

Phase I: Concentrated Solar Power (CSP) (510 MW)
Phase II: CSP and Solar Towers (350 MW)
Phase III: PV (70 MW)

Thus, the Hybrid solution proved a larger capacity than using PV technology only as well as proving much-reduced costs than implementing CPS technol-ogy on its own (African Development Bank, 2012).

Though being costly, the wind farm cases in this paper were crucial to mention as Hornsea One project is set to be the largest

offshore wind farm in the world with a capacity of 1,200 MW while Gabal el Zeit farm is considered to be the largest onshore wind farm in the world with a total installed capacity of 518 MW.

Both projects contribute greatly to their respective country's targets by which Hornsea One project will be capable of helping the United Kingdom achieve its target of having the offshore wind contributing to the electricity generation with one third by 2030. Gabal El Zeit will assist Egypt in achieving its renewa-ble energy targets as apart from the energy mix for 2020 and 2030.

The most important aspect regarding those projects is that they faced the same challenge during construction and operational phases. This challenge was represented by the concerns over bird's migration. Both projects encountered the same challenge but adding also the fish migration problem to the Hornsea One project and also a more difficult challenge for el Zeit farm since its location is vital for migrating birds.

El Zeit farm managed to develop its second approach of the "shut down in de-mand" system which turned to be very effective. The approach was simply an Asystem composed of 212 km distance radars, to advance the process of bird detection. Those radars were connected to a control room where the operator stops immediately once data about which turbines to be stopped for bird mi-gration is available.

OFFSHORE DEVELOPMENTS IN EGYPT

Offshore wind could be an option for Egypt to upgrade its renewable energy capacity to meet its 2020 targets. Considering its outstanding location between the Red Sea and the Mediterranean Sea, Egypt is considered to be a candi-date to host an offshore project. In addition to its great need for renewable energy and the availability of wind data by which Egypt is the only country having a detailed wind atlas in the Middle East. (Mahdi & Bahaj, 2018).

At the height of 50 metres, the Red Sea area set to be the best wind resource, producing a mean power density ranging between 300 & 800 W/m² as shown in the following Figure 5 5. Producing almost 33 GW of wind power, three suit-able areas were located

within the red sea for wind projects. These areas were also of minimum restrictions. Furthermore, the Mediterranean Sea was also investigated and wind potential was found there with a possibility of 13 GW being produced (Mahdi & Bahaj, 2018)

Offshore wind development is worthy although being almost 150 % more cost-ly than to install an onshore project. However, the quality of the resources is greater as well as the availability of areas to develop these projects in compar-ison to the onshore ones. Economic developments to Egypt will be allowed through offshore investments and also pressure on land areas will be de-creased due to being of more importance in commercial uses and tourism. Even though offshore wind provides all of these benefits, there's no general assessment approach to these types of wind projects (Mahdi & Bahaj, 2018).

SITUATION IN EUROPE

FRANCISCO PIZZARO PLANT – SPAIN

Iberdrola, which is the electric utility based in Spain, has announced that plans have already started for building a 590 MW solar project which, is set to be Europe's largest solar PV project upon its completion. The solar plant costing almost EUR 300 million is part of the company's broader renewables strategy. Iberdrola is currently responsible for over 2GW of renewables under construc-tion and processing in Spain (Iberdrola,2020).

Once operational in 2021, almost 375,000 people will be supplied with enough clean energy per year. The mentioned population is greater than the populations of the cities of Cáceres and Badajoz. An area of 1,300 hectares will be occupied by the new construction. During its construction, 1,000 people will be employed. The emission of 245,000 tonnes of CO2 into the atmosphere will be prevented per year (Iberdrola,2020).

WIND SITUATION IN GERMANY

In Germany, unexpected headwinds are facing wind farms and their develop-ment. Lack of complete studies regarding infrasound emissions from wind tur-bines resulting in health ha-

zards with no proper solutions. Also, there is no clue on how to store excess electricity.

The situation is not so good, for example, a lawsuit has been launched against the plan of having new installations too close to Falkenrehde village. There is a claim that the new installations situated only 600 metres from the village thus too close, and that the red kite raptors in the area would be threatened by the turbines (Hessler,2019).

A dramatic decline in the number of onshore wind developments was a result of the legal actions against most of the new projects that multiplied in recent years. According to the German wind energy industry federation BWE, 10 months was the maximum period for new projects to be licensed. But that was until a few years ago, as now the licensing process can take more than two years. That is because legal disputes are holding up the new developments. Having a new development too close to residential areas is something that local pressure groups in Germany will never accept (Christopharo,2019).

VORTEX BLADELESS – SPAIN

Rising in Spain, Vortex Bladeless is a creative approach to harness energy from wind, with various and exciting characteristics making it a revolution in wind power generation. Though being still under development, this initiative considered to be promising in the upcoming years (Vortex,2018).

This technology consists of a vertically fixed cylinder with an elastic rod. De-pending on the wind range, the cylinder oscillates therefore electricity is gen-erated through an alternator system. In other words, it is a hypothetical wind turbine. Vortex innovations will allow great benefits such as efficient clean power, lower costs, no harm to wildlife and finally integration between energy systems (Vortex, 2018).

RECOMMENDATIONS

Solar and Wind power are forms of Sustainable energy that takes the future and demands of future generations into consideration. Adding to the im-portance of the topic globally, sustainable

energy is considered to be a part of the UN's sustainable development goals (SDGs) presented in goal number 7: Affordable and Clean Energy.

Egypt is targeting using renewable energy contributions to achieve its 2020 and 2030 targets of an increased percentage of renewable sustainable energy in its energy mix. All these advances in Egypt can be put under the name of MEGA "Make Egypt Great Again" which is the biggest development campaign in Egypt.

Offshore wind developments should be part of Egypt's future otherwise it would be very challenging to achieve the energy targets. The offshore potential is high in Egypt, not a gift to every country to be located between two seas which could be used for developments. The Red Sea seems to be more prom-ising since it possesses more favourable conditions.

There are various rising developments in both sectors (Solar and Wind) in Europe. Spain is having a great share of these developments as the Francisco Pizzaro Plant looks promising and is set to be the largest in Europe. Also, Spain possesses this booming technology of Vortex Startup. If implemented quickly, it will totally change the windfarms future and will have a global suc-cess. Legal disputes in Germany should be resolved in a short period as the situation is affecting the country's renewable energy targets as well holding some great developments up.

Following are some recommendations for both types of developments to over-come the current challenges:

A. FOR SOLAR PROJECTS:

1. Water and electric supply sources should be carefully planned before construction. Active actions should be taken.
2. Roads leading to the site should be inspected before construction and its ability to withstand the varying loads due to heavy traffic. Training to drivers should be also included to avoid the high risk of accidents.
3. An effective waste management system should be established in an early stage especially in large scale projects.

4. Decisions on technology to be used should be carefully considered, comparing to international projects of the same scale is crucial. The hybrid solution provided in Noor Complex should be studied further to check its impact if it is to be applied in Egypt.
5. Professional site security should be present in the preparation stages of the construction to take care of the expensive equipment used. Site fencing should be put into consideration as well.

B. FOR WIND PROJECTS

1. “The shutdown system” for future projects should be an active ap-proach, not a passive one to prevent loss of production.
2. Staff should be trained and awareness should be increased towards such developed systems,
3. Hornsea Project should be carefully studied regarding its construction, operation and maintenance approaches and taken as a reference in fu-ture developments in Egypt.
4. There is a rising technology in Spain of bladeless wind turbines that gets energy through oscillations. The technology should be investigated more and could be a huge advance for Egypt’s future.

5 Plastic Waste Management

Plastic waste and its influence on the environment and people is a highly discussed topic all over the world. The Worldwide Wildlife Fund (WWF) already said: “The extent of the worldwide plastic flood can no longer be overlooked’” (Worldwide Wildlife Fund, 2019).

Not only the oceans are affected by plastic waste but also our landscapes, people and air. The slow decomposition of plastic is the most urgent issue. Microplastic – the product of the slow decomposition of plastic - is changing the entire biosphere of our planet (Worldwide Wildlife Fund, 2019).

Plastics, which are mainly made of petroleum with some additives, grew up as a popular product for different kind of uses such as food packaging, toys, con-struction tools, and paints and varnishes, etc. Because plastic is cheap, light, break-resistant,

elastic, durable, and can be manufactured in various degrees of shapes, it is impossible to imagine life without it since almost 70 years (Worldwide Wildlife Fund Junior webpage, 2019).

But regarding the massive destroying of our nature with negative conse-quences for biodiversity and possibly human health (European Commission, Directorate-General for Environment, 2018), it is important to find other alterna-tives, to reduce plastic production and to find a way of behaving sustainably regarding its use.

While many countries around the world, especially developing countries like India, have not yet tackled the issue at its root, European Union (EU) countries have started to determine plastics as a global problem many years ago. There-fore they started to find solutions to reduce plastic in many different ways. In this regard, first measures have been taken like the ban of single-use plastic as of the year 2021 (Federation of German consumer organizations, 2018).

Germany and Sweden are one of the EU countries, which tried early to involve programs for reducing plastic waste. They are still trying to improve their sys-tems.

This sub-chapter is focussed on the general prevention of plastic waste. At first, it shows an overview of how much plastic is produced and used world-wide, in India and Germany. Afterwards, it explains integrated solid waste management in general and identifies the different necessary starting points. Therefore there are also key-learnings listed. These key-learnings are actions, which Germany and Sweden installed to reduce plastic production and waste. In this case, it will become clear that Sweden is a pioneer in the sustainable handling of plastic waste.

PLASTICS WORLDWIDE: PRODUCTION AND CONSUMPTION

Plastic has a negative impact on the landscapes, wildlife health and especially the oceans because of its enormous pollution.

Since the 1950s the whole world is producing increasingly plastic. While in 1950 the world just produced 1.5 million tonnes

of plastic per year, it has increased to about 359 million tonnes of plastic per year in 2018. From 2012 to 2018 alone, plastic production increased by approximately 25 % (Garside, 2019).

This huge increase since the last 70 years is also shown by the following Figure 6 1:

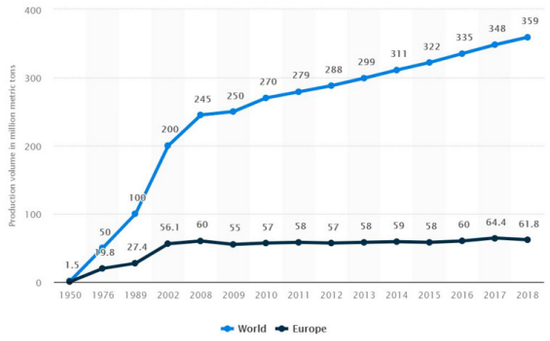

Figure 6 1- Global Plastics Production (Garside, 2019)

With the current point of view, the plastic production is expected to triple by 2050 (MacArthur, D. E., Waughray D., and Stuchtey, M. R. 2016), if no precautions are taken by then. This is confirmed, for example, by the further rise in plastic production from 2017 to 2018 with an increase of approximately eleven million tonnes of plastic (PlasticsEurope – Der Verband der Kunstof-ferzeuger, 2019, p.14).

It is also interesting to know how much plastic is produced by every continent. As you can see in Figure 6 2 the highest distribution of global plastics production is in Asia with 51 %, followed by the North American Free Trade Agreement (NAFTA, which included the USA, Canada, and Mexico) with 18 % and in third place Europe with 17 % (PlasticsEurope – Der Verband der Kun-stofferzeuger, 2019, p.15).

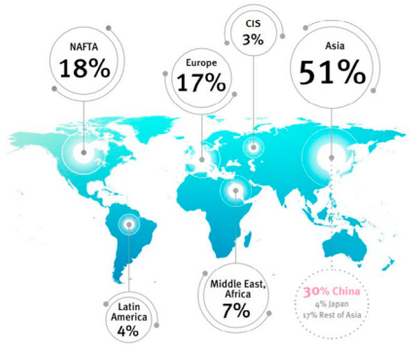

Figure 6 2- Global plastics production, 2018 (PlasticsEurope – Der Verband der Kunstoffer-zeuger, 2019, p.15)

Europe produced 61.8 million tonnes of plastics in the year 2018 but was one of the continents who succeed to reduce plastics production. From 2017 with an amount of 64.4 million tonnes of plastics to 2018 the production decreased by 2.6 million tonnes of plastics, which is a percentage of around 4 % (PlasticsEurope – Der Verband der Kunstofferzeuger, 2019, p.14).

For having the main source of plastic it is necessary to know which industrial sectors are producing most of the primary plastic and which are generating the most plastic waste in the world. The two figures, Figure 6 3 and Figure 6 4 show that in both in production and waste the Packaging industry is in the first place.

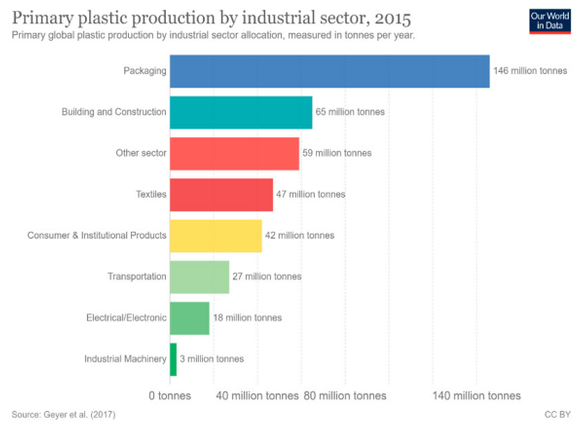

Figure 6 3- Primary plastic production by industrial sector, 2015 (Ritchie and Roser, 2018)

With circa 146 million tonnes of plastic in 2015, the Packaging industry pro-duced more than double plastic than the Building and Construction industry. That is all in all 42 % of the whole primary plastic production by industrial sec-tors regarding the year 2015 (Ritchie and Roser, 2018).

Not only that the packaging industry is the main producer of primary plastic, but it is, in addition, the biggest plastic waste generator in the world regarding industrial sectors as shown in Figure 6 4. While plastic use has a mean life of around 35 years in the Building and Construction industry, the Packaging in-dustry has just a very short ‘use lifetime’ of maximum six months. That is the reason why circa three-quarters of produced primary plastic ended up as waste (Ritchie and Roser, 2018).

Consequently, Figure 6 3 and Figure 6 4 illustrate the dramatic impact of the Packaging industry concerning the massive plastic pollution worldwide.

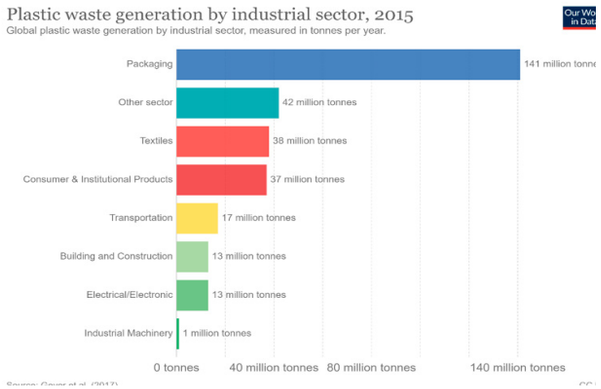

Figure 6 4- Plastic waste generation by industrial sector, 2015 (Ritchie and Roser, 2018)

THE SITUATION IN INDIA

According to figures from the 2012 Central Pollution Control Board, India produces nearly 26,000 tonnes of plastic every day.

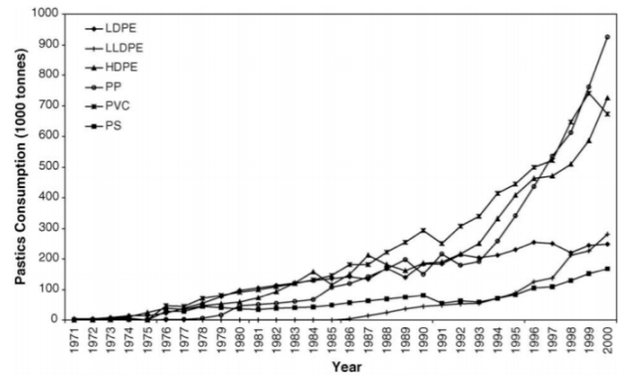

Figure 6 5- Average Expansion Ratio of Virgin Plastics Utilization in India (Dr. R. K. Sri-vastava)

Also, plastic waste remains uncollected a little over 10,000 tonnes a day. Low-density polyethene (LDPE) shows the highest consumption growth in India, closely followed by high-density polyethene (HDPE) and polypropylene (PP) (Figure 6 5) among various types of plastic polymer. Polyethene (PE), PP and polyvinyl chloride (PVC) also contribute significantly to the polymer industry in India, primarily because of their low cost and durability. The commodity plastics, on average, viz. PE, PP, PVC, and polystyrene (PS) make up 80 % of India's total plastic consumption (Figure 6 6) (Tirthankar Banerjee, 2014).

Compared to more developed countries, per capita consumption in India is still low. Indians consume 11 kg of plastic per year compared to an average American of 109 kg, according to the Federation of Indian Chambers of Commerce and Industry (FICCI). But it is predicted that this figure will increase in the coming years.

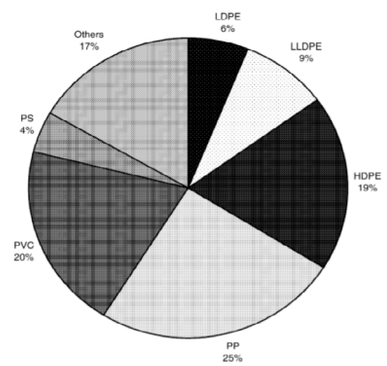

Figure 6 6- Consumption of Different Virgin Plastic Resins

in India (CPMA, 2000)

The packaging is India's largest single plastics sector. In almost half of all packaged goods, the segment accounts for 42 % of plastics consumption and plastics are the material of choice (SGCCI, 2000). In supplement to packaging, plastics are also broadly utilized in customer commodities which include household items, which account for 24 % of plastic consumption. The construction and construction sector, as well as the industrial sector, make up almost 14 % of India's total plastic supply (Figure 6 7).

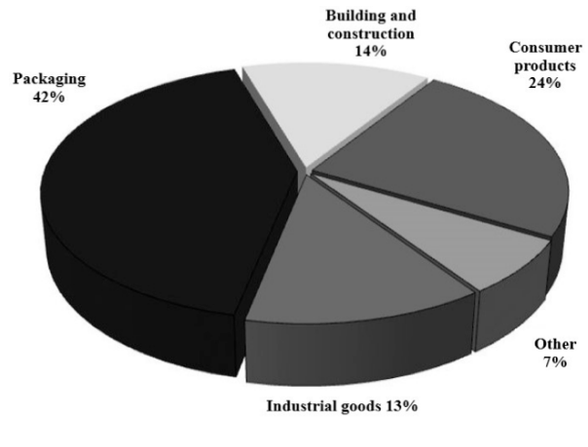

Figure 6 7- Percentage of Plastic Utilization in India by Various Market Division (SGCCI, 2000)

In India, mainly due to its minimal price, chemical structure, physical benefits, and excessive endurance, polyethene, polypropylene, and polyvinyl chloride dictate the market. Polyolefins make up 60 % of India's overall plastic intake (Mutha, 2006).

India produces 9.46 million tonnes of plastic waste yearly, 40 % of which remain uncollected and 43 % of which are used for packaging, most of which are single-use, a new study has reported. Un-Plastic Collective (UPC), a joint multi-stakeholder group, conducted the study to eliminate plastic pollution in nature and push towards a circular economy (News18, 2019). The enormous network of uncertified plastic bag production systems and the insensitivity of municipal waste management are two main reasons why India produces so much plastic waste (Academy, 2016).

Shortage of biodegradability of industrial polymers, especially

utilized in packaging, industry, and farming, focusing public interest on a possibly colossal ecological growth and litter crisis that may possibly go on for eras. Plastic waste clearance can have destructive impacts on the environment and, for this reason, rational approaches should be to regain full energy to maintain ecological sustainability. Integrated Solid Waste Management (ISWM) is the idea to make decisions on waste generation, product reprocessing, and subsequent waste carding.

THE SITUATION IN GERMANY

Germany is popular in the world for its good recycling system and its good handling with plastics. But all in all, Germany is still producing and wasting too much plastic. While this country produced around 14 million tonnes of plastics in 2016, it also consumed the highest amount of plastic packaging waste with about 3.1 million tonnes in the whole EU (6.1 million tonnes plastic waste at all) (Fuhr, Dr. Buschmann and Freund, 2019; European Parliament, 2018; NABU – Naturschutzbund Deutschland e.V., 2018). The amount of plastic packaging waste is also shown in the following Figure 6 8:

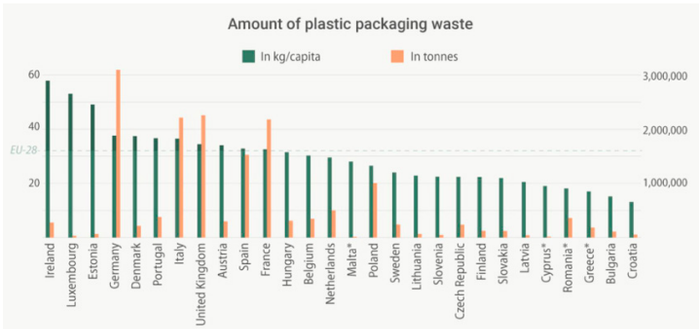

Figure 6 8- Amount of plastic packaging waste in the EU, 2016 (European Parliament, 2018)

Regarding the amount of plastic packaging waste in kg/capita the Germans are (comparing to the whole EU) behind Ireland (~58), Luxembourg (~52) and Estonia (~49) on the fourth place with around 38 kg/capita/year (European Parliament, 2018).

One frightening reason why Germany is producing and was-

ting so much packaging plastic is that 63 % of fresh fruits and vegetables in German super-markets and grocery stores are already packed in plastic. In addition to that, German clients are packing about 34 % of their loose fruits and vegetables in gratis one-way plastic bags. This alone leads to a consumption of around 93 thousand (K) tonnes of plastic packaging per year (Baumermann and Kuchlmayr, 2019).

Besides, annually two billion plastic bags are consumed in Germany, which is around 24 plastic bags per german per year (in the year 2018).

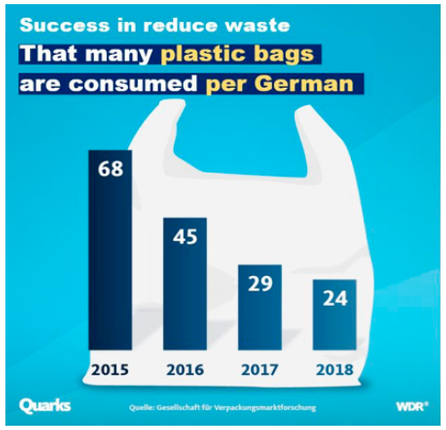

Figure 6 9 – Consumption of plastic bags in Germany, 2015 – 2018 (Ewert, 2019)

Even if the number of consumed plastic bags per capita decreased from 68 to 24 (almost 83 %) in the last four years, it is not necessary to use them in that high amount. The average useful life of one plastic bag is 25 minutes – it causes much more waste and pollutes the environment relative to its use (Deutsche Umwelthilfe e.V., 2015). But all in all, Figure 6 9 shows a positive trend in the right direction.

The main waste which is caused by plastic in Germany is the one with a short useful life – especially plastic packaging. Thus the packaging sector is the main plastic waste producer in Germany like in the whole EU. As a result, the problem of how to dispose of this high amount of plastic sustainably has aris-en.

This, in turn, leads to recycling systems, which are necessary

for disposing of plastic waste and use them in a new way. Germany has got implemented sys-tems for years, which are working well. But just a ratio of 15.6 % of plastic waste generated in Germany is really recycled (in the year 2017). All the other plastics end up in incinerators or is sent abroad (e.g. to Malaysia) (Dierig, 2019).

This is also confirmed in Figure 6 10, which shows that Germany is one of the world's largest exporters of plastic waste. With an amount of 701,539 tonnes of plastic waste and plastic scrap (in the year 2018) Germany occupies the third place of exporting it abroad. This does not only roll the garbage into other countries but burdens also the environment by the high logistic expenditure (e.g. high CO2 emission by the transport by ship) (Buchholz, 2019).

Figure 6 10- The Biggest Exporters of Platic Waste in the World, 2018 (Buchholz, 2019)

Besides the high export of plastic waste, it, however, has to be said that the main idea of recycling and the current implementation of recycling systems in Germany is a good approach for other countries.

6.2 Integrated Solid Waste Management

Solid waste management can be a really daunting task for any country de-pending upon the population and amount of waste generated per year. Collec-tion of the solid waste and transporting the same to disposal facility accounts for the major cost when it comes to the handling of solid waste. Besides these, there are also various health and hygiene-related issues associated with

the collection and transportation and hence requires extra care to be taken. Land-fill sites are most susceptible to contamination of soil and ground-water unless they are managed scientifically (Tirthankar Banerjee, 2014).

In some ways, waste product reuse is also favoured, but there are technical limitations combined with the possibility of potential pollution. Waste burning has had an odour and air pollution concerns, and it is also impractical to find viable due to the inherent properties of waste material. The ultimate goal of the waste management plan is to minimize waste quantities and toxic effects. The principle of minimizing waste has also been widely applied in recent years (Tirthankar Banerjee, 2014).

In Figure 6 11, the role of waste management can be adequately illustrated. The idea of improving a brand that should concentrate on emissions management and resource efficiency and the introduction of green design con-cepts can be done in tandem with waste prevention. Green development is primarily concerned with reducing the environmental impact associated with raw material selection and storage, production, consumer use and product disposal (Figure 6 12). It is an essential part of the strategy for the reduction of waste and pollution (Tirthankar Banerjee, 2014).

According to the Technology Assessment Office, main green design compo-nents are waste reduction and enhanced material handling. Furthermore, when a product has hit the end of life, several supplementary economic values often remain in the products and this easy disposal will make additional savings. The green design facilitates the process by which any product can re-trieve secondary raw material. In addition, the selection of appropriate materi-als is a critical stage in the development of a product and therefore attempts should be made to select such economically feasible and environmentally sustainable raw materials and technology (Tirthankar Banerjee, 2014).

The need to reduce the toxicity of materials wherever possible is an important aspect of raw material selection. These toxic ingredients generate huge prob-lems when the product loses its usability during the waste management stages. Therefore, green engineering approaches significantly reduce the toxicity linked

with any compound without undermining its usefulness and value (Tirthankar Banerjee, 2014).

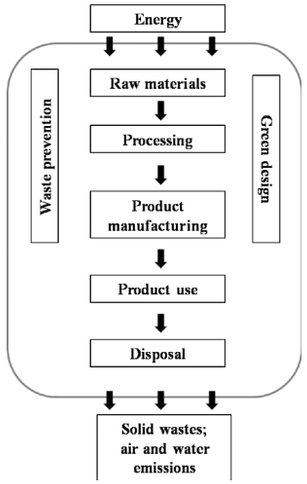

Figure 6 11- Schematic Interpretation of Waste Minimization and Waste Avoidance (OTA, 1992)

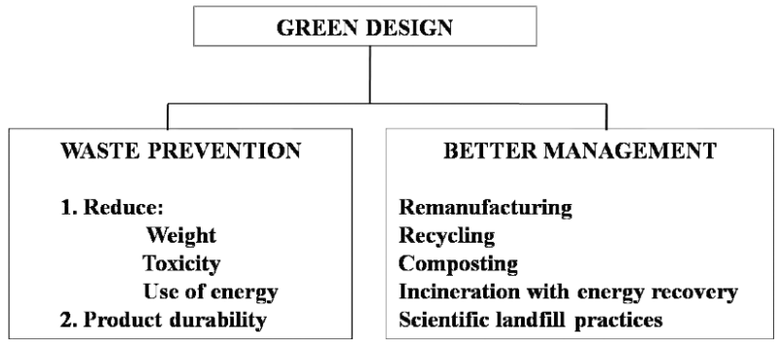

Figure 6 12- Schematic Representation of Green Design (OTA, 1992)

Integrated waste management can be characterized as selecting and applying appropriate strategies, technologies and management systems to achieve specific goals and objectives for waste management. For integrated waste management, there are four basic management options:

I. Source Reduction
II. Recycling and Composting
III. Combustion (Incineration) Waste to Energy
IV. Landfills

The hierarchy of waste as shown in Figure 6 13 describes a range of tradition-al waste management and minimization strategies. The most preferred option in the waste management hierarchy is waste prevention. Prevention of waste is also known as a combination of reduction of sources and reuse of materials. This mitigates the part of a material to be disposed of forwarding to main use and also encourages the reuse of various applications of a particular product (Tirthankar Banerjee, 2014).

Source reduction can be effectively implemented through the design and en-gineering of components and packaging with the lowest possible volume and hazardous substance to better ensure a longer viable life for the product. Re-use is the result of a reduction in the waste hierarchy (Tirthankar Banerjee, 2014).

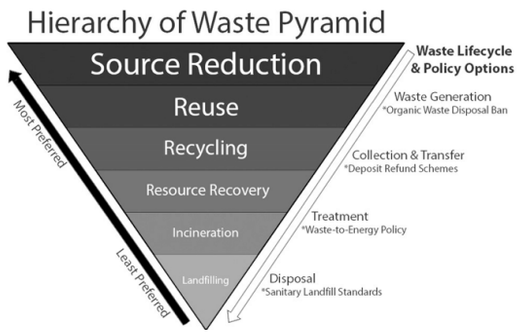

Figure 6 13- Hierarchy of Waste Management (CCAP)

It is a technique of waste reduction where a material is used for the same or new purpose without a physical change. Reusing is preferable to recycling as far as possible because the item does not need to be reprocessed before it can be reused (Tirthankar Banerjee, 2014).

“The reuse of materials for recycling and composting is given the highest prior-ity after waste prevention. Recycling is somewhat different from reuse or recycling and defines the use of waste materials collected to be used as a raw ma-terial for a new combination. It offers the opportunity to reclaim valuable resources and minimize the amount of landfill waste. It may or may not be recycled based on the characteristics of the plastics, but due to possible contami-nation, the plastic recycling process involves

certain technical constresses and special attention is therefore needed” (Tirthankar Banerjee, 2014).

“The three R's practice (reduction, reuse, and recycling) fits well within the concept of sustainable development. The less preferred options of waste management hierarchy are resource recovery, incineration and landfilling, as they contradict the concepts of waste prevention. However, the potential is available to recover a huge amount of energy and resources from the MSW if proper segregation and technology. The hierarchy of waste management, de-spite having some advantages, has some limitations:

I. When combinations of waste management options are used for the treatment of waste, it is of little importance.

II. It also does not take into account the economic aspects of waste management options and thus has some limited applicability in a dif-ferent scenario.

III. Hierarchy does not address specific situations at the local level. MSW incineration in India, for example, is not economically feasible, as MSW contains mostly bio-degradable compounds with lower cal-orific value” (Tirthankar Banerjee, 2014).

Thus, instead of depending on a hierarchy of waste reduction, IWM proposes maximizing the process and also assumes that all choices should play a sim-ultaneous position. Targeted sections of the waste stream were treated by the IWM using a variety of methods and strategies. It is crucial to understand that the parts of the hierarchy connect with each other and that shift can influence or impact another level on one level. Besides, the use of a range of waste management solutions in an integrated system allows the flexibility to choose the safest feasible waste management solution in specific situations (Tirthankar Banerjee, 2014).

PLASTIC WASTE MANAGEMENT – SOURCE REDUCTION

Reducing origin, eliminating waste or reducing waste is one of the best meth-ods and is always placed on top of the waste management hierarchy. The re-duction of the source primarily aims at easing the capacity or toxicity of the produced waste. Source reduction means less consumption and less disposal for the individual consumer or household (Tchobanoglous & Kreith, 2002).

Reduction of the origin involves moving to reusable goods and packaging, with returnable bottles being the most familiar example. The time to contem-plate the lessening of the origin is in the design phase of the product or sys-tem. It can be done by everyone to reduce their origin. Consumers can be in-volved by buying less or more efficiently using products (Tchobanoglous & Kreith, 2002) (Tirthankar Banerjee, 2014).

Source cutback means any alterations in technology, un-processed material, process design, packing, and the use of raw material or commodities to lessen their quantity or harmfulness before last clearance. Rather than being part of effective was-te management, it often acts as a precursor. Lowering supply re-quires reprocessing of the substance, which is forever a su-perior management procedure as it shrinks the expense of was-te management. This could be as straightforward as rejecting an undesirable plastic bag while doing a minor purchase or as complicated as setting up a composting system in the backyard or selecting non-hazardous chemicals cleaning products (Tcho-banoglous & Kreith, 2002).

PLASTIC WASTE MANAGEMENT – FEWER PACKAGING

Plastics operated in packaging are the biggest single division to add to the MSW, contributing a 30 % share of municipal solid waste by weight and a 50 % share by size, as in Germany (Dr. Andreas Jaron, 2008). Packaging con-tributes 35 % in the United Kingdom, 11 % in Germany, and 28 % in overall plastics utilizati-on in the United States. It is also India's most significant plastics application which accounts for 42 % of total plastics consumption (SGCCI, 2000).

Plastics used in the packaging industry are more likely to be disposed of and therefore cause contamination of the environme-nt. Urging people to use fewer plastic bags and urging compa-nies to use a smaller amount of plastic in the packaging division and improving their potential for reuse can significantly re-duce solid waste plastics (Tirthankar Banerjee, 2014).

PLASTIC WASTE MANAGEMENT – PRODUCT REUSE

Reuse of the item involves either continuing use of a compo-nent voluntarily for which it was not originally intended, such as recycling of carton for a second use or extended use of a com-modity. Reuse is a strategy for the decrease of waste generation, where a commodity is utilized for a similar or else different ob-jective devoid of a natural transformation (Tirthankar Banerjee, 2014).

Reuse of plastic is always a better option since the product does not have to be recycled before using it again. Reusable plastics can be used several times hence enabling them to com-pete with products for disposable or single-use. Since there is no energy required for reusing plastics, it is always better than recy-cling. More sturdy and multi-trip way of packaging has developed to be more prevalent in India in the modern period, substituting fewer resilient and one-way replacements (Tirthankar Banerjee, 2014).

PLASTIC WASTE MANAGEMENT – MORE DURABLE PRODUCTS

The increase of the product life cycle is an extremely crucial facet within the principles of waste avoidance. The item that has the greatest durability defi-nitely reduces the ability to put away instantly, thereby boosting the amount of waste generation. Di-versifying product endurance not only eliminates waste products, but also takes fewer resources to produce the product, and such ap-proaches must, therefore, be incorporated to enhance con-sumer sustainability. Due to their low price, easy availability and form of material, plastic products are considerably more likely to be disposed of easily (Tirthankar Banerjee, 2014).

Plastics service life ranges from 1 to 30 years. Mostly, howe-ver, household plastics have a much smaller service life than necessary. While the plastic compound has the necessary du-rability, it is still a human obsessionto dispose them. However, the problem may be reduced by changing public views and prac-tices. Besides, this significantly increases the shelf life of plastic materials and the weighted average usable life of plastic com-

pounds tends to make it the consumer's primary option (Tirthankar Banerjee, 2014).

KEY DEVELOPMENTS FROM GERMANY

In Germany and the EU, it was recognized early on that plastic is harmful to the environment and that solutions must be developed to dispose of it in an envi-ronmentally friendly way. That is the reason why some measures have already been taken in Germany to minimize plastic consumption and to deal with plastic waste.

Already in the early 1990s, there was a trend reversal in Germany about re-ducing the volume of packaging waste including plastic packaging waste. It should also be a start of turning away from the throwaway society. Therefore the packaging regulation (‘Verpackungsverordnung – VerpackV’) was intro-duced in Germany on the 12th June 1991, which is today the packaging law from the 1st January 2019 (‘Verpackungsgesetz – VerpackG) (Das neue Verpackungsgesetz, 2019).

Based on this regulation, the requirements for the prevention and recycling of packaging were made more practice-oriented. Also, the competition in the waste management industry was promoted. For the first time, the German in-dustry was obliged to take back packaging after use and to cooperate in its disposal. Before that regulation, just the local communities were responsible for waste disposal (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, 2019).

All in all the packaging regulation (‘Verpackungsverordnung – VerpackV’) from 1991 lays down the principles, that packaging waste is generally to be avoided and if packaging waste cannot be avoided, then reuse and material recycling must be prioritized over energy disposal (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, 2019).

That is why the ‘VerpackV’-regulation strengthens the plastic recycling system in Germany. Packaging waste is now being used as a source of raw materials so that the proportion of high-quality plastic can be reused using innovative technologies.

In Germany, the dual system is responsible for recycling packaging waste. These include recycling companies (e.g. 'Grüner Punkt') that specialize in col-lecting, sorting and processing recyclable waste. Old plastic is collected from yellow bags/tons and is shredded to flakes by sorting plants after sorting. These flakes are then cleaned, finely sorted again and finally melted into granulate. The resulting recycled material is a secondary raw material from which new packaging (e.g. bottles) can be produced. No new plastic has to be produced from fossil raw materials (Initiative Frosch, 2019).

By 2017, the number of private-sector companies in the recycling sector in Germany had even risen to 451. The largest share of these companies also includes plastic recycling (Breitkopf, 2019).

In the last 25 years, the German government in cooperation with the EU tried to install more actions to reduce plastic. In March 2019 e.g. the European Par-liament voted for the ban against single-use plastic. This ban states that from 2021 certain single-use plastic products will be banned or significantly re-duced throughout the whole EU. It includes plastic products like single-use plastic cutlery, single-use plastic tableware, plastic straws, plastic cotton buds and balloon holding rods (European Parliament, 2019). Some German su-permarkets (like Rewe, Penny and Lidl) already started to reduce plastic straws and single-use plastic dishes or even completely ban them from their assortment (Sueddeutsche Zeitung, 2018).

One of the newest actions, which the German government introduced, is the ban on plastic bags. There is still a high amount of needless plastic bags use in Germany. Therefore the German parlaiment has introduced a legal ban on plastic bags on the 6th November 2019, which is replacing the existing volun-tary agreement of 2015 with the retail industry to no longer sell plastic bags free of charge. Starting from the year 2020 the whole retail industry and their stores aren’t allowed to sell plastic bags anymore otherwise they will face a fine of up to EUR 100,000. Excluded from the ban are unfortunately the thin single-use bags (e.g. for fruits) as well as more stable carrier bags from a wall thickness of 50 micrometres (Tagesschau - German News, 2019).

A further interesting and current growing up action in Germany are the packag-ing-free supermarkets, which especially getting more popular in the big cities of Germany. 50 years ago it was normal to buy groceries without packaging. Everyone took his wooden basket or fabric bag and went to the grocery store and bought the things unpacked. Today it is really rare to have shopping in this way. That is the reason why the trend of packaging-free supermarkets in Germany began. It should stop the increasing waste of packaging and increasing pollution of the environment by plastic.

This trend started already in the 1980s in Canada with the first packaging-free store of the retail chain called ‘Bulk Barn’. In 2014 this trend arrived in Germa-ny and the first packaging-free supermarket opened in Berlin-Kreuzberg. The store ‚Original Unverpackt‘ (English = original packaging-free) started a huge hype. In the meantime, packaging-free supermarkets have established them-selves in almost every federal state capital (Emprechtinger, 2018).

The main concept of the packaging-free supermarket is to fill the products yourself in boxes you bring along. Many of the products are stored in large wall-mounted dispensers, known as bulk bins. But other products like herbs and oil are stored in large glasses and in large canisters, from which it is pos-sible to fill the desired amount. The main principle is to fill everything into own sustainable boxes. This even works with shower gel or detergent. The weight of the boxes brought along is deducted before filling. Everyone is just paying for what they take with them (Flatley, 2019). Furthermore, all products are plastic-free and most of them are sustainable and organic products.

The concept of plastic-free shops is very promising for the future because it saves huge amounts of plastic packaging, which is normally produced with high energy consumption, only to end up as waste shortly after shopping. Moreover, it allows customers to buy only the quantity they need by filling their goods themselves, which additionally reduces food waste (Flatley, 2019).

Thus the growing trend of packaging-free supermarkets ensures that the envi-ronment is not polluted any worse, as plastic is sometimes completely dis-pensed with. Ultimately, these supermarkets also contribute to climate and en-vironmental protection and should, therefore, be further expanded.

Finally, it should be noted that there existing a lot of different implemented ac-tions in Germany to reduce plastic. These measures contribute massively to the sustainable use of plastic.

KEY DEVELOPMENTS FROM SWEDEN

Sweden has developed a process called waste-to-energy (WTE), using the country's waste to convert it into energy. Over half (59 %) of the planet's trash comes to an end in landfills. This, in turn, generates poisonous gasses and infects soil and groundwater and emits greenhouse gases. While Sweden is creating the world as an example. Lower than 1 % of Sweden's household waste is landfilled (Bakshi, 2016) (Yee, 2018).

Sweden has one of the best waste collection systems in which residential are-as are less than 300 metres away from recycling bins or stations. In addition to these, there is also provision for underground pipelines and waste vacuum from residential buildings to these recycling stations. The space occupied by the rubbish is reduced due to this type of waste collection system, and it is also free from any kind of rubbish smell. The collected garbage is then sent to the energy plant in waste furnaces and then burned up to 1,500 degrees Fahren-heit. Rather than burning coal or other gases, these plants burn waste to gen-erate steam that further turns the turbines into electricity generation (Bakshi, 2016) (Yee, 2018).

“Garbage accounts for a very small amount of Sweden's total power supply, combined nuclear and hydropower accounts for about 83 % of Sweden's elec-tricity, while wind generates another 7 %. But the energy generated from gar-bage provides much of the heat for nearly 10 million residents of the country during the winters. In addition, waste energy meets the heating requirements of 1,25 million apartments and 680,000 homes with electricity” (Bakshi, 2016) (Yee, 2018).

“Typically, conventional power plants have large cooling towers that dissipate excess heat, so that only about 40 % of the energy is fully utilized. The trash-powered plant, generating

electricity and heating water for domestic and commercial use, harnesses 90 % of total energy. This provides a bathroom, kitchen and central radiator heating with hot water. This centralized "district heating" system is warming up many Swedish buildings. The system was built over decades to begin in the late 1950s" (Bakshi, 2016) (Yee, 2018).

The Waste to Energy system is not ideal, it can be costly and environmental pollutants are known to be released. Nevertheless, it is also endlessly devel-oping, backed by new technological inventions that enable the WTE to dimin-ish the influence on the environment. "Sweden's waste management system has made it a worldwide leader and, according to Swedish Cleantech, recu-perates more energy from every ton of waste than any other country.

The Scandinavian country has become so good at waste management that it car-ries almost 800,000 tonnes of waste from countries such as the UK, Norway, Italy, and Ireland to feed its 32 WTE plants. Sweden is on its path to accom-plishing zero waste and green energy by 2020, by utilizing 99 % of its waste through recycling and not just throwing it away" (Bakshi, 2016) (Yee, 2018).

RECOMMENDATIONS

This sub-chapter shows that the plastics problem exists worldwide. While measures have been taken for years in developed countries like the EU coun-tries to deal with plastic waste sustainably, there are still difficulties in develop-ing countries like in India. Nevertheless, even in developed countries, too much plastic is still consumed. Above all, the high proportion of short-lived plastics such as plastic packaging is alarming. For this reason, countries around the world should adopt the simple four basic management options of integrated solid waste management, which are 1. Source Reduction, 2. Recy-cling and Composting, 3. Combustion (Incineration) Waste to Energy and 4. Landfills.

In addition, developing countries should follow the example of countries such as Germany and Sweden, where sustainable plastic measures have been successfully introduced. Above all, Sweden should be mentioned as a role model that has succes-

sfully developed and implemented the waste-to-energy process. Even though developing countries usually lack the money to invest in these improvements, their governments should plan for a state budget for this in the future. Furthermore, they should try to ask developed countries for finan-cial support in order to be able to realize the sustainable plastic measures.

In case the majority of the countries all over the world will not improve and act now (especially developing countries), plastic pollution will increase world-wide in the next twenty to thirty years. The litter pollution with plastics of the oceans will not end, further animals have to die why hundred species could die off and CO2-emissions will continue to rise sharply, which in turn will have a negative impact on climate change.

The worldwide plastics problem will never be solved if most countries do not pull together by acting sustainable regarding plastic waste management.

6 Changes in the care sector and their impacts on the living situation of elderly people in Germany

During the next years, Germany will face a big problem with housing old peo-ple. The baby-boom generation, the generation after World War II, start to re-tire. Besides, people are getting older because of a healthier lifestyle and bet-ter medical care. Because of these facts, the number of elderly people will in-crease rapidly in the next few years in Germany (Terragon AG, 2020).

One big challenge will be to accommodate all these people. It will be difficult because the elderly want to stay as long as possible in their own home and do not want to go to a retirement home. But even if they wanted to go to a retire-ment home it will be a problem, because they are practically full (Borchert, 2019).

A new law in most of the federal states does not improve the situation. In North Rhine-Westphalia, it says for example that existing retirement homes need to have an 80 % single room rate. Newly built retirement homes are limited to 80 rooms and need to have a 100 % single room rate. The law was introduced to meet the demand of senior citizens and politicians for more privacy. It has ful-filled its goals, but it led to reduction of beds in retirement homes (Borchert, 2019).

These changes will be a great challenge for the government and social institu-tions. Politicians and local communities already try to find alternatives to cur-rent care facilities. There are some facilities already established that fit more to the requirements of the politicians and the elderly people. They provide more privacy for the inhabitants and promote a common life together (Czycholl, 2019).

DEMOGRAPHIC CHANGES IN GERMANY

The demographic change describes the change of the age structure in a country (IHK, 2015). For this, it considers different aspects. For example the birth rate and mortality rate, the life expectancy and the in-migration and out-migration (Destatis, 2020a).

Current demographic changes

At the moment the change of the German population is enormous. The rate of younger people decreases and the number of older people increases. Every second person in Germany is older than 45 years at the moment. Every fifth person is older than 66 years (Destatis, 2020a). The people around 60 is the generation after World War II. The highest birth rate was counted in 1964 with 1.4 million births in one year. This year is known as the Baby-Boom-Year. Af-terwards, the birth rate decreased (Pötzsch, 2020).

During the Baby-Boom every woman got approximately 2.5 children in their life according to the statistics (Pötzsch, 2020). After decreasing birth rate, women get currently only 1.57 children per person in Germany. An additional problem is that women get children later than in previous years. In 1970 wom-en have been around 24 years old when they got their first child. At the mo-ment they are nearly 30 years old when they are getting their first child (Desta-tis, 2020a).

Furthermore, people in Germany have a longer life expectancy because of better medical care. In 1950 the life expectancy was still 64.6 years for men and 68.5 years for women. At the moment it is 79.1 years for men and 84.1 years for women. But life expectancy will increase further in the future. Accord-ing

to the statistics in 2060 men will have a life expectancy of 84.8 years and women 88.8 years (Radtke, 2019).

Another important aspect for the demographic change is the in- and out-migration in Germany. Because of war and political unrest, people from certain countries came especially during the last few years to Germany (lpb-bw.de, 2020). Most of them, around 1.1 million people, came in 2015. In 2018 there were 400,000 thousand people who came to Germany. Also these immigrants, in each age, have to be considered in the demographic change (Destatis, 2020b).

Impacts of the demographic change in the care sector

Because of all these facts, the population in Germany changed between 1990 and 2018 a lot, as can be seen in Figure 7 1. The younger population de-creased while the older generation increased (Destatis, 2020c).

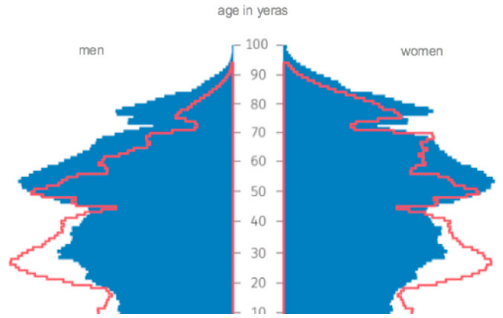

Figure 7 1: Age structure of the population in 1990 and 2018 (in thousands) (Destatis, 2020c)

The pension system in Germany works because of financial levies. The cur-rently employed persons generate the retirement of the current pensioners. But this model does not work well when there are not enough young people to generate retirement for the older generation. Especially when the number of old people rises from year to year (Pflegeversicherung-experten.de, 2016).

The trend will endure over the next years. If a moderate development of birth rate, rate of expectancy and net migration will be assumed, in 2060 even more people will be old and retired. Around 28 % of the population will be over 67. That affects 21.1 million people in Germany. At the moment 16.1 million (19 %) of the population are older than 67. The problems that arise from these chang-es will be to provide good health care for the older population and to build more age-appropriate accommodations (Pflegeimmobilien-abc.de, 2018).

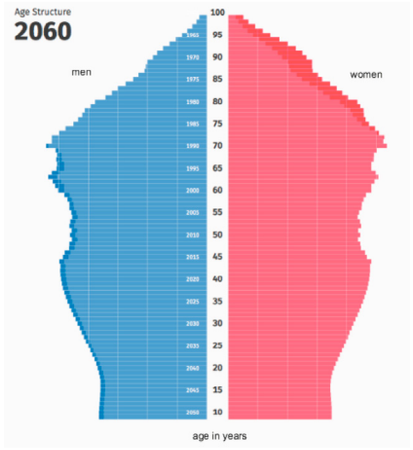

Figure 7 2: Population projection for Germany 2060 (Pflegeimmobilien-abc.de, 2018)

While increasing the older generation during the next years, there will be not only a higher demand for care facilities but also for nurses and care people. This will be a problem because there will be less young people compared to the old generation. Furthermore, the work as a nurse is not very popular at the moment in Germany. There will be a huge gap of employees if the government does not start to work against it (Bünemann, Sonnenburg, Stöver, 2016).

CHANGES IN THE CARE SECTOR

Demographic change is not the only factor forcing the care sector to rethink its approach. Also, the needs of elderly people changed over the years. To meet the new requirements the laws

had to change as well. This is why the re-quirements for the care sector needs to be redefined.

CHANGE OF LAW FOR CARE PROPERTIES

In 2006 was a law in Germany enacted which is called federalism reform. It should reduce the multifaceted links between the government and the federal states. Additional it should articulate the legislative responsibilities more clear-ly (Winter, 2019). With this law, the legislative competence for the public-law right of residences has been transferred to each federal state. Before it was the responsibility of the government. In the meantime, every federal state has its own right to residences. As a result of this, the constructional requirements in-creased in most of the federal states (Langhoff and Ulrich, 2017).

For most of the federal states, it is important to increase the single room rate because they want to improve the living situation and the privacy for elderly people (Langhoff and Ulrich, 2017). Because the right is in every federal state different, North Rhine-Westphalia will be taken here as an example.

In 2003 the legislative of North Rhine-Westphalia decided different rights for existing residences and new-build residences from 2018. In new buildings, it is not allowed to have more than 80 rooms. Every room needs to be a single room with 14 m2 and needs to have a separated bathroom. There are no dou-ble rooms allowed anymore. Existing buildings have protection for their rooms. They only have to reach a single room rate of 80 % (Borchert, 2019).

Even though residences had 15 years to fulfil the requirements, most of them started almost two years before. Many of them were not able to reach the 80 % single-room rate. In North Rhine-Westphalia are around 2,200 care facilities with 180,000 beds. In October 2018 succeeded around 73 % to implement the single-room rate. But many of the residences failed, 37 of them closed com-pletely and many reduced the beds in the residences. Against this, only 18 new residences opened in 2018. This means a reduction of 1,604 beds com-pared to September 2017.

Instead of creating additional space for elderly people, which is urgently needed because of the demographic change, the law leads to less space for them (Borchert, 2019).

Changing needs of older people in care facilities

Retirement homes have a bad reputation. Many people have in mind that people are left alone and are on their own. Also that they have to live in multi-bed rooms and there is not even the smallest activity during the day. Another concern is that they are never alone in the rooms. The roommate could have many visitors or is bedridden and needs a lot of care. It always seemed that quality of life and self-determination are not existing in a retirement home (Pflegeimmobilien-invest.de, 2019).

But the life of the elderly is currently in a major change. The elderly people, as well as the policy, requires more quality of life and self-determination for old people in general. In retirement homes, it will be realized by implementing the single-room rate of 80 %. In addition, they have to improve the offer of activities and community activities. Furthermore, a little shop where the elderly can buy some sweets or other small things would significantly increase their inde-pendence. Having flexible schedules for serving meals is another idea of in-creasing independency in retirement homes. These alternative methods must be retained to improve the quality of life and independence of elderly people (Pflegeimmobilien-invest.de, 2019).

Even when they still live in their own home with or without care it is possible to improve the living situation. The biggest problem for the elderly is loneliness. They need more programs which brings the people together and strengthens social contacts (bmfsfi, 2015). Another important point is for better health care. They need to have good access to medical health care. This is often not easy because old people have usually several doctors who are mostly not in the same city. The goal should be to avoid an inpatient need for care as long as possible (Ritter and Hohmeier, 1999).

TRENDS IN CARE FACILITIES

To counteract these problems the politicians and local communities wants to offer older people more residential alternatives. Some of them have become developed and established over time. They offer seniors a more independent way of life and a great social life together. Because not everyone needs to move into a retirement home immediately if a little care is needed or the part-ner dies. The three most popular alternative housing possibilities are retire-ment homes abroad, multi-generational houses and seniors shared flats or houses (Czycholl, 2019).

RETIREMENT HOMES ABROAD

Retirement homes abroad are gaining popularity. Most of them are located in Eastern Europe, for example in Poland, Czech Republic, Bulgaria or Hungary. But even in Spain, these retirement homes are located. The benefit is that the costs are much cheaper than in Germany. A nice side effect is that the elderly can discover a new country. Some of them choose a retirement home in an-other country because they have been often on holidays there. So they can spend their pension in the place where they used to spend their holidays (Pflegeheime-Seniorenresidenzen-im-Ausland.info, 2018).

The retirement homes are specialised for German inhabitants. Nurses are speaking German and the quality is much higher than in local retirement homes. All of them have a German quality level. It is also possible to pay the stay with the German pension and care allowances. The costs in these coun-tries are much cheaper than in Germany. Because of that, there will be fewer problems with funding. It is interesting for those people who cannot afford a German retirement home or a shared senior house (Pflegeheime-Seniorenresidenzen-im-Ausland.info, 2018).

But there are also disadvantages to staying in a holiday country. It is far away from the family in Germany, so it can be a very emotional challenge. Further-more, hospitals do often not have the same standard as German hospitals. This can be a big problem in case of an emergency. Especially when the re-tirement home is in the countryside. An additional problem can be a different climate. They can suffer under constant heat for example in Spain. This can lead to health problems. Advantages and disadvantages should therefore al-ways be weighed carefully (Pflege.de, 2018).

MULTI-GENERATIONAL HOUSES

In a multi-generational house are living people from every generation togeth-er. They aim to create a meeting place for different generations where people can help and support each other. Young people can help the elderly and the other way round. Everyone can join the multi-generational house, independ-ent of age or nationality. The only criterion to move in is to be engaged. More than 5,000 multi-generation houses are by now distributed all over Germany (Wüstenrot, 2019).

They are supported by a federal programme of the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth in Germany. With this programme, the houses can be supported between the years 2017 and 2020 with EUR 40,000 within a year. Three-quarter are paid by the Federal Ministry for Family Affairs, Senior Citizens and one-quarter will be paid by the municipality or the state. The state wants to support the cohesion of local people. 540 houses dis-tributed all over germany are supported by the federal ministry (Mehrgenera-tionshaeuser.de, 2019).

The House has for every person or every family a separated apartment. Addi-tionally, there is mostly one common area where people can meet. The com-mon area serves as a big living room for everyone. An exchange between the inhabitants can take place here or joint activities are carried out. The ex-change of ideas leads to many project ideas or offers of the houses (Mehrgen-erationshaeuser.de, 2019).

The programme offers a wide range of activities in the houses. Most of the ac-tivities are carried out by engaged inhabitants. The activities can be very dif-ferent. For example computer tutoring, babysitting, language courses or thea-tre projects. Everyone can contribute their abilities and talents to help others. Many activities cannot exist without the voluntary engagement of the inhabit-ants. Some activities are also carried out or supported by the federal pro-gramme. It includes childcare, learning and creative services for children and young people, training courses for (re-)entering the profession, language courses for migrants and much more (Mehrgenerationshaeuser.de, 2019).

With their offers, the multi-generation houses are geared to

the existing local needs. They work very closely with the local community together to coordinate their activities. This avoids duplications of activities and fills gaps in the local market (Mehrgenerationshaeuser.de, 2019).

The biggest challenge for a multi-generation house is to find people who have a lot of trust and tolerance towards others. Because many different people live together. This can lead to conflicts between inhabitants. It needs many ar-rangements, especially for the common area (Wüstenrot, 2019).

SENIORS SHARED FLATS OR HOUSES

Shared flats for elderly people is very popular for people who retired and are alone. There can be different types of shared homes. It is possible to share a flat with other elderly. In this case, everyone has its own room. Living room, kitchen and bathroom are shared rooms. It is the same concept as student shared flats. The other possibility can be a house with several flats and every person lives alone or with a partner in one flat. There are common rooms where the inhabitants can meet (Pflegehilfe.org, 2019).

For both situations, separated care can get involved. This possibility ensures often a long stay in a shared flat or house. Another big advantage is that the inhabitants can help each other and can look after each other. The people are less alone and have someone to talk to or to do some activities. It can be a great relief for relatives (Pflegehilfe.org, 2019).

In the case of sharing a flat, the costs are much lower instead of living alone, because all costs for living, food and care can be divided. But also if someone lives in a shared home, the costs are often lower instead of living on its own. Once that costs for daily care (if needed) can also be divided. The apartments in a shared house are often already barrier-free or have an emergency system installed. These are all costs which can be saved (Pflege.de, 2019).

Disadvantages of this alternative are that in a private shared flat the external care needs to be self-organized. Sometimes there can also be disagreements between the roommates. In a sha-

red flat, it is more difficult to stay out of the way and there is less privacy. In a shared house it is often no right to have a say with new inhabitants, this can also lead to disagreements (Pflegehilfe. org, 2019).

RECOMMENDATIONS

To deal with these problems in the future, Germany needs to continue to im-prove the care sector. More places must be offered in retirement homes in the future and more alternative housing options must be created.

But one of the biggest problems is that care facilities, in general, have a nega-tive image in Germany. Everybody tries to move as late as possible in a care facility. During the already progressing changes, it should be thought about how to improve the image of care facilities. Alternative housing possibilities are on a good way in that direction and also retirement homes should work on their image. The single-room rate is a good beginning. But also this one has not only advantages because it promotes the reduction of beds. An improve-ment could be reached with the help of an image campaign, this could be helpful to overcome prejudices.

In general, retirement homes should be improved in so far that old people have the opportunity to live more independent. That they can eat for example to different times or can buy some things in a small shop in the care facility. Also the alternative care facilities should follow the aim of an independent life. Apart from this, they should offer more activities for the elderly and more ser-vices, so that they are less alone.

Concerning demographic change, the policy must ensure that more beds are made available in retirement homes. Also, alternative housing possibilities need to be better promoted and further developed by the policy. To fit the re-quirements of the elderly, both retirement homes and the alternative housing opti-ons are in charge to provide a better and self-determined life for the elder-ly. But to achieve these goals in Germany there is still a long way to go.

CONCLUSION

To achieve sustainable development goals concerning urban planning, a wide variety of environmental, social, and economic needs must be addressed and met. Urban planning is primarily concerned with solutions that tackle social and economic problems and successfully overcomes them. Everyone needs to consider the environmental changes that are taking place on a wide scale and magnitude.

Countries such as Finland and Germany have started to think about the future and are taking proactive steps to tackle environmental issues. Helsinki has used the idea of brownfield regeneration to fulfil the need for growing de-mands on housing. This could be the exact resource needed for some large cities across the globe, where more housing is required to satisfy the increas-ing population. Germany, on the other hand, has changed from plastic waste management to sustainable methods. The best approach for plastic waste management is using Integrated Solid Waste Management concepts that are source reduction, recycling, composting, combustion, and landfills.

South Korea's waterfront renovation is a prime example of urban and cultural transformation. The same values should be applied such that the social and environmental dimensions stay in harmony. Similarly, Egypt is promoting the use of renewables. Not only can the use of solar and wind energy help reduce the impacts on the atmosphere but also conserve energy for futu-re genera-tions. All countries must recognize their capacity and invest more in renewable energy sources based on available resources and geographical conditions.

In a country like Iran, which needs to reconsider sustainability priorities, there is a need not just for the country's people but also for the government to take the necessary steps. The urban planning laws and regulations need to be checked at both the local and national levels. On a similar basis, it is important to take into account the standards and regulations for the elderly care sector in Germany. More improvement is required in the retirement homes to provide a better and self-determined life for the elderly. Besides, more care facilities should generally be made available

by the government to counteract the de-mographic change.

Urban planning concepts such as the utilization of renewable energy sources, plastic waste management, brownfield redevelopment, waterfront regenera-tion and elderly care facilities need solid support from the government and people. Changes do not happen overnight just like Rome was not built in a day. To create a better future in the context of sustainable cities, consideration should be given to adopting the philosophy of sustainable urban planning, purposeful collaboration, a clearer understanding of environmental goals, economic and social implications in the long term and evaluation of alterna-tives available.

Given the authors' suggestions and findings based on the numerous case studies and examples from different parts of the world, the planet will certainly progress towards sustainable urban targets if they are accepted, applied and genuinely practised.

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APPENDIX 1:

3D HELSINKI

The City of Helsinki publishes two 3D models of Helsinki: one of them is a semantic city information model and the other visually high-quality reality mesh model. All data pub-lished are open source and users can use them to analyse the sustainability of the city in terms of energy consumption, greenhouse gases emission or the environmental im-pacts of traffic etc. The 3D mesh model can be found in this weblink: https://kartta.hel.fi/3d/

Here is a screenshot of the 3D model of Jätkäsaari (2017):

(City of Helsinki, Helsinki's 3D city models, 2019).

APPENDIX 2:

10 Principles for a Sustainable Development of Urban Waterfront Areas (Moretti, 2008)

1- Secure the quality of water and the environment

The quality of water in the system of streams, rivers, canals, lakes, bays and the sea is a prerequisite for all waterfront developments. The municipalities are re-sponsible for the sustainable recovery of derelict banks and contaminated water.

2- Waterfronts are part of the existing urban fabric

New waterfront should be conceived as an integral part of the existing city and contribute to its vitality. Water is a part of the urban landscape and should be uti-lized for specific functions such as waterborne transport, entertainment and cul-ture.

3- The historic identity gives character

Collective heritage of water and city, of events, landmarks and nature should be utilized to give the waterfront redevelopment character and meaning. The preser-vation of the industrial past is an integral element of sustainable redevelopment.

4- Mixed-use is a priority

Waterfronts should celebrate water by offering a diversity of cultural, commercial and housing uses. Those that require access to water should have priority. Hous-ing neighbourhoods should be mixed both functionally and socially.

5- Public access is a prerequisite

Waterfronts should be both physically and visually accessible for locals and tour-ists of all ages and tourists of all ages and income. The construction of public spaces should ensure high quality to allow intensive use.

6- Planning in public-private partnerships speeds the process

New waterfront developments should be planned in public-private partnerships. Public authorities must guarantee the quality of the design, supply infrastructure and generate social equilibrium. Private developers should be involved from the start to ensure knowledge of the markets and to speed the development.

7- Public participation is an element of sustainability

Cities should benefit from sustainable waterfront development not only in ecologi-cal and economic terms but also socially. The community should be informed and involved in discussions systematically from the start.

8- Waterfronts are long term projects

Waterfronts need to be redeveloped step by step so the entire city can benefit from their potential.

They are a challenge for more than one generation and need a variety of charac-ters both in architecture, public space and

art. Public administration must provide the impulse on a political level to ensure that the objectives are realized inde-pendently of economic cycles or short-term interests.

9- Re-vitalization is an ongoing process

All master planning must be based on the detailed analysis of the principle func-tions and meanings which concern the waterfront. Plans should be flexible, adapt to change and incorporate all relevant disciplines.

To encourage a system of sustainable growth, the management and operation of waterfronts during the day and at night must have the same priority as their con-struction.

10- Waterfronts profit form international networking

The re-development of waterfronts is a highly complex task that involves profes-sionals from many disciplines. The exchange of knowledge in an international network between contacts involved in waterfronts on different levels offers both individual support and information about the most important projects, completed or in progress.

LIST OF FIGURES

List of tables

Homa Javadi, Ahmed Ali, Mahmoud Hassan, and Ahmed Aziz

4. SUSTAINABLE CONSTRUCTION

ABSTRACT

A Sustainable construction system is the ultimate solution for solving existing construction issues like high costs, wasting material and energy resources, increasing carbon emissions, global warming, etc. Despite many problems that construction is facing, sustainable construction systems succeed in saving energy, time and material through many different approaches that are discussed in this research. By reviewing the state of the art, considering case studies and applying personal experiences, the concept of the zero-energy building, the impact of using the precast system on sustainable construction, recycled materials, and demolition waste and eco-friendly bricks are discussed as an approach to reach sustainable construction. The outcome of this study will meet the major needs of a sustainable system as reducing energy usage, materials' waste and the construction's duration and cost. These systems have not been merged previously; therefore, this paper provides a new advanced sustainable system with various new benefits and fewer errors.

Keywords: Sustainable Construction, Zero-energy Building, Precast Construction, Recycling Construction Waste, Eco-friendly Bricks

INTRODUCTION

Due to global construction expansion, many lands and forests have been in decline. The lunar land area has been reduced and this has affected the amount of free oxygen in the atmosphere. Additionally, the temperature of the tropospheric layer increased, and the thickness of the ozone layer decreased.

As a result of unsustainable construction, natural ecosystems have been altered or destroyed. Energy consumption in the combustion process has increased, resulting in the production of air pollution and noise pollution from combustion engines (Marinakis et al. 2017). Cities consume energy, generate waste and heat, and consequently, irrational exploitation of fossil energy resources will lead to their destruction (Harvey, 2006).

We are now at a stage when fossil energy resources are running out, then here sustainable construction can be a solution. Talking about the zero-energy building (ZEB), it needs to be taken into consideration that the background of this idea refers to sustainable construction.

As it is clear, sustainable construction is not a new subject in neither construction, consumption, maintenance nor disposal phase (Dabaieh, Makhlouf, and Hosny, 2016). Sustainable construction is a subset of sustainable design, which may be one of the most important contemporary architectural trends (Hopfe and McLeod, 2015). Thus, in the first part of this research, the concept of ZEB and its relation to sustainable construction will be described.

Another discussion related to sustainability is precast design and construction. The construction industry has come a long way in reaching a new industry called prefabricated housing. Of course, in this new industry, the science of architecture has not made much progress and is still one of the disadvantages of a prefabricated home, the failure to implement modern architectural styles in design and form design. However, this knowledge has been aided by many engineers around the world, given the great importance of people's need for housing and high growth rates (Elliott, 2016).

construction.

The style of construction and construction is such that the dead load of the building will be greatly reduced. The size of the foundation and the foundation of the structure will also be reduced and even fewer materials will be involved. The manpower is also reduced due to the many parts being built off the project site. All of this has resulted in a significant reduction in cost along with an increase in execution speed, which encourages engineers to build prefabricated homes (Elliott and Jolly, 2013).

Some of the advantages of pre-casting are full insulation against cold and heat, ease in erection for different structural elements, high durability through time, the possibility of reusing the precast units elsewhere and so forth (Jeon et al. 2019). Then, the second part of this research will be devoted to precast construction with a focus on Egyptian sustainable cities. The construction industry is one of the oldest industries in the world (Odediran et al. 2012).

The ancient peoples started to construct buildings using the available natural resource such as wood and blocks made from soil and so on. The modern world today and the high population of the world make the construction industry a great indicator of the overall health of the nation’s economy.

The construction demand increase has led to an increase in other industries, but the generated waste coming from the construction industry is considered a massive problem facing our world (Jaillon, Poon, and Chiang, 2009). So, to create new methods and techniques to deal with construction waste it is essential to cover this increase in demand but with a sustainable approach (Tama, 2008).The industry has the responsibility for the earth's natural resources consumption (Behera et al. 2014). Iron, sand, stones, and other limited resources are consumed in massive quantities to provide the needs of the markets. Also, construction sites produce a massive annual amount of waste, whether through construction, renovation, or demolition processes (Kofoworola and Gheewala, 2009).

This waste often goes to dumps and landfills. However, if more care is taken this waste might have a tremendous possibility for reuse if, given proper destinations and correct processing, recycled materials can be used instead of those extracted from

nature to produce usable building materials, with the same quality that can be achieved compared to virgin materials (Behera et al. 2014). Accordingly, the third section of this research will illustrate the relationship between recycled construction waste and sustainability.

Finally, from the material point of view, it is important what kind of materials are used in sustainable construction.

We are entering into a new era where the increasing cases of climate change conditions are setting the drivers for most of our developing strategies. Many policies and actions are being implemented by governments to reduce greenhouse gas emissions. In developed countries, the built environment accounts for up to 40% of such emissions. (Pérez-Lombard, Ortiz and Pout, 2008). Generally, bricks are one of the most commonly used materials in the construction industry.

Traditionally, clay bricks have been widely used because of its simple and economically cheap construction cycle. However, the manufacturing of such masonry bricks has negative impacts on the environment, contributing to the climate change struggle. Mostly, fired clay bricks are molded, as the name suggests, by applying relatively high temperatures.
Such a process results in unnecessary energy consumption as well as embodied carbon throughout the life cycle of the material (cradle-to-grave).

Furthermore, the manufacturing process of traditional bricks is said to have harmful impacts on indoor air quality (IAQ), causing health issues that might be beyond repair. Thus, a holistic lifecycle framework (potentially BIM-based) for the design, construction, demolition, and reuse is essential for heightened sustainability.

SUSTAINABLE ZERO-ENERGY BUILDING; AN INVESTIGATION OF ZEB’S PERFORMANCE

SUSTAINABILITY AND ZERO-ENERGY BUILDINGS

According to the UN World Commission on Environment and Sustainable Development, today's needs must be met without hurting the capabilities of future generations to meet their needs.

Due to increasing energy demand, limited fossil energy

resources, rising prices, uncertainty and instability of the energy market, environmental pollution and global warming in recent decades, the necessity of sustainable design is felt greatly.

Sustainable design with the three important approaches: reduce, re-use and regenerate is a solution for solving the mentioned problems (Azhar et al. 2009). Two of the approaches to solve the energy crisis are first, optimizing energy consumption and production and the second is using renewable energy resources. (Abdellah et al. 2017). To match energy production, demand must be limited.

Energy conservation is more cost-effective than increasing supply economically and environmentally. The economic benefits of energy conservation (saving) combined with solar energy are fundamental solutions to the challenges of sustainability.

Creating a sustainable zero-energy building encompasses all aspects of sustainability in terms of energy conservation, building recovery, integration, reducing the use of materials, protecting and improving the site, selecting low-cost materials, maximizing longevity, protecting water and sanitizing buildings, minimizing waste and use of renewable energy instead of non-renewable energy (Harvey, 2006).

Paying attention to energy consumption and energy generation is an important issue that not only contributes to the conservation of fossil energy sources and reduces their use, but also provides a good basis for renewable and energy efficiency. For instance, European countries and the US have set up a comprehensive energy consumption plan by 2030, including building green cities, using the DH-CHP system, extensively energy-efficient buildings, cultural platforms, and appropriate awareness, which includes social programs (Lijnen, 2011).

In India, commercial and residential buildings account for approximately 33% and in the US 35% of total electricity consumption. Therefore, it is crucial to enforce standards to save energy, to accurately determine and control the amount of energy consumed in buildings. Buildings, based on statistics, consume 35 percent of all energy produced.

The second step is to consider the use of solar and wind renewable energy as an effective solution. To meet climate challenges and reduce the significant share of energy consumed in buildings, the goal of sustainable zero energy buildings in the world must put forward (Anderson, Robinson and Ma, 2016).

WHAT IS THE ZERO-ENERGY BUILDING?

In zero-energy buildings, the connection between the energy sources and the building is not interrupted, except that the sum of the annual energy trade with the complex outside the building is zero. Slowing and then reducing the peak of energy consumption will return the same amount of energy received to the power system of the complex.

The technical features of the zero-energy building can be the use of solar energy to supply electrical energy. The zero-energy building focuses on building layout to absorb maximum clean solar energy and the insulation to reduce the amount of energy loss and reduce it to the minimum possible as well as using the clean and renewable energy facilities on site (Cooper, Kosasih and Yan, 2011).

The unique feature of zero-energy buildings is that their net annual energy consumption is almost zero. The zero-energy building is an important step towards reducing energy consumption and offsetting energy consumption through the production of renewable energy. In a zero-energy building, part of the energy is supplied by the sun, and the other by renewable energy resources like biomass and land exchange. Building orientation, space layout, insulation in the building, architecture design, controls and utilizing modern standards are the effective factors in reducing energy consumption by 90% in similar typical buildings.

The economic efficiency of produced energy makes the cost of design and installing the equipment more beneficial. The precise and useful layout of the building requires the use of engineering simulation software to maximize the absorption of solar energy.

The software analyses various shadows on the building. One of the ways to reduce and conserve energy is to use LED lighting in a zero-energy building. This includes optimizing production

ENERGY RESOURCES OF ZERO-ENERGY BUILDINGS

The main goal of designing and building ZEB is to use renewable energy sources and become independent from fossil fuels (Marszal and Heiselberg, 2009). To provide a zero-energy building, various sources of renewable energies can be applied. As is clearly described in table 1.1, renewable sources for supplying zero-energy buildings are divided into two types of on-site and off-site suppliers (Table 1.1). Applying on-site renewable energy sources decrease environmental impacts since it minimizes energy conversion losses, energy transmission, and energy transportation. In a ZEB project, the typical utility generation sources include wind, hydroelectricity, photovoltaics, biofuels and solar hot water (Crawley, Pless, and Torcellini, 2009).

On the other hand, the off-site supplier option generates energy by using or purchasing off-site renewable energy sources. Biomass, wood pellets, waste streams, PV, utility-based wind, and hydro-electronic are considered off-site energy supplies (Marszal and Heiselberg, 2009). To make it clear, figure 1.1 represents the energy need such as gas (heating) and electricity (lighting, cooling, etc.) of a zero-energy building, which is provided by on-site technical systems. The efficiency of the zero-energy building has a direct relation to the efficiency of building technical systems (E

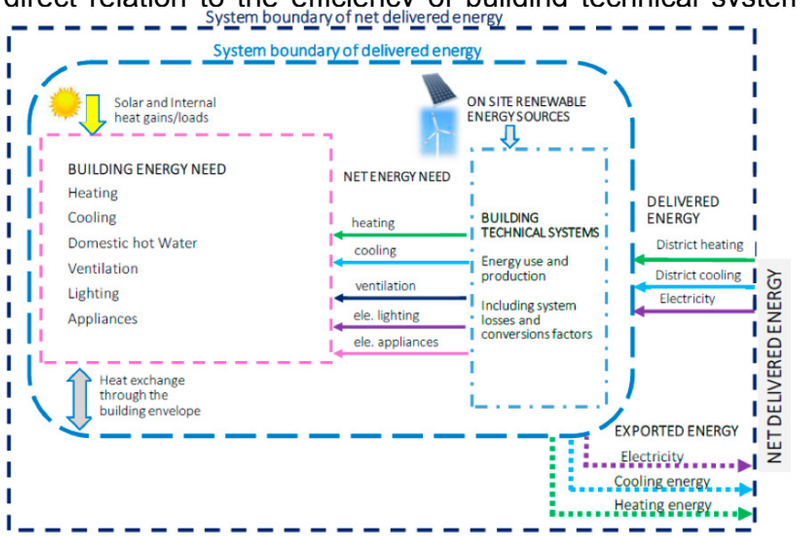

Figure 1.1 ZEB energy boundary, (Berardi, 2018, p. 22)

ZEB Classification	ZEB Supply-Side Options	ZEB Definitions
On-Site Supply Options		
A	Use renewable energy sources available within the building's footprint and directly connected to the building's electrical or hot/chilled water distribution system. (Examples: Photovoltaic, solar hot water, and wind located on the building.)	YES: Site, Source, Emissions Difficult: Cost If the source and emissions multipliers for a ZEB:A are high during times of utility energy use but low during times the ZEB is exporting to the grid, reaching a source or emissions ZEB position may be difficult. Qualifying as a cost ZEB may be difficult depending on the net-metering policies in the area.
B	Use renewable energy sources as described in ZEB:A and Use renewable energy sources available at the building site and directly connected to the building's electrical or hot/chilled water distribution system. (Examples: Photovoltaic, solar hot water, low-impact hydroelectric, and wind located on parking lots, adjacent open space, but not physically mounted on the building.)	YES: Site, Source, Cost, Emissions Difficult: Cost If the source and emissions multipliers for a ZEB:B are high during times of utility energy use but low during times the ZEB is exporting to the grid, reaching a source or emissions ZEB position may be difficult. Qualifying as a cost ZEB may be difficult depending on the net-metering policies in the area.
Off-Site Supply Options		
C	Use renewable energy sources as described in ZEB:A; ZEB:B, and ZEB:C and Use renewable energy sources available off site to generate energy on site and directly connected to the building's electrical or hot/chilled water distribution system. (Examples: Biomass, wood pellets, ethanol, or biodiesel that can be imported from off-site, or collected from waste streams from on-site processes that can be used on-site to generate electricity and heat.)	YES: Site, Difficult: Source, Cost, Emissions A ZEB:C source and emission position may be difficult if carbon-neutral renewables such as wood chips are used or if ZEB has an unfavorable source and carbon multipliers. This can occur if a ZEB exports energy during times that the utility has low source and carbon impacts, but imports energy when the utility has high source and carbon impacts. ZEB:C buildings typically do not reach a cost ZEB position because renewable materials are purchased to bring on-site—it would be very difficult to recoup these expenses by any compensation received from the utility for renewable energy generation.
D	Use renewable energy sources as described in ZEB:A, ZEB:B, and ZEB:C and Purchase recently added off-site renewable energy sources, as certified from Green-E (2009) or other equivalent renewable-energy certification programs. Continue to purchase the generation from this new resource to maintain ZEB status. (Examples: Utility-based wind, photovoltaic, emissions credits, or other "green" purchasing options. All off-site purchases must be certified as recently added renewable energy (Green-E 2009). A building could also negotiate with its power provider to install dedicated wind turbines or PV panels at a site with good solar or wind resources off-site. In this approach, the building might own the hardware and receive credits for the power. The power company or a contractor would maintain the hardware.)	YES: Source, Emissions NO: Site, Cost ZEB:D buildings may qualify as source and emissions if they purchase enough renewable energy and have favorable source and emissions factors. They will not qualify as site and cost.

Table 1.1 Renewable energy classification for ZEBs (Crawley et al. 2009, p. 7)

DESIGN PRINCIPALS OF ZERO-ENERGY BUILDINGS

Based on the world challenges for improving the conditions related to energy shortage, a consensus has been made that in the building sector the priority must be given to high energy efficiency and then incremental improvements. Aiming to this goal, the guideline of Energy Performance of Building Directive (EPBD) under the title of “Nearly zero-energy building” urged all European Union Members to obey the rule, which guarantees that new buildings must be almost zero energy buildings by December 2020 (Berardi, 2018).

Therefore, the importance of the design phase in sustainable construction is taken into account. In ZEB projects, for instance, a smart solar concept as one of the on-site renewable resources affects the principals of design, in which geometry, placement, and direction of the windows, thermal insulation and so on take the priority of key design variables (Athienitis and O'Brien, 2015).

Polly et al. (2016) in an investigation to maximize the design efficiency of ZEB, categorized design principles of ZEB to four categories of building efficiency, renewable thermal energy, solar potential, and load control. In each category, there are some interrelated sub-principals by which the high efficiency of ZEB design can be achieved (

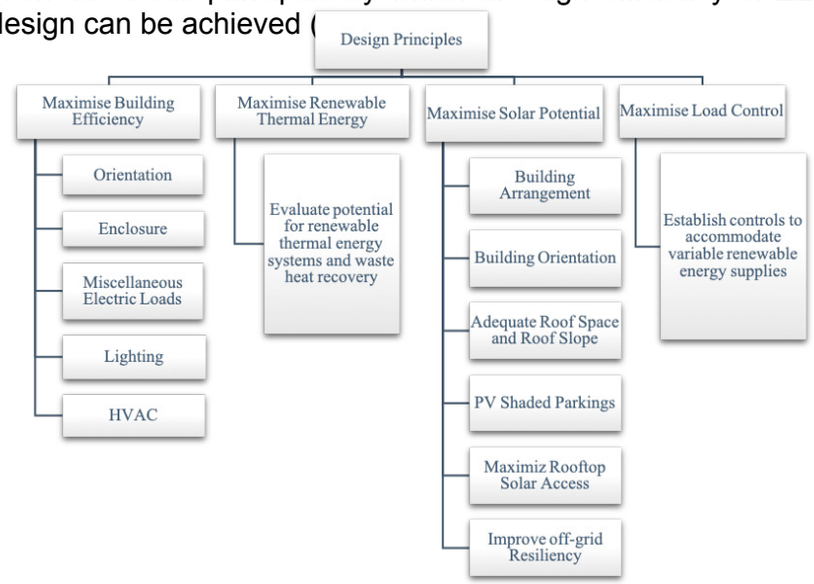

Figure 1.2 ZEB Design Principals (Adopted from Polly et al. 2016, pp. 5-7)

COST-EFFECTIVENESS OF ZERO-ENERGY BUILDINGS

The cost-effectiveness of zero-energy buildings refers to both costs that they prevent during the lifecycle of the building and the construction costs of the building. Considering the cost-effectiveness of zero energy buildings that they provide during the usage; the definition of net-zero cost energy should be explained. In fact, in a cost net-zero energy building, the money which has been paid from the utility to building owner for exporting the energy to the grid equals the cost paid to the utility by building owner for the used energy from the grid.

However, turning this definition into action may seem ineffective, as the rate of services (electricity and gas) mostly changes, and the cost of generated and delivered utility can hardly be the same (Berardi, 2018). In this approach, a system of 100-KW PV is required to provide credit for the generation of utility in a cost zero-energy building. Likewise, to make a zero-energy building more cost-effective the following parameters are taken into consideration (Torcellini et al. 2006):

- High energy saving (65%)
- Time-of-use
- True-net-metering agreement

In addition to other advantages of zero-energy buildings, as it defined, zero energy buildings make up the energy that they consume over a year. Although the initial cost of ZEB buildings is high and also the maintenance of these buildings requires a high price, a zero-energy building can save a lot of money over the lifecycle of a building. Table 1.2 represents the cost analysis of the zero-energy building in four cities of the United States (Petersen, Gartman and Corvidae, 2019).

	CZ2	CZ3	CZ4	CZ5
Modeled City	Houston TX	Atlanta, GA	Baltimore, MD	Chicago, IL
Utility Energy Rate ($/kWh)	$0.096	$0.121	$0.147	$0.122
Baseline Energy Use Intensity (kBtu/sf/yr)	22.0	23.6	26.9	33.1
Proposed Energy Used Intensity (kBtu/sf/yr)	13.0	13.3	13.8	16.0
Solar PV Size (kW)	6.5	6.2	6.8	8.4
Baseline Cost ($)	$228,479	$242,243	$253,254	$346,848
Incremental Cost for ZER Homes ($)	$2,065	$6,094	$5,993	$5,368
Incremental Cost for ZER Homes (%)	0.9%	2.5%	2.4%	1.5%
Incremental Cost for ZE Homes ($)	$21,240	$25,314	$24,693	$30,736
Incremental Cost for ZE Homes (%)	9.3%	10.4%	9.8%	8.9%
Incremental Cost for ZE Homes with ITC ($)	$15,488	$19,548	$19,083	$23,125
Incremental Cost for ZE Homes with ITC (%)	6.8%	8.1%	7.5%	6.7%

Table 1.2 Cost analysis of ZEB in the USA (Petersen et al. 2019, p. 17)

As it is shown by the following bar chart (Figure 1.3), the price of these projects is expected to change and they will be more economical shortly since the construction industry and demands are predicted to moderate the price and cost-saving (Petersen et al. 2019).

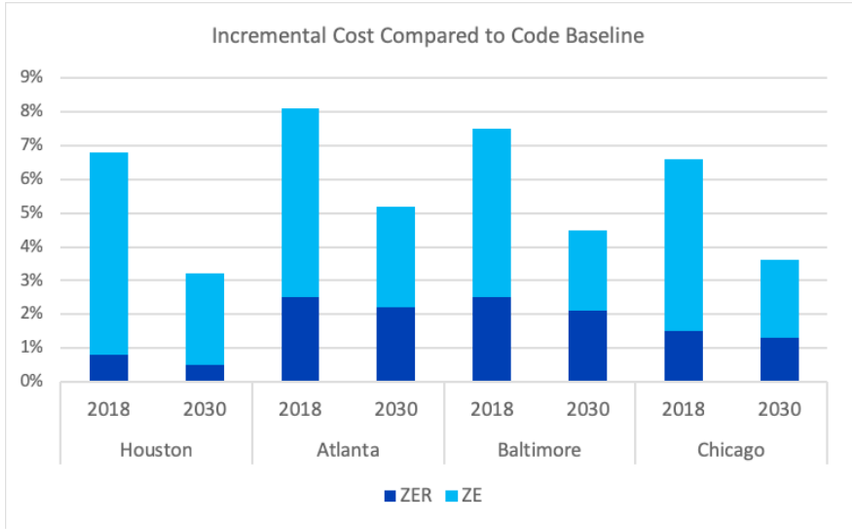

Figure 1.3 Price comparison of ZE (Zero-Energy) and ZER (Zero-Energy-Ready homes in the USA (Petersen et al. 2019, p. 26)

ENERGY EFFICIENCY OF ZERO-ENERGY BUILDINGS

In general, the zero-energy building aims to minimize energy use and to produce energy for building usage. However, there has to be a balance between energy production and energy usage of the building. Reduction of energy consumption is a result of some implementation such as adaptable passive designs, mechanical systems, lighting systems, and residents' behavior. In a study of a typical Sydney house, it was simulated that applying ZEB instruction reduced 94% of unwanted heat waste. Generally, energy efficiency has three main elements including (Anderson, 2016):

BUILDING ENVELOPE

This is where the indoor environment becomes separated

from the outdoor environment to provide thermal comfort and efficiency for residents. The climate condition of the location has a direct relation with the type of the envelope. For example, in the case of high or low temperature, a solid separated non-engaging envelope will be applied. On the contrary, an engaging envelope will be applied in a comfortable climate condition in which occupants interact well with the outdoor environment.

MECHANICAL SYSTEM AND HVAC

The performance of the mechanical system and HVAC depends on the outdoor climate. In fact, in some climates, there is no need for the HVAC system. It has been suggested that 20% of energy consumption is devoted to the HVAC system in developed countries.

LIGHTING

Artificial lighting has the amount of 30% of energy consumption. By producing heat, artificial lighting in ZEB has a great influence on the HVAC system and the building's thermal load. Depends on the season the generated heat could be beneficial (winter) or become a disadvantage (summer). Making more daylight is a way to decrease the heat produced by artificial lighting to 50%-80%.

Following, figure 1.4 illustrates the difference between the annual energy efficiency of a normal building and a zero-energy building in Canada using on-site solar energy (Athienitis, 2018).

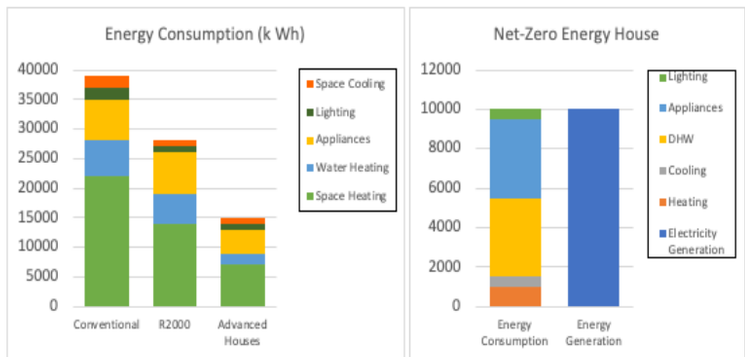

Figure 1.4 A comparison between the energy consumption of non-ZEB and ZEB in Canada (Athienitis, 2018, p. 4)

EXAMPLE OF THE ZEB BUILDING (ANDERSON, 2016)

Sustainable Buildings Research Centre – University of Wollongong. Located in Australia, the project of the Sustainable Building Research Centre (SBRC), was designed to bring more sustainability to the Australian construction industry. The site area of the building is 8000 m2 and the building is 2600 m2 as a double story. SBRC as an academic center includes education and trading centers, high-bay laboratories, academic offices, and exhibition spaces. Moreover, the project uses natural lights and a passive ventilation system.

BUILDING ENERGY SYSTEM

Instead of conventional brick veneer construction, the technique of reverse brick veneer construction was applied in this project, since it provides more stability in the indoor environment. To be more accurate, an insulated envelope (steel cladding and timber) covers the thermal mass in this approach. To avoid dissipation, as table 1.3 shows the details, the building is isolated by a high degree of insulation. Moreover, the building is provided with double glazed windows, curtain walls and glazed doors.

Materials	Insulation Level (R-Value)
Concrete slabs	3.2 m2K/W
External Walls	2.8 m2K/W
Roof	3.2 m2K/W

Table 1.3 Insulation degree of the building's sectors (Anderson, 2016)

Because of the cutting-edge technology, SBRC's energy efficiency is high. To reduce the intensity of HVAC energy, a ventilation system that implies in-slab Hydronics and ground heat exchange. To have enough lighting, an intelligent system of low energy lighting controls the daylight level and whenever necessary artificial light is replaced by Pyroelectric/Passive InfraRed (PIR) sensors. To provide thermal comfort, both north and south wings of the building were equipped by solar PV arrays with an inclination of 30◦ and 70◦ and Building Integrated Photovoltaic Thermal (BIPVT) panels. In addition to on-site solar energy resources, this building uses an off-site source of solar energy,

which is distributed to the building through the SBRCs electricity system.

BUILDING MECHANICAL SYSTEM

HVAC in this building includes cooling/heating and natural ventilation that is applied by the envelope's air holes and automated windows. This natural ventilation system maintains the building's temperature between 20◦C-24◦C and if the temperature exceeds or decreases form this range, the mechanical system will be applied. To provide heat, exchange loops that are in the ground exchanges the heat. The pressure of this ground loop system is fixed by a water pump with variable speed.

Avoiding lighting intensity, a system of low energy was designed, which can be controlled by occupants from a control panel or when photoelectric sensors identify the presence of the residents. Besides, wasted light in this system decrease substantially, since the sensors balance the indoor lighting following natural lighting in the outdoor. Energy monitoring systems were applied as shown in figure 1.5 such as solar log, building management system and portable Power Quality (PQ) and Indoor Environmental Quality (IEQ).

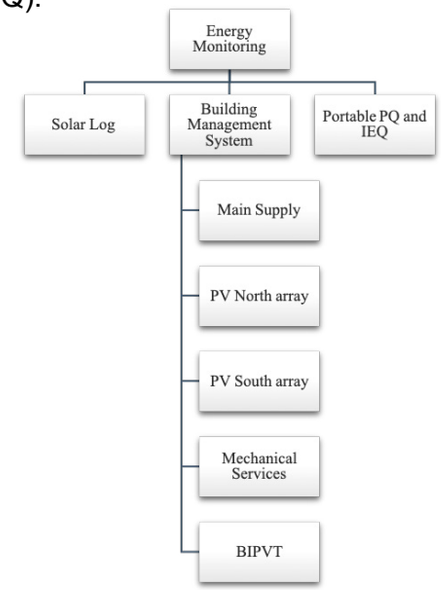

Figure 1.5 SBRC's energy monitoring system (Adopted from Anderson, 2016, pp. 60-61)

SUMMARY

This research emphasized the importance of zero-energy buildings as a tool to have a clean environment, reducing carbon emission and dependency on fossil fuels, saving natural resources, and save the natural resources for the next generation. In this paper, initially, the concept of sustainability in buildings and the zero-energy building were discussed. Then, the zero-energy resources and design principles of zero-energy buildings were presented. This report answered four main research questions regarding energy efficiency, cost-effectiveness, technical methods and design variables of zero-energy buildings. The review of the case study made the theoretical part of this report more tangible. Finally, it can be concluded that although achieving a zero-energy-energy building is a challenging objective, the use of renewable energy resources has the potential to create a balance between ZEB projects.

PRECAST CONSTRUCTION IN EGYPTIAN SUSTAINABLE CITIES

It all started in 2015 when United Nations member states adopted Sustainable Development Goals (SDGs). Its main goals are ending poverty, plant protection, making sure that peace and prosperity will reach all people all over the world, and so on as it is shown in Figure 2.1 (El Baradei, 2019; URL 2).

Figure 2.1 United Nations SDGs 17 Goals, retrieved from URL 2

In 2016 Egypt has adopted the UN SDGs and localized it to fit Egypt's needs that are referred to as "Egypt's Vision 2030" focusing on solving Egypt main problems in addition to following the UN global SDGs goals, this vision covers the three main dimensions of sustainable development: social, economic and environmental (VanGeem, 2006; URL 2).

SECTION AIM AND OBJECTIVE

In this section, the focus will be on sustainable cities and communities in Egypt, especially in using precast construction as a sustainable system and its effect on the progress of this point regarding "Egypt's Vision 2030". It will also discuss the precast advantages and how it can help to achieve even a portion of this goal. Also, our second main objective will be suggesting some solutions to solve the precast problems that the Egyptian market is facing now in addition to illustrating some new approaches for the market to use.

The benefits of the precast system and the relation to some

actual qualitative data from previous work experience by the author are given to illustrate these points using real case data and analysis. Also, the method to improve this system in Egypt to reach its maximum efficiency compared to using it in Finland for example.

STATEMENT OF THE PROBLEMS

Precast face worldwide problems besides its qualities regarding efficiency and sustainability and time efficiency. Those problems can be summarised into one sentence, which is “Lack of proper experience”, due to this major problem so many small obstacles have appeared such as (Polat, 2008):

- People and the industry are resistant to changes
- Fear of precast cost
- Lack of skilled precast designers which lead to bad or wrong design.

- Incorrect management and production.
- Miscommunication
- Discoordination
- Lack of skilled employees in the production and installation field.

Therefore, to solve these problems, the main major issue, which is “Lack of Experience” must be solved.

SCOPE LIMITATIONS

This section will discuss the precast construction role in sustainability around the world especially in Egypt, on the other hand, the problems, reasons, and solutions that face this industry will also be discussed, but it will not include the details regarding the traditional system used.

Moreover, there is not enough precast construction awareness all over the world, also there is a major fear of the industry all over the world especially in Egypt with a huge lack of knowledge about the system, which leads to the resistance to implementing the precast system.

RESEARCH QUESTIONS

This section aims to answer the following questions,

Q1. How sustainable is precast?

Q2. Factors and reasons for not using the precast construction system worldwide and especially in Egypt?

Q3. How is Precast related to Sustainability goals in Egypt?

Q4. What are the causes and possible solutions to this problem?

METHODOLOGY

The methodology used in this section is both literature review and qualitative analysis with some data and information from the author's previous cases. The author has the company's authorization to use all data needed to demonstrate the problems, advantages and actual precast construction projects. Two different case studies are discussed, describing and summarizing the advantages of using the precast system.

DEFINITION OF THE PRECAST

It is the system when structural elements such as column or beam are produced in a factory or yard inside a fabrication mold with mass production to cover a specific project and then these elements are cured and transported to the construction site for installation and adjustment process (Allen and Iano, 2019). For example, figure 2.2 represents a sample of a precast column.

Figure 2.2 Sample of precast Column (by the Author)

ADVANTAGES

Advantages of precast include (VanGeem, 2006; El Baradei, 2019; Lachimpadi et al. 2012):

- Faster production, ease in erection for different structural elements and overall less project duration.
- High-quality control.
- High durability through time.
- Reduces materials waste.
- Integrated project delivery
- More improved safety and health system.
- High level of sustainability
- Flexibility and optimization

PRECAST ELEMENTS EXAMPLE LIST (LACHIMPADI ET AL. 2012)

- Precast slabs
- Precast columns
- Precast beam
- Precast wall panels
- Precast staircase

PRECAST AND SUSTAINABILITY

The precast construction system is one of the most sustainable systems in construction, relating to its advantages of efficiency of the material used, durability and resistance to noise, corrosion, fire, weather, hurricanes, flood, rain, and earthquakes. With the environmental advantages that the systems offer, reducing radiation and toxicity by providing a barrier against them. It's a production process that required less material due to the exact design method used with the minimum tolerance that is achieved by the quality control inspection (VanGeem, 2006). Figures 2.3 and 2.4 illustrate clearly the usage of precast elements such as movable fences and dome for a cathedral.

The precast construction system saves energy, recycles materials by the demolition of old precast buildings and reusing them again as a road base or using it to protect shorelines. Another

advantage of precast units is that we can disassemble the units and re-use them again in another site, for example, re-using a project fence for one site after it ends in another project due to the ease of erection and re-erection of the fence precast units (Benn, Edwards and Williams, 2014).

According to LEED (Leadership in Energy and Environmental Design rating system) (VanGeem, 2006), which is the standard for certification and design guide for sustainability in construction, the precast construction projects can achieve up to 23 points for this certification for new buildings (Council, 2005). Table 2.1 represents a project checklist and precast concrete points according to LEED.

Figure 2.3 Example of precast movable fence (By the Author)

Figure 2.4 precast dome for cathedral (By the Author)

LEED Category	Credit or Prerequisite	Points Available
Sustainable Sites	**Credit 5.1**: Site Development, Protect or Restore Habitat	1
Sustainable Sites	**Credit 5.2**: Site Development, Maximize Open Space I	1
Sustainable Sites	**Credit 7.1**: Heat Island Effect, Non-Roof	1
Energy and Atmosphere	**Prerequisite 2**: Minimum Energy Performance	-
Energy and Atmosphere	**Credit 1**: Optimize Energy Performance	1—10
Materials and Resources	**Credit 1.1**: Building Reuse, Maintain 75% of Existing Shell	1
Materials and Resources	**Credit 1.2**: Building Reuse, Maintain 95% of Existing Shell	1
Materials and Resources	**Credit 2.1**: Construction Waste Management, divert 50% by weight or volume	1
Materials and Resources	**Credit 2.2**: Construction Waste Management, divert 75% by weight or volume	1
Materials and Resources	**Credit 4.1**: Recycled Content, the post-consumer recycled content plus one-half of the preconsumer content constitutes at least 10% (based on cost) of the total value of the materials in the project	1
Materials and Resources	**Credit 4.2**: Recycled Content, the post-consumer recycled content plus one-half of the preconsumer content constitutes at least 20% (based on cost) of the total value of the materials in the project	1
Materials and Resources	**Credit 5.1**: Local/Regional Materials, use a minimum of 10% (based on cost) of the total materials value	1
Materials and Resources	**Credit 5.2**: Local/Regional Materials, use a minimum of 20% (based on cost) of the total materials value	1
Indoor Environmental Quality	**Credit 3.1**: Construction Indoor Air Quality Management Plan, During Construction	1
Innovation and Design Process	**Credit 1.1**: Apply for other credits demonstrating exceptional performance it	1
Innovation and Design Process	**Credits 1.2**: Apply for other credits demonstrating exceptional performance	1
Innovation and Design Process	**Credits 1.3**: Apply for other credits demonstrating exceptional performance	1
Innovation and Design Process	**Credits 1.4**: Apply for other credits demonstrating exceptional performance	1
Innovation and Design Process	**Credit 2.1**: LEED Accredited Professional	1
Project Totals		23

Table 2.1 Project checklist; precast concrete points (Adopted from VanGeem, 2006, p. 45)

FACTORS AFFECTING USING PRECAST GLOBALLY

Despite its advantages, factors are affecting the use of precast construction systems worldwide and in Egypt as well. Due to the lack of experience in the precast construction field, the following are generated (Polat, 2008; Arditi et al. 2000):

- Components similarities of precast construction system problem that are not possible to understand by contractors and designers

- Insufficient education material and programs in universities discussing precast construction in most of the engineering programs such as structure engineering
- Shortage in experts precast structure design
- Most contractors and designers think that architectural design is limited regarding creativity when we use the precast construction system in comparison with the traditional system that gives more options.
- Most designers now believe that precast buildings perform well in an earthquake, on the other hand from experience in Egypt consultants have concerns regarding this matter when using the precast system
- Transportation costs can be discouraging.
- The coordination process between client, consultant, contractor, and designers are poor and need to be improved.

PROBLEM-SOLVING METHODS AND TECHNIQUES

To solve the lack of knowledge problem we must start from universities by implementing the precast material in detail with all of its technicalities, architectural, structural and coordination fields of precast industry must have more data and experiments with the universities.

Students must visit precast construction sites and factories to observe the production and erection process themselves, also they need to know about the precast components, the material used, and the coordination process used in real life. Afterward, a student should submit an assignment regarding what they have learned and all the questions they have.

The student should have some case studies summary tasks to enlighten them about all the different details they need to know and to learn more about all the facts and problems that face this field (Polat, 2008; Dulaimi and Tanamas, 2001).

RELATION OF PRECAST WITH SUSTAINABILITY IN EGYPT

The requirement of the Egypt vision 2030 is to construct almost a new infrastructure and new sustainable cities by the year 2030 (as shown in figure 2.7).

To meet this goal, most of the construction systems converted from traditional methods to a precast construction system due to its main advantage of saving time with the same, if not, a better quality. Accordingly, important growth took place in the precast industry in the last 4 years. Shown by figure 2.5, the new capital city parking lot in Egypt is built using the precast system combined with cast in-site method.

Figure 2.5 New capital city precast and cast in-site car parking project (by the Author)

The new capital city will consist of 21 residential districts to have the capacity to contain double the population in Cairo, with a new park bigger than the New York City park and some artificial lakes with educational institutes, hotels, mosques, churches, hospitals, and malls (URL 4).

The new administrative capital, New Mansoura City and New Alamein City (Figure 2.6) are three of the main new cities that Egypt planned to construct soon including many residential projects in them to sustain the increase of the population (URL 5).

Figure 2.6 Precast Fence for a construction site in New Alamein City (by the Author)

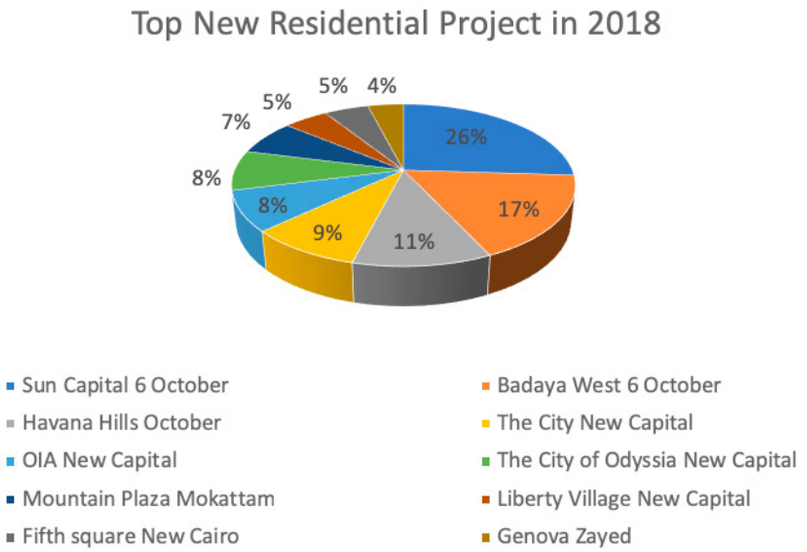

Figure 2.7 Top New Residential Project in 2018, (Adopted and retrieved from URL 6)

RESISTANCE FACTOR TO THE GROWTH OF PRECAST CONSTRUCTION IN EGYPT

Regarding the need to use the precast system to cope with this fast track project the problem of lack of experience faced this system and the process of convincing the consultant about the advantage of the system and its safety regarding earthquakes and having better quality than the traditional system took place. Precast construction companies such as Orascom construction (concrete products division), which the author of this paper worked in, used to go into a negotiation for months before submitting the offer just to prove the advantages of precast construction which negatively affects planned time duration.

Another problem faced by the precast construction companies is the lack of experienced laborers, installation workers, and engineers, that had been solved but with the cost of losing some time and decreasing the profit by creating training courses both practical and theoretical to those who were in need. As a new system, the coordination issue appeared between the site, design team, consultant companies, and client that slow down the progress of the project and increasing the project planned schedule by almost 15%. Another problem that companies face is the absence of experienced designers in Egypt.

Few design companies had enough experience to be the only option for proper design and this limitation led to the increase of the design cost and also increase the design duration which affects the cost negatively, leading to one of two scenarios, either increase cost on the client or reduce profit for precast construction companies.

The availability of proper trucking companies that can transport a special precast element from the production factory to the construction site is also limited. With a negative effect on the cost, only regular trucks are available, for precast construction companies to overcome this problem the full production line for producing special precast elements was relocated to construction sites saving transportation cost and time.

Regarding raw materials used for production, they are freely available, but the real problem is the accessories which are not

available in Egypt and must be imported from other countries with a huge cost. As a result of adding transportation cost and taxes on its original price.

Figures 2.8, 2.9. 2.10 and 2.11 represent some of the precast construction projects in the last 5 years for ORASCOM construction-precast products division.

Figure 2.8 First Precast Garage in Egypt - New Capital Opera 500 Project (By the Author)

Figure 2.9 Production of precast Element for a product hub in Ain Sokhna city- ASPH (By the Author)

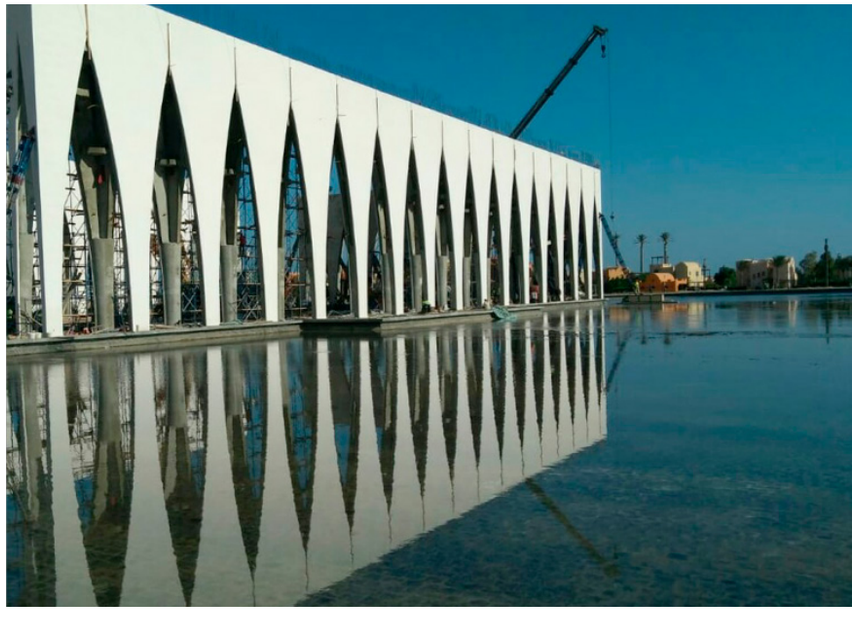

Figure 2.10 Production of the biggest precast panels in Egypt up to 21 meters in GOUNA City - GOUNA Conference and concert center

Figure 2.11 Precast Segment rings with diameter of 12.60 m under Suez Canal (Author)

CASE STUDIES

CASE STUDIES OBJECTIVE

The goal of having case studies is to illustrate the advantages and disadvantages in the system and how sustainable is the pre-cast construction to adjust our used traditional methods to avoid the disadvantages that cause problems.

AMRAPALI DREAM VALLEY TOWERS

Amrapali Dream Valley, mixed CIS-Precast high-rise residential towers, designed by Architects Gian P Mathur (GPM, India), and E. Construct, U.A.E is the structural designers. The project is vetted by IIT Delhi (Lachimpadi et al. 2012).

Figure 2.12 Dream Valley: Overall Layout Plan, (Lachimpadi et al. 2012) up to 21 meters in GOUNA City - GOUNA Conference

Figure 2.13 Typical apartment floor plan, (Lachimpadi et al. 2012)up to 21 meters in GOUNA City - GOUNA Conference and concert center (By the

SUMMARY AND RESULTS

This project is in west Greater Noida, Delhi NCR, with a total of 47 high- rise towers, 379 villas and other developments. With a total built-up area of 10 million square feet, a total of 3.7 million square feet were planned to be constructed using the precast system, in this case, we will only talk about one building that contains 12 apartments/floor, the carpet area of 430 sq ft, as illustrated by the table 2.2 (Lachimpadi et al. 2012).

Dream Valley – Series A (Tower A1-A7), High Rise Residential Buildings	
Overall built-up Area (Precast+CIS)	10 Million Sqft
Built-up area planned in Precast	3.79 million Sqft
Built-up area of A series (A1-A7)	8.82 lacs Sqft
Structural frames	2B+G+18 Floors
Total apartments	1500 apartments; 12 apartments per floor
Structural system (Sub-structure)	Raft foundation (CIS)
Structural system (Super-structure)	Hybrid Precast Construction (Shear walls & Core in CIS)
Basement, Ground & terrace work	Cast In Situ
1st to 18th floor	Precast beams, wall panels, balconies, claddings, staircase, & hollow core slabs
Total precast concrete volume (m3)	~16000
Total Nos. of Precast elements (Tilts + HCS)	25000

Table 2.2 Details of tower A of the case study (Lachimpadi et al. 2012)

From this case study, it was found that the precast construction can greatly respond to the market demands, mixing precast with the cast in place system can offer more efficiency for time, quality and cost. Using the precast system for mass production of precast elements reduces the cost of production, reduces the construction time and labor required on-site that impact directly in the cost. Using the flexible design and longer clear spans precast construction it is considered to be one of the most sustainable methods of green building objectives (Lachimpadi et al. 2012).

UK PRECAST COMPANIES (LIST AND EXPLANATIONS)

A questionnaire survey held in January 2006 in the UK, four precast companies were interviewed to investigate their policies, procedures and the used construction systems, how are they managing the ecological range in environmental protection and resources used, these are referred to as A, B, C, D (Holton, Glass, and Price, 2010). Table 2.3 represents the comparison of some characteristics for each company such as age, ownership, products and so on

Characteristic	Company A	Company B	Company C	Company D
Age	Established over 100 years	Elements of the company have been established over 100 years	Established over 50 years	Established 1972
Ownership	UK based plc quoted on the London stock market	Part of a privately owned Belgian industrial group	Part of an international group of companies, which are quoted on the Danish stock market	Privately owned UK based company
Products/markets	Concrete and natural stone hard landscaping products for the UK construction, home improvement and landscape markets	Roofing and cladding solutions to the UK construction and house building markets	Aircrete products for the UK construction and house building markets	Prestressed flooring and roofing products, stairs, staircases, terracing units and bespoke items to the UK construction market
UK infrastructure	18 quarries, 38 manufacturing sites of which 18 are precast, 12 service centres, 5 regional sales offices and 12 administrative offices	3 concrete tile factories, 3 clay tile factories and a head office	4 manufacturing plants at 3 locations plus a network of distribution depots and a head office	1 manufacturing site comprising 3 factories and associated offices
Employees	Approximately 3000	Approximately 1000	Approximately 350	Approximately 150

Table 2.3 Comparison of some characteristics for each company (Holton et al. 2010)

RESULTS

In this questionnaire and interviews of the four companies in the UK, it was found that managing for sustainability for all companies is based on the approach of the ISO 14001. Development for the organizations are focusing on improving their environmental performance towards eco-efficiency and also doing a good job in achieving socio-efficiency for achieving a sustainable system by broadening their focus on sustainably and trying to use their human capabilities with the best methods (Holton et al. 2010).

FINDINGS

Precast construction system is a sustainable system that is used worldwide and for the past 5 years, this industry has grown in Egypt. Most of the new sustainable cities in Egypt had implemented precast construction. Despite its many advantages, this system is still facing problems. To improve the adoption of precast construction different types of awareness are needed, starting from awareness at universities by including a proper data in the course of precast industry with many practical pieces of training and case studies about the topic, this would increase the number of capable professionals needed in the design process and also in the construction process.

The government has a huge role regarding community awareness by implementing the precast construction widely in their projects and highlighting its advantages for the whole community. As for the on-going precast construction companies, internal training programs must take place to implement the proper

For the employee to improve his skills, companies must launch training programs for different BIM uses in precast. Another method of increasing the employee skills is by sending him to a country that has more experienced and complicated projects of precast so that the employee could learn the latest techniques and methods used in these countries.

SUMMARY

Egypt vision 2030 was launched in 2016 so that the country can cope with the world changes, especially with the sustainability goals of the UN “SDGs 2030”. The focus of this section is on Sustainable cities and the community's goal using precast construction as a sustainable system. Advantages of the precast construction such as faster production, durability, reducing waste and cost are illustrated.

On the other hand, the problems facing the precast industry from lack of experience and clients concerns of usage for that system are also stated, not only that, solutions to solve this problem by different types of awareness systems are discussed, the method used is a mixture of qualitative and quantitate analysis by using two different case study regarding the topic and the author background as a precast construction engineer for the past three and half years in Egypt.

RECYCLING CONSTRUCTION AND DEMOLITION WASTE (CDW)

Recycling could be defined as the process of reusing unwanted materials to be available for use in the production cycle (Tam and Tam, 2006). This process can reduce raw material consumption, decreases waste generated volume and provide the market with more jobs for more people.

Starting this process with efficient collection and separation systems is crucial. Even though the system of waste classification is not the same in all countries, generally, CDW generated in two classes. The first includes stones, concrete, mortar, and ceramic, which can be considered as the most quantities for CDW. The second class related to metal, glass, wood, plaster, plastic, and more (Eduardo Souza, 2019).

DEFINING CONSTRUCTION AND DEMOLITION WASTE

Simply, waste is any kind of equipment, product, and the material becomes useless (Ferguson, 1995). Construction waste is generated in many shapes and always mix different kinds of materials such as plastic, steel, soil excavation, and others (Zainun and Othman, 2015).

To start managing the construction waste it needs to be a clear definition for waste, ‘what is waste’ and at what time the product or material is considered to be waste. But there is no exact definition for construction waste (Osmani, 2012) and here the most commonly used definitions. Waste can be considered as the material needed to be discarded because it has fallen out of the chain of utility or normal commercial cycle (Ferguson, 1995).

The Building research establishment defines construction waste as the difference of the quantity of material that has been purchased and those used in the project (Kulatunga et al. 2006). The Environmental Act (1990) defined waste as the produced scrap material, liquid waste, or other excess substance of any process (Al-Hajj and Hamani, 2011). According to Hong Kong Polytechnic waste can be defined as any product that is produced and removed from the construction, demolition, and renovation processes of building and civil engineering structures (Al-Hajj and Hamani, 2011).

Construction waste according to Harvard Green Campus Initiative, 2004 as any kind of material of solid waste that results from construction, renovation, remodeling, and demolition operations (Madushanka et al. 2018). The European Council Directive 91/156/EEC defines Construction waste as any useless material that needs to be discarded by the holder (Ferguson, 1995).

Shown by table 3.1, different types of CDW generated in Finland from buildings, rehabilitation or demolition of buildings estimated by 18.40 million tons in 2011 and 16.0 million tons in 2012. These quantities were divided into two major categories: hazardous CDW and Non-Hazards CDW (Deloitte, 2015).

Waste category	Quantity generated in 2011 (million tonnes)	Quantity generated in 2012 (million tonnes)
Non-hazardous CDW	**18.1**	**15.9**
- CDW from buildings (estimated)	(1.7)	(1.5-2)
- Soil (estimated)	(appr. 16)	(appr. 14)
Hazardous CDW	**0.33**	**0.15**
Total CDW	**18.4**	**16.0**

Official statistics for Finland include soil waste that cannot be used on-site or recycled. Non-hazardous CDW from buildings, rehabilitation or demolition of buildings presented for 2011 and 2012 are estimated based on other sources than official statistics of Finland

Table 3.1 Quantities of generated CDW in 2011 and 2012 in Finland (Deloitte, 2015).

According to the Finland statics website the generated amount of construction and demolition waste estimated by 15.06 million tons with approximately 14.37% of the total. Figure 3.1 shows the distribution of waste generated by the sector (Espo and Vahvelainen, 2017).

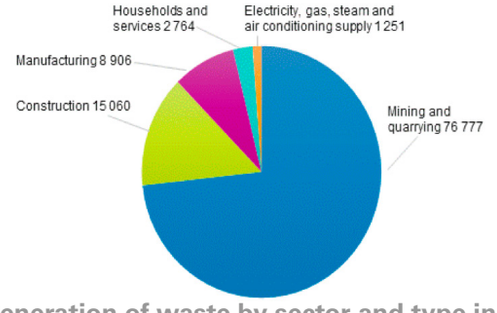

Figure 3.1 Generation of waste by sector and type in 2015, 1,000 tonnes per year (Espo and Vahvelainen, 2017)..

Table 3.2 lists the amount of waste generated in Finland 2015, 2016, and 2017 respectively. Table 3.2 was generated from the statistics Finland website under the following selection criteria (Figure 3.2).

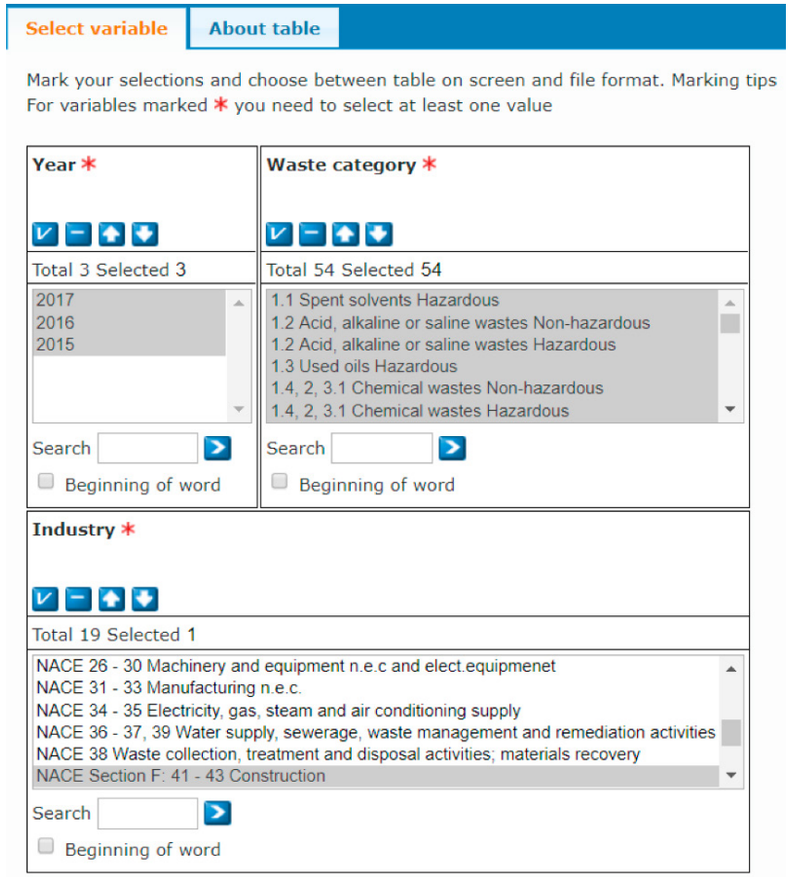

Figure 3.2 selection criteria used to generate Table 3.2

Waste generation in 2015 - 2017 by Waste category, Industry and Year			
NACE Section F: 41 - 43 Construction			
	2015	2016	2017
1.4, 2, 3.1 Chemical wastes Non-hazardous	0	0	36
1.4, 2, 3.1 Chemical wastes Hazardous	0	0	0
3.2 Industrial effluent sludges Non-hazardous	23	3	0
3.3 Sludges and liquid wastes from waste treatment Hazardous	0	0	2
6.1 Metallic wastes, ferrous Non-hazardous	43,929	53,131	67,850
6.2 Metallic wastes, non-ferrous Non-hazardous	1,929	2,734	11,555
6.3 Metallic wastes, mixed ferrous and non-ferrous Non-hazardous	66,583	69,871	85,060
7.1 Glass wastes Non-hazardous	196	161	95
7.2 Paper and cardboard wastes Non-hazardous	40	22	0
7.3 Rubber wastes Non-hazardous	122	0	0
7.4 Plastic wastes Non-hazardous	6,917	6,802	8,712
7.5 Wood wastes Non-hazardous	278,857	263,996	192,343
7.5 Wood wastes Hazardous	809	4	532
8 (excl. 8.1, 8.41) Discarded equipment (excluding discarded vehicles, batteries and accumulators wastes) Hazardous	45	54	0
9.1 Animal and mixed food waste Non-hazardous	2	0	0
9.2 Vegetal wastes Non-hazardous	2,929	1,026	749
10.1 Household and similar wastes Non-hazardous	1,397	5,966	6,908
10.2 Mixed and undifferentiated materials Non-hazardous	3,000	7,763	0
10.3 Sorting residues Non-hazardous	12,317	20,074	22,280
10.3 Sorting residues Hazardous	0	31	0
11 Common sludges Non-hazardous	314	29	255
12.1 Mineral waste from construction and demolition Non-hazardous	1,226,394	1,267,270	1,081,313
12.1 Mineral waste from construction and demolition Hazardous	47,267	48,311	61,857
12.2, 12.3, 12.5 Other mineral wastes Non-hazardous	9,791	4,360	44,054
12.2, 12.3, 12.5 Other mineral wastes Hazardous	32,562	32,914	39,269
12.4 Combustion wastes Non-hazardous	50,608	2,900	683
12.6 Soils Non-hazardous	13,165,490	11,964,391	13,065,747
12.6 Soils Hazardous	105,166	60,115	36,845
12.7 Dredging spoils Hazardous	0	4,720	0
12.8, 13 Mineral wastes from waste treatment and stabilised wastes Non-hazardous	3,664	8,520	488
Total	15,060,351	13,825,168	14,726,633
Of which hazardous:	185,849	146,149	138,505

Table 3.2 Construction waste generated in Finland 2015, 2016, and 2017 (statistics Finland)

CDW ENVIRONMENTAL IMPACT

The relationship between construction waste and demolition is straightforward since the products used in construction work come from industrial processes whose raw materials are derived from nature, thus generating a lot of waste during these manufacturing processes and thus returning to the environment again, causing a lot of pollution.

Therefore, waste production should not exceed the absorptive capacity of the environment until the supply of raw materials is continuous.

In other words, construction and demolition wastes have an impact on the environment, most of the generated waste goes to landfills or burning which causes different types of pollution such as climate changes, eutrophication, acidification, and Dispersion of harmful substances (heavy metals, summer smog) considered as the most important outcomes by the ministry of environment in Finland (Junnila and Horvath, 2003).

EXAMPLE OF ENVIRONMENTAL IMPACT

The environmental effect for any building starts from the acquisition of raw material and during production, usage, and ends by disposal as defined in ISO 14040 (1997). The following case study was implemented in southern Finland shows the environmental impact for the construction and demolition process as well as maintenance and use. The building area equals 15600 m2 and volume 61700 m3 and consists of five stories (Junnila and Horvath, 2003). Table 3.3 gives some information about the building parameters such as location, service life, gross floor area, etc.

Building parameters	Value
Location	Southern Finland (Northern Europe)
Service life	50 years
Gross floor area	15,600 m^2
Gross volume	61,700 m^3
Structure	Five floors, cast-in-place concrete, posttensioned floors
Envelope	Brick and curtain wall combination
Operating energy	
• Heat	72 $kW \cdot h/m^2$/year
• Electricity	97 $kW \cdot h/m^2$/year

Table 3.3 Building parameters (Junnila and Horvath, 2003).

Table 3.4 shows the environmental impact for the building for 50 years life cycle starting from building materials passing by construction, electrical service, heating services, other services, and maintenance till demolition.

ENVIRONMENTAL ASPECTS THAT CUMULATIVELY ACCOUNT FOR 80% OR MORE IN EACH CATEGORY.

Office Building	Climate change (ton CO_2 equivalent)	Acidification Kg SO_2 equivalent	Summer smog (Kg H_2C_4 equivalent)	Eutrophication (Kg PO_4 equivalent)	Heavy metals (Kg Pb equivalent)
Building Materials	4800[a]	19000[a]	7600[a]	1900[a]	7.4[a]
Construction	820	5800	530	960	0.3
Electrical Service	25000[a]	59000[a]	4900[a]	5500[a]	3.8[a]
Heating Services	11000[a]	25000[a]	2400	2300[a]	1.2
Other Services	3900	11000	2600[a]	4000[a]	0
Maintenance	1600	8400	5700[a]	850	2.1[a]
Demolition	440	4400	680	720	0.3
Total	48000	130000	24000	16000	15.0

Table 3.4 The impact of an office building for 50 years lifecycle (Junnila and

The study has divided the construction process into two major elements that have a noticeable environmental impact first, equipment used in the process and not permanently attached to the building, second building materials especially concrete. The demolition process has not a significant impact except acidification and the major reason is transporting waste to landfills.

DEFINITION OF WASTE MANAGEMENT

Management of waste is the accurate name of some activities that deal with the collection, transportation, disposal of waste or recycling and monitoring of waste (Pongrácz, Phillips, and Keiski, 2004). It is necessary to plan for the future and presently do the management of waste, in terms of transportation and numbers and capacity of treatment facilities, required. The polices for waste management need to develop to maintain a good system for collection to ensure effective and successful treatment and disposal (FDES, 2018).

WASTE MINIMIZATION DEFINITION

The term waste minimization has a broad definition over the world. It can be defined as any method that could help to reduce the volume of generated waste. According to the European Union, waste minimization is the method to prevent and/or reduce the production of waste from its source and increasing the quality of generated waste by reducing the hazards and supporting reuse, recycling, and recovery (Pongráez, Phillips, and Keiski, 2004, June).

CAUSATIVE FACTORS OF CONSTRUCTION WASTE

The construction waste generation process starts in the pre-construction stage passing by the construction stage and till the finishing stage. Many factors affect construction waste quantity that figure 3.3 describes the causes (Essays, UK, 2013). Controlling project stages such as design, procurement, site conditions, and workers will result in a significant impact on waste reduction

Delivery methods	Procurement	Construction Waste	Rework, Variation and negligence	Operation
Delivery schedules			Unskilled laborers	
Purchase of inadequate materials			Time restraint	
poor quality of material			Poor communication	
No take-back schemes			Poor coordination between trades	
Poor advice from supplier			Inclement Weather	
Poor supply chain management			Lack of awareness	Culture
Damages due to transportation	Handling		Lack of incentives	
Inappropriate handling			Lack of support from senior management	
Poor product knowledge			Lack of training	
Inappropriate Storage				

Figure 3.3 Causative factors of construction waste (Al-Hajj and Hamani, 2011).

WASTE MANAGEMENT HIERARCHY

Many countries have applied the waste management hierarchy concept. In developed countries in the European Union, for example, this concept is used to frame waste management options and it is a part of waste legalization (FDES, 2018). The waste hierarchy is used to rank material and waste management options such as prevention, minimization, reuse (including remanufacturing), recycling, energy recovery, and disposal (FDES, 2018). Figure 3.4 illustrates the waste management hierarchy.

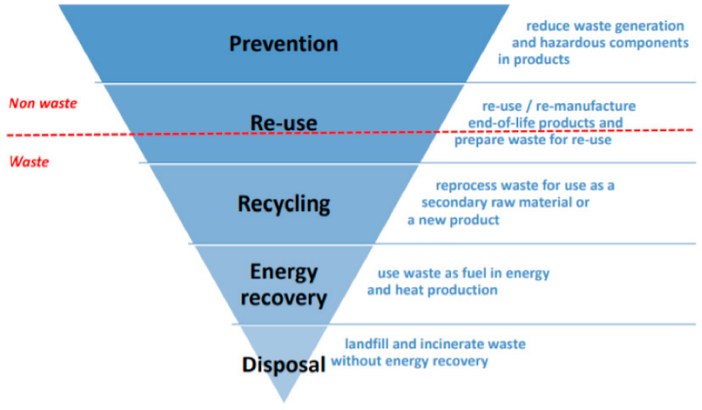

Figure 3.3 Causative factors of construction waste (Al-Hajj and Hamani, 2011).

According to this figure, the hierarchy system starts with prevention which is the most preferable option and ends by disposal which is the last option (FDES, 2018).

Reduce

in the design stage and manufacture of the product, using the minimum quantity of materials by changing or modified design and using hazardless materials (Wang and Tam, 2015).

Reuse

It is the process of using the product again in its main form for the original purpose of an alternative one with or without renewal (Pongráez, Phillips, and Keiski, 2004).

Recycle

Reproduction of waste materials for its original usage or other purposes in case of reuse of the original material is not applicable (Pongráez, Phillips, and Keiski, June 2004).

Recovery

Is the process that diverting waste from landfill (Pongráez, Phillips, and Keiski, June 2004). It can be also defined as the

conversion of non-recyclable material to energy such as electricity, heat or fuel that can reduce the amount of waste that goes to landfills (Essays, UK, 2013).

Disposal

The last option for waste that cannot be reused, recycle, or recovery and ends by landfill.

RECYCLED AND REUSED MATERIALS IN THE CONSTRUCTION INDUSTRY

Concrete

Concrete recycling becomes more needed these days giving the outcome of the demolition. Processability to reuse this concept leads to minimizing the quantity of waste and construction costs (Kumutha and Vijai, 2010). Recycled aggregate produced by special crusher by using hardened concrete as raw material for this process.

Shown by figure 3.5, the concrete process of recycling is started by sending concrete to crushing equipment with large jaws and impactors. The first stage is to break the concrete up then run it through secondary impactor, then the concrete moved through a screen to remove dirt and particles and to separate aggregates into small and large sizes. water flotation, separators, and magnets may also be used as an additional process to remove specific elements from the crushed concrete. These are the steps for recycling concrete (Sonawane and Pimplikar, 2013).

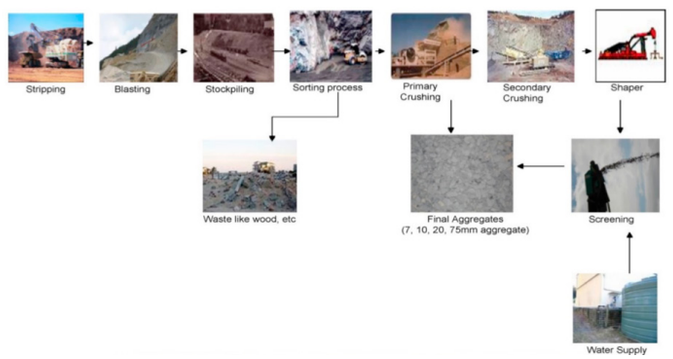

Figure 3.3 Causative factors of construction waste (Al-Hajj and Hamani, 2011).

CASE STUDY ENTERPRISE PARK

Project: Enterprise Park at Stapleton in Denver
Concrete quantity: 7,900 cubic yards (using recycled aggregates)
Usage: Foundation and tilt-up panels
Responsible company: Recreate Materials, Inc
Aggregates quantity: 2,305 tons.

The first stage was the foundation used around 2200 cubic yards of concrete consists of 620 tons of recycled aggregate mixed with fly ash approximately 115 tons. The total weight of recycled materials in the foundation was equal to 735 tons. Another 5700 cubic yards in concrete was used in tilt-up panels that contain approximately 1570 tons of recycled aggregates and that was the major use of recycled concrete in a tilt-up application on record according to the Tilt-Up Concrete Association (Shah and Pitroda, 2011).

STEEL (WORRELL AND REUTER, 2014)

The steel manufacturing process can be achieved by mixing of two major materials which are iron ore and coal, both are going together into a blast furnace with high temperature, or by using scrap recycling, which is prepared in an electric furnace. The amount of steel production for the whole world reached 1547MT in 2012.

The Roman Empire was the first who started recycling steel it was done by collecting war instruments in pits and burn it to produce new weapons. Steel can be used endlessly and changed into new items without loss of quality. For example, in western Europe, the steel scrap that is used to produce new steel is about 50-55%.

The recycling process leads to decrease the consumption of electrical energy by 80%, producing a lower environmental influence and abolishing completely the extraction of raw materials, as well as, too much lower emissions to the environment in general, using an electric furnace to producing steel from scrap lead to lower emissions of CO2 and total energy consumption. Table 3.5 represents some recycling rates in the steel industry. Many products can be made from steel scrap such as wires,

nails, rebar for reinforced concrete, and some other metal profiles made from scrap.

Application Area	Estimate for 2007 (%)	Target for 2050 (%)
Construction	85	90
Automotive	85	95
Machinery	90	95
Appliances	50	75
Containers	69	75
Total	83	90

Table 3.5 Steel Industry Recycling Rates (Worrell and Reuter, 2014).

NEWSPAPER WOOD

This product idea was innovated in Norway, wherever over 1million tones of cardboard and paper are recycled once a year. The process is to roll up the paper and solvent-free glue to create wood panels, then chopping it into usable planks. The wood will then be treated to be waterproof and flameproof (Lori Zimmer, 2011).

RECY BLOCKS

These colorful bricks are made up of previous plastic luggage, which is notoriously troublesome to recycle in the other method. Recycled luggage or plastic packaging are placed in a very heat mold and compelled along to make the blocks. They are too lightweight to act as bearing walls; however, it can be used to divide up rooms or out of doors areas (Beitiks, 2010).

BOTTLE BRICKS

This proposal may be different because it depends on manufacturing a client smart specifically thus it will later be used as an artifact. Numerous corporations currently create bottles in cuboid or alternative tessellation shapes, to form them easier

to move (Wilson. 2013). Figure 3.6 shows the sample of bottle bricks.

Figure 3.6 Bottle bricks (Wilson, 2013)

GYPSUM/PLASTERBOARDS

The amount of 15 million tons of gypsum board are generated every year in the whole world during the production, construction, and demolition works which causes a massive environmental impact due to landfill. In the landfill process, plasterboards produce a massive amount of hydrogen sulfide (H_2S) gas.

The main issue of the recycling process is contamination in loads, plasterboard waste usually is mixed with metals, glass, bricks, and plastics that's can slow the recycling process.

The recycled mineral powder makes up 94% of the wallboard waste recycled and can substitute virgin mineral raw materials at the gypsum intense industries (Kuosa, 2012). Figure 3.7 represents the recycling of gypsum boards.

Figure 3.7 Plasterboard recycling (Kuosa, 2012)

The recycled plaster/gypsum boards could be used in producing new plasterboards, cement manufacture, and agriculture. The recycled boards can make up 22% of the feedstock for new plasterboard products without affecting quality, also up to 33% of recycled boards reported as successfully integrated with new products.

MINERAL WOOLS

The method of recycling of mineral wools composite panels is developed by Eurobond, this method separates the two components of composite boards to mineral wool and steel and the separated items could be used to produce new panels (Kuosa, 2012). Illustration of the segregation and recycling process is shown in figure 3.8.

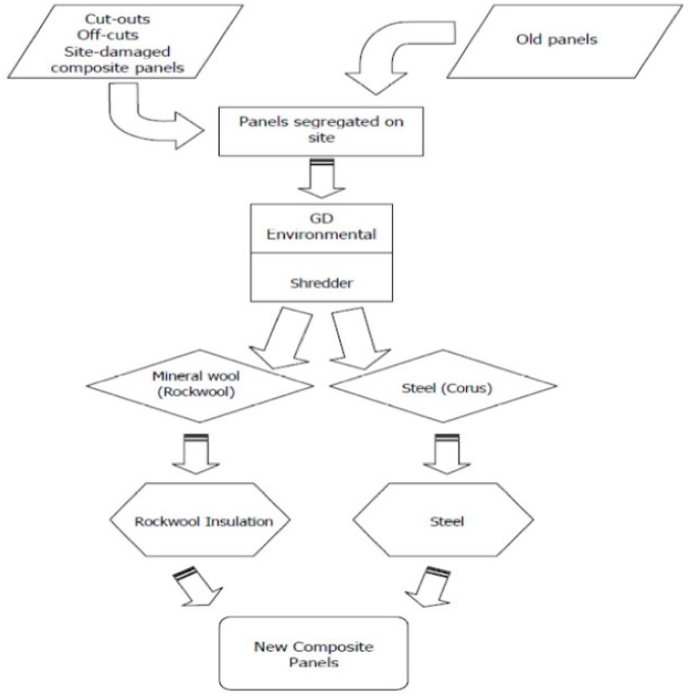

Figure 3.8 Flow chart illustrating the segregation and recycling process (Kuosa, 2012)

SUMMARY

The problem of CDW is considered as an important issue facing the concept of sustainability. This paper presented the problem from different aspects by explaining waste definitions, classification, environmental impact, waste management, examples for recycling and reuse of waste, and finally, the governmental decrees and decisions that have been applied in Finland to face the problem. CDW can also be generated by wars and conflicts the same as in Syria and Iraq, millions of tons of CWD were produced due to the ongoing wars and are a sustainability problem.

During the reconstruction of those destroyed cities, clear criteria must exist when dealing with this massive amount of waste to optimize the maximum benefits.

To solve the problem of CDW and to reach construction and demolition waste closed-loop, more supports for research programs for CDW, which will help maximize the value of waste are needed. Also, it's needed to innovate new methods to treat with CDW. To minimize the CDW, above mentioned causative factors need to be avoided. This can be done through the proper optimization of new technology such as using Building Information Modelling (BIM).

BIM concepts and tools can be efficiently utilized in the design, procurement and handling activities in a project to perfectly minimize CDW. Also, it is required to increase the level of awareness and professionalism for construction field workers to avoid material waste and rework for activities.

ECO-FRIENDLY BRICKS AND SUSTAINABILITY

TRADITIONAL VS. ECO-FRIENDLY BRICKS: LIFETIME ENVIRONMENTAL IMPACT

Traditionally, clay bricks have been used regularly. This is no surprise since its easy, resilient and cheap construction application cycle. However, the manufacturing of traditional masonry bricks (e.g., limestone clay block, concrete block, cast stone blocks) has negative effects on the environment, and by implication contributes to climate change (Global Warming Potential "GWP"). Particularly, clay bricks masonry is mostly made by being exposed to fire and high temperatures, and hence carbon emissions. Furthermore, utilizing fly ash and clay additives from traditional bricks are in most cases inefficient in terms of environmental impact as well as health (Oti, Kinuthia and Bai, 2009).

THE IMPACT OF CHEMICAL REACTION ON THE CLAY BOND

The limestone inside the soil, with the presence of water, will grow the pH components due to OH ions. As a result of such high pH conditions, pozzolanic reactions arise. The SI and Al that integrate and shape a part of the clay matrix to form a form of loose Ca2+, resulting in cementation compounds. These compounds are responsible for enhancing the mechanical performance of the clay soil. Nonetheless, such improvement usually results in longer production periods (Oti and Kinuthia, 2012).

INSULATION OF TRADITIONAL BRICKS

A clear limitation of traditional bricks is that they cannot be laid when raining heavily or in freezing temperatures. Additionally, traditional bricks have poor water-proof characteristics as well as weak thermal insulation performance (Doran, 1986). The major cons of traditional bricks that have a cavity, there is a limitation about the cost to add layers to plug these cavities. It's possible to enhance the performance of insulation by using some chemicals like urethane board but it's expensive to fill all the cavity it will lead to high-cost factors. Besides, wet areas traditional bricks need time to dry (Fewins, 2004). All these factors lead us to look for alternative masonry, which is Eco-friendly bricks.

ECO-FRIENDLY BRICKS

It can be defined as an environmentally friendly brick made from recycled substances like recycled glass and aggregate construction and natural material like straw, hemp, and bamboo. The main characteristic of the Eco-Block is to catalyze the nitrogen oxide and other polluted material into safe-to-use materials. Occasionally photocatalyst is used to enhance the outer surface layer of eco-bricks. The photocatalyst is a material like titanium, which forms a chemical reaction when it absorbs light (Hossain and Cheng, 2016).

ECO-FRIENDLY BRICKS TYPES AND HOW FEASIBLE ARE ECO-FRIENDLY BRICKS AS THERMAL INSULATION FOR BUILDINGS?

HEMP CRETE BRICKS

Hemp Crete is indeed an incredible natural and sustainable insulation material. It can be used in construction as well as insulation of the building envelope. Conveniently, hemp has a lime plaster skin which eliminates the need for gypsum and vapor barriers, thus less material uses and less embodied energy/carbon. Figure 4.1 illustrates an example of Hemp Crete eco-friendly bricks.

On a technical note, Hemp Crete is a mixture of hemp, which uses the internal of the hemp straw and some blinder additives as well as natural glue-like lime making it overly durable. Additionally, Hemp Crete can resist fire for safety and mold for healthy indoor air quality. Moreover, it acts as a regulator wall, meaning, it regulates the indoor temperature and humidity levels due to its thickness. However, an industry limitation to the wide application of such material can be literacy levels of workers. Hempcrete requires an extra set of tools, knowledge, and experience.

Figure 4.1 Hemp Crete Bricks, Eco-friendly bricks (James,2020)

RESOURCE AND RESERVES

Hemp is a renewable resource. It can gather with excessive yields on the basis and can be extensively grown in Ireland. Lime, on the other hand, is non-renewable. But it is wealthy in limestone ore and the prevailing available international reserves of limestone globally are very huge (Daly et al. 2012).

HEMP CULTIVATION AND PROCESSING

The cultivation of hemp requires low extra inputs; low ranges of fertilizer and mechanized paintings resulting in s transport emissions (INRA, 2006). Processing of hemp is a low affect operation; it's far primarily based completely on mechanical strength (González-García et al. 2010).

INTERLOCKING BRICKS

It is the compressed mixture of soil between sand and cement which characterized has the ability of earthquake resistance and economical on average 25% less in cost than fired brick.

I

NTER-LOCKING PROFILE FEATURES

As figure 4.2 represents, it is the block, which is a male face on one side, and another female face at its edge and from the lower surface of the block called bed and from the top called Ridge (Deepak, 2010).

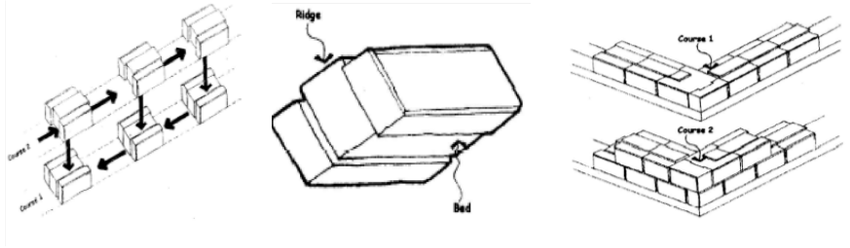

Figure 4.2 Placing of Inter-locking Blocks (Deepak, 2010)

INTER-LOCKING MASONRY SYSTEM

Fly-ash inter-locking blocks can be dry-stacked by using mortar slurry and also can compressed earth blocks (Figure 4.3). Dry stacking is much less system of building masonry unless the first two layers of blocks above the DPC damp-proof course and the head of courses to roof band aren't laid on mortar.

They depend on the mechanism of inter-locking to supply resistance to carry out loads. Dry stacking's outcome is Economical which reduces the cost of buildings that save time, skilled labors and costly materials especially cement the demands for unskilled laborers for making dry stacking. One example of a dry-stacked structure is Egyptian pyramids, which resist external forces on their self-weight (Deepak, 2010).

Figure 4.3 the image shown form of Interlocking Bricks (FCS, 2020)

RECYCLING PLASTIC WASTE ECO-FRIENDLY BRICKS

Everyday recycling waste materials increases rapidly, according to 2012 report global industry analyst the plastic consumption worldwide is evaluated at 260 tons and by 2015 reached 297.5 million tons. Plastic is very light, flexible, cheap and moisture resistant. The usage of plastic increases every day in many fields. The innovative method of reusing waste materials by using soil and plastic to produce geo plastic bricks. The uses of geo plastic bricks in the pavements to prevent land pollution and decrease the cost of rigid pavement and create an eco-friendly environment. Geo plastic bricks are not only used in the rigid pavement but also used in the construction partition wall of residential and industrial buildings; shown in figure 4.4 (Ferroukhi et al,2013).

Figure 4.4 Plastic bricks and Recycle plastic material bricks (ESH, 2018)

ECO-BRICKS MADE OF PLASTIC

Simply by using a high temperature of the water and compressed the plastic, you can produce the eco durable bricks with the required shape and size. The product will be non-toxic and eco-friendly which produces 95% lower greenhouse gas emission compared to concrete and clay bricks, furthermore, it characterized with very high insulation (Baluchami, Neelaveni, and Murugesan, 2012).

PRODUCTION OF BRICKS THROUGH WASTE MATERIALS

Literature explains that to utilize waste material to produce bricks, the process is divided into three main categories, based on manufacturing variations: Geo-polymerization, firing, and cementation.

WHAT ARE THE IMPACTS OF ECO-FRIENDLY BRICKS ON INDOOR AIR QUALITY?

There are various methods to produce Eco-friendly blocks many countries now use the waste materials and recycling processes to obtain Eco bricks. Companies convert the plastic waste in construction by fusion methods. Machine dubbed the blocker turns plastic debris into construction material, some machine rag the plastic into pieces then superheat water so it can convert any type of plastic into construction materials. Waste is diverted from landfills, deems such bricks have a high ability to resist cracks or crumbles compared to traditional concrete bricks, more importantly, producing less greenhouse gas emissions.

PRODUCTION OF ECO-BRICKS BY USING STONE SLUDGE AND FLY ASH

Many different waste materials are used in brick industries like stone sludge, fly ash and natural fibers. Fabrication of Eco-friendly Bricks by using stone sludge and low-grade silicon carbide is possible using 5% up to 40% of low-grade silicon carbide (LGSC).

Excavated soil is reused as a raw material in eco brickmaking and standard of the percentage of raw materials in Eco-brick making which is using 10% granite sludge, 30% LGSC and 5% brick waste grinder will produce grade 2 Eco bricks under temperature 1050 °c. Water absorption of eco brick has increased. Also, the ratio of LGSC increases but the compressive power increased at the same time as water absorption decreased at this point the operation of temperature Enhanced to 1,020°c (Min-Hsin, Tsai, and Yi-Le).

Another way by replacing fly ash and quarry dust by a certain amount of admixture on cement, the scientists make trials to demonstrate that the percentage of cement content can be changed with quarry dust 25% without any change in the physical properties and compressive strength (Rangabhashiyam et al. 2014).

FLY ASH AND GEOPOLYMERS

Based on the experiment Fly ash materials is the best alternative to traditional burnt clay, by using (60%-80%) fly ash and lime (10%-20%) and gypsum (10%) fed into a mixer and sufficient water, it concludes FaL-G bricks. It is adequate for construction which is more economical and has high strength and durability compared to traditional bricks (Mistry et al. 2011).

Geopolymers resins and blinders are considering one of the most efficient additives on flash because of its resistance of fire, high thermal insulation and heat resistance coating, mostly river sand is used in geo-polymers it is not graded properly but can be specified to the strength of steel in bricks which manufactured sand without silt or organic wrinkles (Subramani and Sakthivel, 2016). Figures 4.5 and 4.6 present the schematic diagram and processes of manufacturing fly ash bricks.

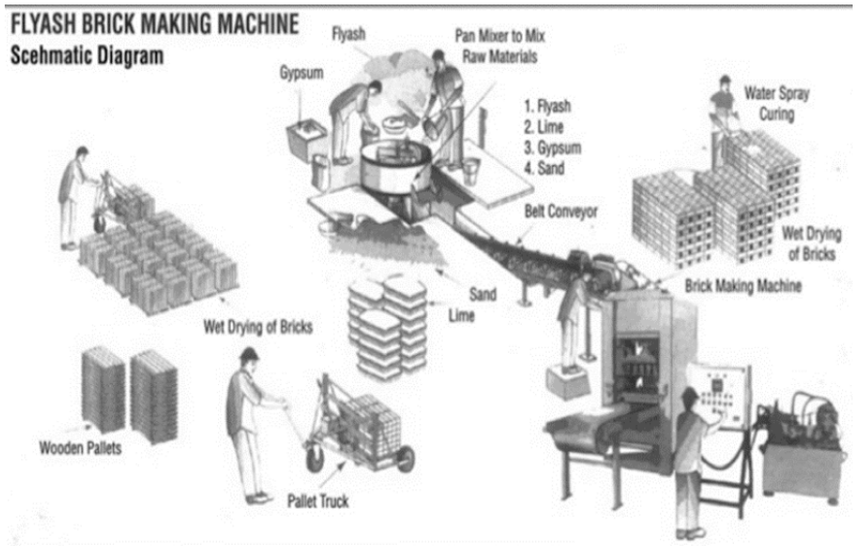

Figure 4.5 Schematic of manufacturing fly ash bricks; FaL-G Bricks (Pradeep, and Gowda, 2013)

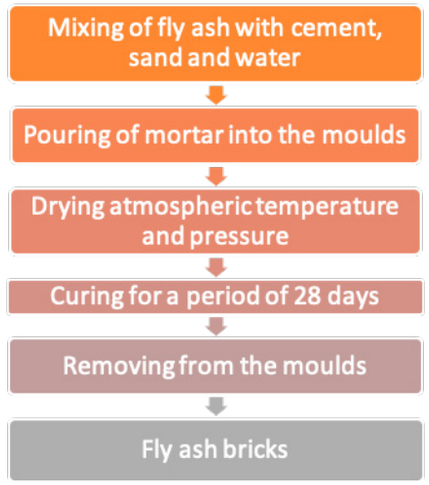

Figure 4.6 The processes of the manufacturing fly ash bricks (Kaushike and Maitra, 2015)

RESEARCH CASE STUDY

Tata Power is one of the biggest Indian companies in electric utilities decided to begin a fly ash bricks in Jojobera to offer an entrepreneurial possibility to the local tribal generation (Kaushike and Maitra, 2015).

MARKET STRATEGY FOR BRICKS PRODUCTION

The country expends approximately 180 billion tonnes, which means to consume 340 billion tonnes of clay yearly. The result destroys the top layer of soil and becomes unfertile for a long period. The government is critically worried about the soil erosion for production high amount of bricks because of the extensive housing needs. Engineers innovate the property and durability of fly ash bricks to increase the implementation of buildings and develop the construction of rigid pavements, irrigation works, and tanks. The high amount of fly ash is available and around thermal electrical stations. Then, they set up small units near to the thermal electrical stations to decreases the cost of transportation fees (Kaushike and Maitra, 2015).

USING RICE STRAW IN BUILDING

Every year, approximately 4 million tons of rice straw are produced in Egypt as an agricultural residue (Grace et al. 2009). Unfortunately, in Egypt, there are many sources of air pollution (e.g., open-air waste burning and the cement industry as a whole). Consequently, in the past decade, the black cloud has been frequently present in Cairo (Marey et al. 2010).

Because of disposal by burning rice straw which causes seriously chronic chest disease. This study demonstrates the economic comparison between using rice straw bales and traditionally built with cement bricks which saving 40% of direct cost and also decrease energy consumption and thermal insulation (Grace et al. 2009).

ADVANTAGES OF USING RICE STRAW FOR BUILDING

Straw is a natural fiber. Ancient Egyptians used it in mummification found in their tombs and buried in layers, as though sometimes straw will degrade like all fiber material such as wood, cotton fabric, and paper.

This process depending on the method of storage as the moisture plays a main role in the temperature.to manage a moisture straw structure should be controlled wood-framed (Summers, Blank, and Jenkins, 2003). The straw-bale building is possibly underutilized construction method, in the 1800s USA, built straw bale load-bearing walls (Roberts, 2002).

COST ANALYSIS BETWEEN MASONRY BRICK AND THE STRAW BALE BRICKS

This study concludes the savings by using straw bale units in building load-bearing walls systems instead of masonry bricks. The analysis proved to decrease a direct cost of about 40% when using straw bale units to build a unit of area 3 x 3 m2 with wooden roofing and plain concrete foundation. Also, helping to reduce energy consumption that made an environmental profit.

Moreover, rice straw bales are high insulation properties that decrease the usage of heaters and air conditions and inside the houses (Grace et al. 2009).

CONCLUSION

This research emphasizes the importance of sustainable construction, starting from zero-energy buildings, then explaining the role of precast construction, recycling materials, and demolition waste, and finally, eco-friendly bricks as an approach to decrease negative impacts on the environment by saving natural resources, preventing distractive effects of global warming and to serve to the next generation.

Regarding zero-energy building, it can be concluded that although achieving a zero-energy-energy building is a challenging objective, the use of renewable energy resources has the potential to create a balance between ZEB projects. Based on data in this report, the concept of zero-energy buildings still needs to be improved. To have a smart zero-energy building in the future, the recommendations are to have:

- Mmore energy optimization, active solar system and passive solar system need to be integrated
- Large organized energy systems need to break down to small controlled energy systems
- Optimized designs need to be integrated with operating strategies
- More comfort in zero-energy buildings there must be a predictive control over the energy and also cost performance of the building

As far as the precast system is concerned, the relation between precast construction and sustainability is a fact that no one can deny. The industry is facing some big problems that have to be fixed, but with some dedication, hard work, and better vision, precast construction will prove its true core as one of the most sustainable construction systems.

Likewise, from the recycled material and demolition waste point of view, it can be concluded that project material problems such as mismatch or oversupply could be avoided. This can be done by providing the necessary time for project procurement and supply chain stages. Also, the existence of a precise schedule for

the project that shows the specific dates for all activities helps essentially in saving project materials.

Additionally, it is required for any project to have an effective material tracking system that can help to control project materials. This tracking system would also benefit project parties avoiding mistakes that could occur due to the lack of connection between them.

Finding new ideas and technologies is essential to develop a waste management system. These ideas could include, for instance, creating an online platform to connect all involved parties, minimize waste and making the whole process faster, easier and more controlled. Finally, waste could be wealth with effort, innovation, management, and technology.

It can be elucidated that there are various psychographic, product-specific and demographic factors affecting consumers' preferences for eco-friendly bricks. It is noteworthy for sustainable bricks manufacturers to work closely with governing bodies to establish robust awareness programs to promote the ideals of eco-bricks, with a long-term goal to foster green construction methods, ensuring a fair portion of energy-efficient constructions in the built environment.

To put the use of eco-bricks into perspective, such a sustainable construction approach can have unique benefits to buildings' performance, namely, cost-efficiency, high strength, water resistance, carbon-neutral and low amount of mortar. Indeed, many countries have tended to use Eco-friendly bricks especially hemp Crete because of It maintains a steady temperature, It does not shrink and crack, It is a bio-degradable material, It provides a very healthy environment and It is a breathable material, plus It is actually gaining a lot of strength over time and It can be simply used for insulation.

Moreover, it absorbs the moisture and humidity within the building, and it is one of the best sustainable building materials and carbon emissions produced are very low from hemp Crete.

Hemp Crete puts the power back in the community's hands. It is easy to grow, affordable and environmentally friendly. A community can build a home in a short space of time using sustainable materials such as locally grown wood and hand-cast hempcrete bricks.

FINAL WORDS

The report has identified that in recent years construction sustainable projects have had a significant increase. A sustainable building needs to be maintained and used through accurate management strategies, otherwise, it can be even inefficient if it is used normally. Therefore, management and control over sustainable construction projects play a key role to keep this ambitious goal of making cities more liveable and sustainable.

More importantly, what has been researched in this article was all about the economic and environmental aspects of sustainable construction; however, the importance of social aspects on construction and vice versa is kept yet. Therefore, to get a more accurate result of the efficiency of sustainability in design and construction it is necessary to know the residents' behavior and cooperation towards this approach.

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LIST OF FIGURES

LIST OF TABLES

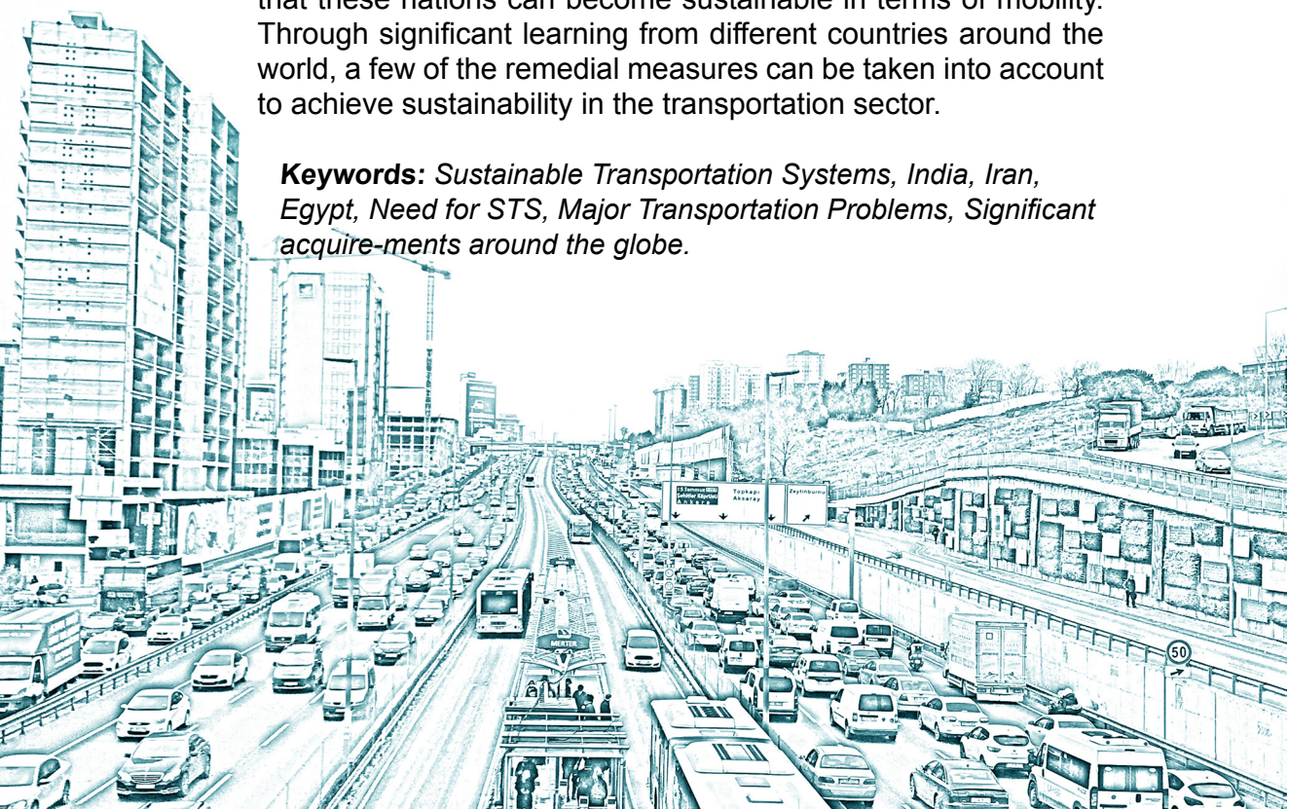
Homa Javadi, Ahmed Ali, Mahmoud Hassan, and Ahmed Aziz

5. SUSTAINABLE TRANSPORTATION SYSTEMS

ABSTRACT

Sustainability illustrates the basic human urge to build a better society for the future and to leave a beneficial and enduring legacy. It has become a challenge for the world, especially the developing countries to accomplish environmentally sustainable transportation systems. This chapter defines sustainable transportation systems, its objectives and its indicators. It aims to identify the need for sustainable transportation in developing nations like India, Egypt and Iran, where there is continuous urbanization. This chapter focuses on the major transportation problems in India, Iran and Egypt and provides reformative measures that can be adopted from developed countries so that these nations can become sustainable in terms of mobility. Through significant learning from different countries around the world, a few of the remedial measures can be taken into account to achieve sustainability in the transportation sector.

Keywords: *Sustainable Transportation Systems, India, Iran, Egypt, Need for STS, Major Transportation Problems, Significant acquire-ments around the globe.*



INTRODUCTION

Progress in any region of the world is now unreasonable without recogni-tion for sustainability. One of the greatest challenges is that countries around the world are facing is to achieve environmentally sustainable transportation systems, particularly developing countries. In terms of sus-tainability, transport is a particularly challenging field. It is essential for the economic and social structure of all the nations but it has many negative environmental and health consequences (Wiederkehr, 2003).

“The goal of sustainable transportation is to ensure that environmental, social and economic considerations are factored into decisions affecting transportation activity” (Burwell, 2006 and MOST, 1999). There should be a link between economic stability, environmental protection and social advancement when sustainable development is applied to transportation systems (Rodrigue, 2017).

People rely on transportation to take them where they need to go in their daily lives. Effective and reliable transportation gives us the freedom to move where we want to be or where we need to be. It makes the busi-nesses and economy thrive and helps us develop our communities. Sus-tainable transport is the key enabler of an inclusive economy and social growth moving us closer to a future where sustainable development is a reality for all (Goals, 2016).

The objective of this chapter is to propose ways to reduce transport’s im-pact on the environment to a degree that is consistent with sustainability. This chapter explains the need for Sustainable Transportation Systems (STS) in developing countries like India, Egypt and Iran.

It identifies major problems with respect to transportation in these coun-tries and explains possible sustainable methods and applications with the help of significant developments from different parts of the globe that could encourage developing countries to become sustainable in terms of transportation systems.

This chapter contains seven sections. Section 1 introduces the importance of Sustainable Transportation Systems (STS).

Section 2 ex-plains the need for STS in developing countries like India, Iran and Egypt. Section 3 outlines the definition, objectives and indicators of STS. In sec-tions 4 and 5, significant and major transportation problems in India, Iran and Egypt are identified and reformative measures have been men-tioned. Section 6 explains the significant steps taken by different coun-tries of the world to make their cities sustainable. Section 7 concludes with possible recommendations for developing countries like India, Iran and Egypt.

THE NEED FOR SUSTAINABLE TRANSPORTATION SYSTEMS IN DEVELOPING COUNTRIES

Urban areas of developing countries like India are witnessing alot of is-sues like poor air quality, an increase in greenhouse gas emissions, chronic congestion, an increase in the number of road accidents and a rise in the number of private automobiles mainly motorcycles (Singh, 2016).

Each city in India is eminently polluted and no doubt 22 out of the world's 30 most polluted cities are in India. This causes the general health of the cities to deteriorate and makes India an unattractive destination for tour-ism and international investment (Sengupta, 2019).

Recently, the World Health Organization stated that nine out of ten peo-ple breathe polluted air and 7 million people die every year as a conse-quence of such dangers. All these effects on health can add up to years of loss of human life. Research in 2015 showed that India's air pollution eliminates 3.2 years from the life expectancy of 660 million people living in the country (Irfan, 2019).

Cairo is Egypt's capital, with a reported 12 million people in 2016 and a suburban population of 20.5 million, making it the biggest city in Africa and the Middle East (Monem, 2020).

As new societies are being created, Greater Cairo's scale is getting larg-er. The growth in population, including the high migration rates from rural to urban areas, makes it one of the largest population densities in the globe. This dense population creates elevated emission standards and causes traffic congestion (Monem, 2020).

Traffic woes seem to represent the lives of the citizens of Cairo. More than 20 million people live in this area, and with more than 2 million cars, most of them spend a disproportionate amount of time in traffic jams (Radwan, 2015).

Iran has one of the biggest oil and gas resources in the world. Because of this cheap and accessible energy, the nation's energy consumption is far higher when compared to the international mean standards. For exam-ple, the per capita energy consumption is 15 times higher than Japan and 10 times more than the EU. As a major global energy consumption, the transportation sector accounted for 12.5 million gallons of fuel in 1967 to nearly 310 million gallons in 2009, this extreme increase in fossil fuels have had a major negative impact on the environment (IEA, 2014).

Due to the mass use of cheap gas, most of the metropolitan areas, espe-cially Tehran, have faced serious air pollution problems and the govern-ment has continued to subsidize this product to keep its price at an af-fordable level, instead of spending more on public transportation infra-structures. These policies have led to more car dependency and as a consequence more air pollution and traffic problems. It is worth mention-ing that motorized vehicles are responsible for 75-80% of the air pollution in Tehran (Jacobson, 2012).

Iranian cities including Tehran, Mashhad, Isfahan, Shiraz, and Ahwaz are among the most polluted cities in the Middle East. Widespread use of older diesel vehicles has put public health in danger by producing a large amount of air pollutants.

Considering the facts and figures from developing countries like India, Egypt and Iran, methods to make the transportation systems sustainable should be implemented effectively by the developing nations.

SUSTAINABLE TRANSPORTATION SYSTEMS

In this section, the definition of sustainable transportation systems, its ob-jectives and its indicators are discussed.

DEFINITION

There seems to be no specific definition of sustainable development, sus-tainability or sustainable transport (Beatley, 1995). According to the Brundtland Commission, 1987, sustainability can be defined as Sustain-able development “meets the needs of the present without compromising the ability of future generations to meet their own needs.”

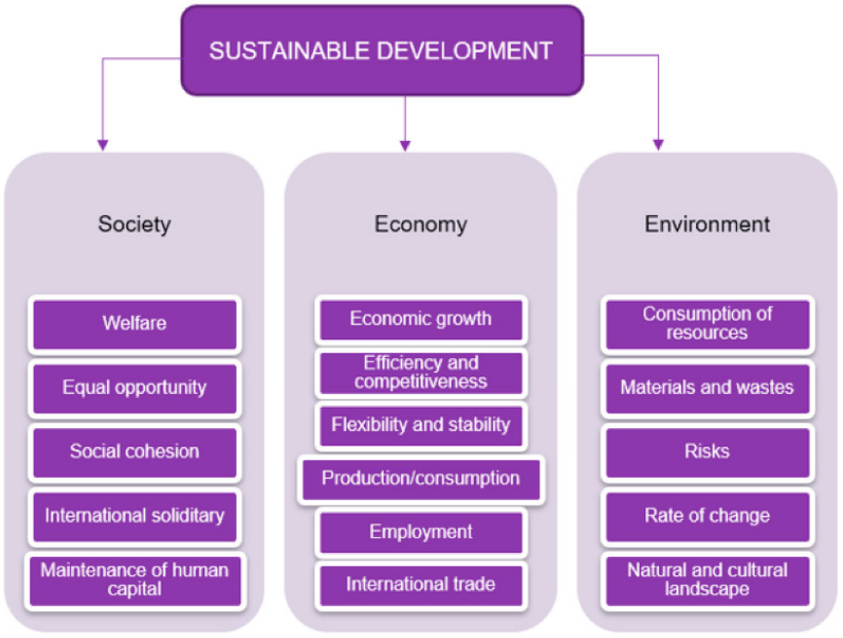


Figure 3-1 Three performance dimensions of sustainable development

Figure 3-1, shows the factors that are measured in terms of dimensions like society, economy, and environment in order to perform a sustainable development study. The social factors include welfare, equal opportunity, social cohesion, international soliditary, maintenance of human capital. The economic factors include economic growth, efficiency and competi-tiveness, flexibility and stability, production/consumption, employment and international trade. The environmental factors include consumption of resources, materials and wastes, risks, rate of change, natural and cul-tural landscape.

The aim of the environmental component is to consider the reciprocal impacts of the built environment and industry practices and to tackle envi-ronmental issues in all areas of the transportation sector. The goal of the economic element is to focus on the development of economic efficiency. The aim of the social dimension is to upgrade living standards and quali-ty of life (Rodrigue, 2017).

OBJECTIVES

The prevalent objectives for sustainable transportation include: (Litman, 2019)

- Enhanced diversity of transport systems:

It usually means enhancing facilities such as cycling, walking, pub-lic transit, carsharing, telecommuting and attempting to create more transit-oriented and walkable communities.

- Development of smart growth of land use:

This involves land-use policies that promote more versatile, in-fused, networked, multi-modal advancement and to provide low-cost housing inaccessible locations.

- Reduction of emissions and conservation of energy:

It may include more fuel-efficient vehicles, switching to renewable energy sources and a decrease in transport by motor vehicles.

- Optimal pricing for transportation:

It provides further value-based roads, parking, gas and automobile pricing.

INDICATORS

It is usually best to have a balanced set of metrics representing a mix of economic, social and environmental goals for comprehensive and sus-tainable transport planning (Litman, 2011).

- Social indicators cover public health, income, urban life (environ-mental performance as observed by visitors and residents) and community cohesion (interac-

tion quality among the members of the community) and impacts on historical and cultural properties (such as typical community activities and historical sites) (Litman, 2011).

- Economic prosperity related to the advancement of society to-wards economic goals such as prosperity, higher income, profita-bility, job opportunities, and social welfare. The word “welfare” ap-plies to overall human well-being and satisfaction (as used by economists). While this difficult to gauge explicitly, economic indi-cators are primarily intended to increase benefits hence metrics like growth, employment and prosperity are used (Litman, 2019).

- There are different types of environmental impacts. They are water, noise and air pollution, degradation of the landscape such as pavement or damage to environmentally productive land, topsoil erosion, sidewalk related hydrological interruption, non-renewable resources depletion, effects of heat island that is increasing in the surface temperature resulting from the pavement (Litman, 2019).

MAJOR TRANSPORTATION PROBLEMS IN INDIA, EGYPT, AND IRAN

Mentioned below are the major challenges that act as a barrier for India, Egypt, and Iran to achieve sustainable transportation systems.

INDIA

The major problems related to Transportation in India are mentioned below.

GROWTH IN THE NUMBER OF VEHICLES

The Indian automotive industry is continuously booming which is benefi-cial for the economy but there is an ecological drawback to be consid-ered: Indians do not make proper use of public transport but rather use cars and two-wheelers. In major cities, the use of public transport or mass transit options has declined from about 80% in 1994 to 25% to 35% in 2018 (Prasher, 2019).

Vehicular growth has been much faster than the growth of population in India. From 2001 to 2006, the number of vehicles registered multiplied rapidly. Most of these vehicles were motorcycles. In contrast, the physical infrastructure could not compete with this growth. The length of the met-ropolitan road went up from 252,001 km to 411,840 km in 2001 by 2011. The number of vehicles enrolled per million over the last decade has ris-en by 219% (Singh, 2016).

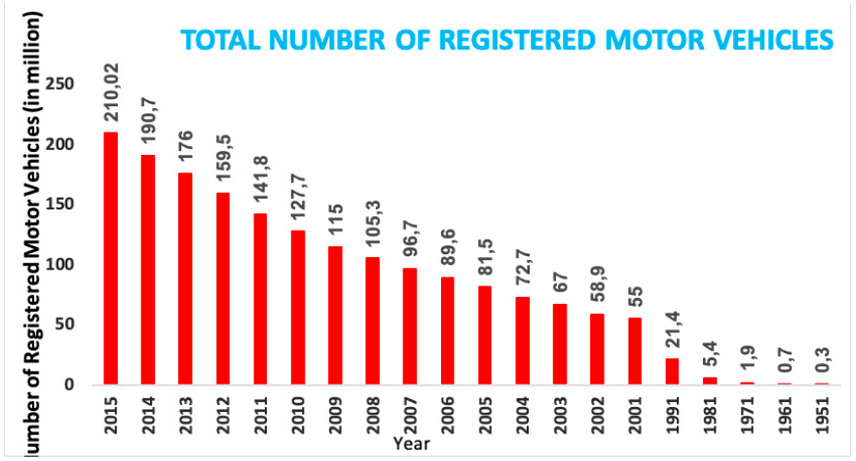


Figure 4-1: Total number of registered motor vehicles
Adapted from: (Chattopadhyay, 2018)

Figure 4-1 shows that from 0.3 million in 1951 to 210 million in 2015, the number of vehicles registered in India increased by 700 times (Chattopadhyay, 2018). The graph represents number of registered mo-tor vehicles (in million) on y-axis and the year on x-axis.

While the two-wheelers’ and four-wheelers’ shares were 73.5% and 13.6% respectively. Busses accounted for 1% of all registered motor ve-hicles and goods vehicles accounted for 4.4% of all the registered motor vehicles (Chattopadhyay, 2018).

In India, there are about 32 various types of vehicles like motorcycles, cycle-rickshaws, bicycles, auto-rickshaws (‘tuk-tuk’), trucks, buses and cars. In India, heterogeneous vehicles share the same road space. Due to this rapid motorization, there are higher trips per capita, severe con-gestion, and longer journeys (Singh, 2016).

AIR POLLUTION

According to the study of the Global Burden of Disease (GBD) in 2010, pollution from outdoor air is one of the world's top 10 risks and the top six risks in Asian developing countries. Traf-fic congestion has a greater ef-fect on developing countries like India as 1.4 million people have died as a result of air pollution (Singh, 2016).

For instance, In Delhi, air pollution last year was likely to reach serious or emergency levels. Breathing the air was like consu-ming 50 cigarettes a day for Delhiites. More than 10 million cars and trucks are the biggest emitters from Delhi. Most of these ve-hicles are operating on two-stroke engines that generate greater air pollution than four-stroke engines. Ve-hicles produce 40-80 percent of the total emissions of the region based on the time of the year (Irfan, 2019).

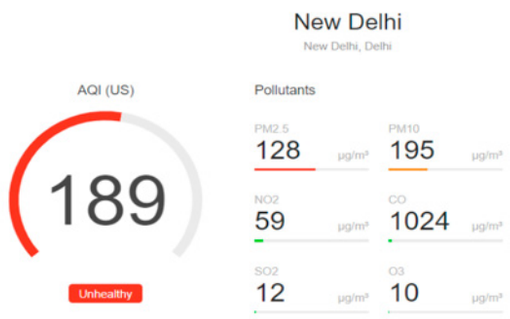


Figure 4-2: Air Quality Index of New Delhi (air-quality.com, 2019)

Figure 4-2 shows the Air quality index of New Delhi from the year 2019 and indicates that this level of AQI is unhealthy for the environment.

Delhi officials are responding to air pollution by implementing the odd-even traffic rationing scheme, temporarily shutting down the brick kilns and factories. However, the air quality in Delhi has improved in recent days. The analysts say it is because of shifts in the weather and not the policy (Irfan, 2019).

DECLINATION IN PUBLIC FLEET USAGE

In India, the percentage of mass transit is decreasing. Accor-ding to the census data in March 2016, in the absence of ade-quate transport facili-ties, more than 50 percent of the working population (except for agricul-ture and domestic workforce) are still working at home or traveling on foot to their place of work (Singh, 2016).

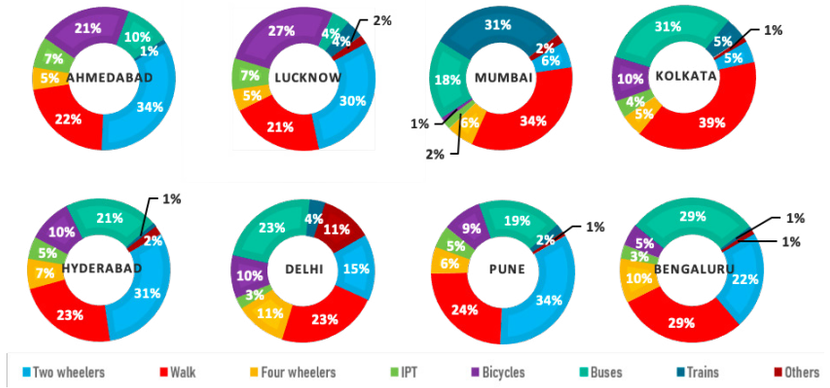


Figure 4-3: Mode of travel to work in major million-plus population Indian cities. Adapted from: (Chattopadhyay, 2018)

Figure 4-3 shows the results of the 2011 census, where the number of people in Indian cities using non-motorized modes of transport to travel to their workplace is quite high.

In the four of the seven cities studied by the Ministry of Road Transport and Highways, the average bus fleet has been decli-ning steadily. In most cities, there is a huge shortage of bus and its services (Chattopadhyay, 2018).

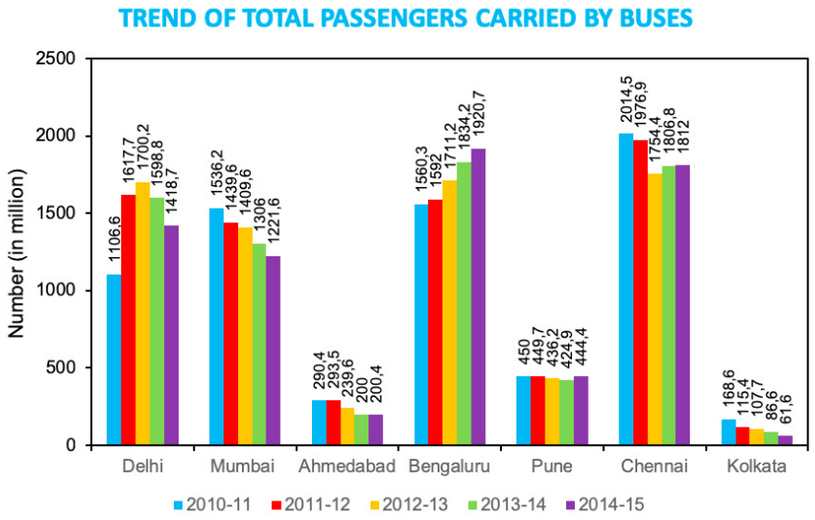


Figure 4-4: Trend of total passengers carried by Buses
Adapted from: (Chattopadhyay, 2018)

Figure 4-4 depicts the reduction in the number of passengers carried by bus in the major cities of India.

EGYPT

The main problems include:

TRAFFIC CONGESTION IN CAIRO

Traffic congestion in Cairo can be explained by many reasons. Govern-ment allowances on fuel make petrol and diesel prices relatively cheap, which makes it easier to have the daily com-mute trip by car on the road. Even mega highroads projects will not be enough compared to the in-creasing number of cars and traffic congestions (World Bank, 2012).

Considering the lack of parking facilities, the cars are either parked in the street blocking the traffic or circulating in traffic. Many citizens use the Metro, but Metro coverage is small com-pared to a city as big as Cairo, buses are also old and not safe. Furthermore, minibuses and Taxis are transporting a large num-ber of citizens, but they still need to be safer, faster and more accessible, since they lack organized pick up and drop off points

(World Bank, 2012).

Road crossings and pedestrian routes are available but they are few and mostly blocked by street sellers. Basic road tran-sportation network ele-ments such as intersections, traffic lights, and U-turns are badly man-aged. In addition, the behaviour of drivers and weak law enforcement made it easier for drivers to break the traffic rules (World Bank, 2012).

HIGH TRAFFIC ECONOMICAL COST, AROUND 4 PERCENT OF EGYPT'S GDP

Cairo's traffic congestion costs Egypt as high as 4 percent of its GDP in yearly. These economic costs of congestion are more than delays in trav-el, and consumed fuel can be included, health effects from poor air quali-ty and accidents, and of course eco-nomic productivity is impacted. Add-ing all combined, the econo-mic costs of traffic congestion a year could be as high as 4% of Egypt's GDP. In other words, an economic cost to Egypt of up to EGP 50 billion a year (USD 8 billion/year) (World Bank, 2012).

POOR AND UNATTRACTIVE INFRASTRUCTURE FACILITIES FOR PEDESTRIANS

Sustainable transport, such as walking and biking, are highly affected by urban environment perceptions. Walking and biking are the first options for western societies when making an urban transportation mode choice. On the other hand, in a recent study done by (Masoumi, 2019), 72% of the MENA region residents prefer not to walk due to long destinations. Due to unattractive routes and inconvenient transport facilities, they are 2.2 times more likely to not walk (Masoumi, 2019).

The choice of riding in your own car against biking or cycling can be changed when transportation policy and urban planning authorities en-hance the overall condition of public transportation and non-motorized infrastructures like walking and biking routes and other environment-related issues in the built environment (Masoumi, 2019).

IRAN

Iran's urban population accounts for almost 70% of the total 82 million and it is on an increasing trend at an average annual rate of almost 3%. It is expected to keep the same rate during the following decade. Main traf-fic problems are normally related to the points that the population is con-centrated, regarding this country including a megacity (Tehran) and a few large cities.

Cities with more than one million citizens are classified locally as "metro-politan areas" (Statistics Center of Iran, 2012).Tehran with 12 million in-habitants is the most densely populated city and is facing many chal-lenges in terms of traffic and transportation (Allen, 2013).

While the overall car ownership level is lower than developed nations, Iranian major cities suffer from congestion, air and noise pollution and accidents. In Tehran, 16 million vehicular trips take place on an office day; and the average speed during peak hours in the Central Business District is around 15 km/h. Other metropolitan areas have almost the same conditions as Tehran (Soltani, 2017).

Emissions from heavy traffic are considered one of the main sources of air pollution, it poses a serious threat to public health as well as global warming. According to the statistics, Iran is the seventh-largest producer of greenhouse gas emissions, while in terms of population it stands 17th in the world (Soltani, 2017).

As Iran is not an industrialized country, this means that vehicular emis-sions and car reliance are quite high. Therefore, while the major cities are encountering these challenges, there should be solutions and amendments for the transportation sector. One of the best solutions is improving the efficiency and development of public transportation sys-tems especially more sustainable ones like electrified railways.

CAR OWNERSHIP AND USE

One of the problems that are noticeable in cities is car ownership rates. Nationwide levels of car ownership in Iran are in the top 50 in the world. There are around 17 million active automobiles in use over the country, while the nation's overall population is almost 82 million. This means one car for every four-five persons and from this, the urban population pos-sessed more than 85% of these cars (Statistics Center of Iran, 2012).

Another important challenge is one passenger cars that are so common in cities. According to research in large cities like Tehran, the vehicle oc-cupancy rate is normally just around 1.5-1.6. In a city like Tehran, popula-tion density is high and this creates traffic congestion and as a conse-quence, the demand for more road and parking space (Soltani, 2013).

To tackle these problems government agents have tried to face this de-mand by providing more parking places and constructing or expanding more road lines. Shiraz, a city in the southwest of Iran, for example, spends around 90% of its annual municipal budget for building new roads, highways, and overpasses (Soltani, 2013).

The development of the car industry in Iran, the availability of cheap fuel, and a growing economy have had an impact on this trend to encourage people using private cars and it is expected that this trend will continue.

POOR PUBLIC TRANSPORT

Iran is a developing country and most of its cities are transforming from a traditional version and try to adapt to modern urban planning but some shortages make this process slow. One of the major obstacles is the shortage of sufficient public transport (Allen, 2013).

Among more than 1000 cities in Iran just five major cities, including Teh-ran, Mashhad, Isfahan, Tabriz, and Shiraz, have urban subway lines, and construction of new systems is under planning and feasibility stages in other metropolitan areas. Tehran Metro network (with 148 km of urban lines and 98 km of suburban) provides nearly three million trips per day. Its metro system with four-minute headway in peak hours can give almost 18 hours of service per day (Allen, 2013).

Although authorities try to invest in metro development, lack of

financial supports, challenging topography and geography conditions of Tehran make it difficult to reach their goal fast.

In the rest of the country, metro development has been encountered simi-lar barriers. Apart from the high level of costs for constructing a metro line ($80-100 million per km), other important obstacles comprising: short of state-of-the-art excavation equipment, a shortage of experienced system designers and builders, boring risks and difficulty of civil works in pres-ence of underground water. Moreover, various international sanctions against Iran have made it very complicated to acquire essential equip-ment from abroad.

Also, there are arguments around the issue of whether subways are a suitable solution for many of the Iranian cities or not. In relatively low ur-ban population density areas subways cannot possibly recover their maintenance and operation costs. For instance, the Tehran Metro system that carries the most passengers only recovers 25% of its operational costs through ticket sales and advertising. In all metropolitan areas, ex-cept for Tehran, buses are the main mode of public transport (Land Transport Authority, 2014).

However, their numbers are far from the ideal situation. In total, there are around 25,000 buses in service in Iranian cities, which equates to an av-erage of one bus for more than 2,000 urban residents. In some large cit-ies, bus provision is much lower. Shiraz, Tabriz, and Ahwaz only have one bus for 3500, 5600, and 2400 people respectively. By comparison, Singapore, Hong Kong, and London have one bus for 1300, 1100, and 1000 people, respectively (Land Transport Authority, 2014).

Apart from the number of buses that may consider insufficient for city travels, urban bus services are weakened by traffic jams. As a result of slow-moving buses (average speed of 20 km/h, with 20-30 minutes headway) satisfaction rate has been lowered among the citizens (Soltani A. and Ivanki , 2011).

Also, bus stations and terminals do not provide suitable comfort and safe-ty for passengers. Due to poor urban development and sprawl around the metropolitan areas, some groups of people especially those low-income families and migrant popula-

tions who settle in suburban neighborhoods do not have access to the bus service coverage (Soltani A. and Ivanki , 2011).

Another important challenge related to public transport is that investment in bus fleet and infrastructure tends to be far lower than real demand. By and large, with all considerations in mind, it is inevitable that buses have an uncomfortable and unreliable picture in the mind of citizens, and as a result have been considered as a “mode of the last choice”.

There have been some improvements to increase the acceptability of this important mass transit system. Five cities including Tehran, Mashhad, Isfahan, Tabriz, and Shiraz, have introduced either a Bus Rapid Transit (BRT) system or separated lanes for normal buses. Tehran’s BRT routes (ten lines) transport about 2 million passengers daily but still, many plac-es do not have access to BRT stations by walking distance.

CAR-DEPENDENCY

The most pleasing transportation system among middle and high-income urban citizens in Iran is private cars. There is a common belief that there is no other competitive mode in terms of reliability, comfort and accessi-bility. Also, for some people, it is considered as a means of freedom, pri-vacy, independence and identity. This can be right to some extent be-cause of the poor public transport modes (Allen, 2013).

Moreover, car use has been strongly supported by governme-nt policies. Low fuel prices and automobile taxes, keeping road tolls at a low price, building road infrastructure everywhere as the most priority and the main way of transportation and the internal car production is at an all-time high. A mixture of these factors as well as some cultural beliefs have ended up people driving their private cars for everyday activities.

In addition to cars, another important reason for traffic congestion and air pollution is the vast use of motorcycles as a means of travel and delivery of goods and foods. In Tehran, there are almost 3 million active motorcy-cles in use. Motorcycles are popular because they are fairly cheap to buy, easy to keep, nimble to ride on congested streets, and exempt from some traffic restric-

TRAFFIC CONGESTION AND PARKING SHORTAGE

Congestion in urban and suburban areas, especially in Tehran are a big challenge and is an issue of concern for city governors. More than 3 mil-lion cars circulate daily on the streets of the capital – a major part of them belong to people who live in suburban areas that work in Tehran and commute from their homes (Atlas Tehran, 2015).

To have a rough perspective about that number, some traffic experts es-timate that Tehran's roads capacity limit is 700,000 cars; it means that there are more than 4 times active cars over its capacity. According to statistics, residents of Tehran spend an accumulative 4.3 billion hours annually in traffic jams (Atlas Tehran, 2015).

Due to the huge volume of traffic, parking shortage has also become criti-cal, especially in city center areas where jobs and activities are concen-trated. Although there is some public multi-story parking, it cannot supply enough space for millions of cars, so people have to park their vehicles alongside the streets.

According to the urban planning regulations, to develop new residential complexes, it is mandatory to provide a minimum of one parking space per unit. Usually, this rule does not apply to commercial, office and indus-trial buildings that potentially have a high number of daily visitors. For example, in Tehran the ratio between parking supply and demand is around one per four, this figure is far low at 1:13 in the central business district.

TRAFFIC SAFETY

Iran is one of the most dangerous places to drive worldwide. Annually more than 20,000 people die in traffic accidents. Among the casualties up to 50 percent of them are pedestrians. One-third of the fatal accidents happen in cities and the rest take place while people drive in rural areas (Zamanian, 2014).

Driving carelessly and faster than allowable speeds within urban areas (above 60 km/h), incompetent separation of cars and foot travelers, a de-ficiency of pedestrian intersections and overpasses are safety problems in Iran that needs to be taken into consideration (Soltani, A. and Mozayani, S., 2013).

INEQUITY IN TRANSPORTATION

Accessibility to schools, workplaces, hospitals and other essential ser-vices is an important affair for vulnerable and low-income groups in every society. Iran as a country that most of its population categorized as low to moderate-income is not excluded from this issue. However, the govern-ment has not been so successful to come up with solutions in providing effective public transport services to be available for all society's classes.

As a result, low-income people have difficulty in reaching their necessary destinations and services at affordable expenses because of a lack of transportation. Moreover, people with disability problems face daily ob-stacles in their urban environment, which could be tackle at relatively low cost through the construction of ramps and elevators or designate special parking areas.

REFORMATIVE MEASURES

Possible measures that the developing countries like India, Egypt, and Iran should follow are mentioned below.

INDIA

In cooperation with the World Bank, the Ministry of Road Transport and Highway (MoRTH) initiated the "Passenger Mobility Enhancement" cam-paign. The government may well initiate a program to promote state-owned bus transportation enterprises by investing in technology to de-crease their losses (Singh, 2016).

The federal government is attempting to change emissions regulations for specific class automobiles to Bharat Stage VI which is the equivalent of Euro VI by 2020. The choice was made to effectively outpace to Euro VI standards from Euro IV emission standards for diesel and petrol (Singh, 2016).

The concerned authorities must take full advantage of huge investments in mass transit systems to enhance the pedestrian

area around metro stations. Ensuring safe access to these transport networks will go a long way in India (Dalkmann, 2013).

Switching from private/personal transportation to mass public transporta-tion will significantly reduce vehicle emissions. To increase the use of public transportation in Indian megacities, importance should be provid-ed to the development and design of the advanced bus transport systems (Kumar, 2017).

EGYPT

UTILIZING BIM IN ROAD PROJECTS

BIM is defined by The National Building Information Model Standard Pro-ject Committee as “a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge re-source for information about a facility forming a reliable basis for deci-sions during its lifecycle from inception onward” (Rokooei, 2015).

Nevertheless, BIM cannot be only perceived as a 3D drawing representa-tion of a building or a facility, but it is a unique mixture of the optimum uti-lization and implementation of digital information including time (4D) and cost (5D) during the complete project lifecycle. Also, the lifecycle of its deliverables was taken into consideration (Kim, 2015).

In other words, BIM is simply creating 3D models based on documented information that can be accessed digitally in a Common Data Environ-ment (CDE) (British Precast Concrete Federation, n.d.). The document’s information is linked to the 3D model in a way that enables information to be shown when an element in the model is touched. This information can be, for example, the material type, cost or quantity.

BIM benefits are not exclusive to the technical point of view but deliver an intelligent and integrated working platform for productivity and sustaina-bility improvement throughout the project life cycle (Elmualim & Gilder, 2014). Contribution to sustainability can be viewed in three aspects, namely, social, economic, and environmental, which can be used as met-rics for sustainability measurement, and BIM helps in all these aspects (Chong, et al., 2017).

The advantages of such usage are numerous, (Hall, 2018) confirmed these advantages when he mentioned the top benefits of using BIM in roads infrastructures:

a) Traffic Flow:

Complex transport network and traffic volumes can also be pre-sented in BIM Models. Planning and controlling the traffic volume can be fore-casted using BIM as well (Wang , et al., 2014).

b) Collaboration and Communication advancement:

Paper-based drawing systems did not provide such collaboration or 3D imagination or sharing opportunities that BIM allows for dif-ferent road project stakeholders. Cloud servers now can be used to provide a data-sharing service for all disciplines in one platform. Items that can be shared for instance might be models or coordi-nate planning. Models can be ac-cessed beyond; they can be ac-cessed on the site with different mobile or tablet BIM apps that provide updated information all the time.

c) Model-Based Cost Estimation:

The costing and estimating process used to take much time and had many drawbacks when done manually. BIM provides the Model-based cost estimation approach, that can be defined as the fifth dimension of BIM. This approach saved estimators time that can be used to focus on other factors that affect the project greatly, such as risk analysis and construction assemblies’ identifications.

d) Preconstruction 3D Visualization of projects:

Before the construction phase, the project can be planned and visualized using BIM. Changes can be done easily by different stakeholders through the visualization phase which saves money and time spent on rework. This can help especially in road pro-jects because the owners are mostly government and state au-thorities who mostly have different points of view.

e) High-quality final product:

The 3D GPS enabled machine design-based construction proce-dure in roads increases the coordination reliability, which affects directly the quality of the final product. Common BIM tools sharing boosts the connection level between field workers and office de-signers in different pro-

ject lifecycle phases. This helps in better decision making for technical issues appearing in the site. Recent-ly, augmented reality instruments can be used for higher accuracy.

f) Better facility management and handling procedures:

Information exchange is so important in the postconstruction phase. BIM offers a precise and continuous digital record of data for built structures. These data would be used for road maintе-nance operations. The handover process follows the same pattern of data delivery from contractor to owner, who in these road pro-jects are mostly public and state-owned.

USING ITS IN TRANSPORTATION

ITS stands for Intelligent Transportation Systems. ITS is an international approach aimed at using advanced computers and communications to make transport act smarter, faster, safer and more convenient (Department of Transport, n.d.).

ITS makes the infrastructure function more efficiently, therefore mitigating the requirement of more roads, lanes, and highways. For instance, the transmission of real-time data to traffic signals to adjust their timings ac-cordingly can lead to a smoother flow of traffic. The smoother flow leads to a forty percent reduction in stops, a twenty-five percent reduction in commute time and ten percent reduction in fuel consumption (leading to over one million gallons of fuel being saved annually) and reducing harmful emissions by over twenty-two percent (Radwan, 2015).

ITS can greatly help reduce consistency for traffic jams by over twenty percent, which would otherwise toll commuters more than a billion hours and nearly three billion gallons of petrol annually (Radwan, 2015).

Through ITS, transport agencies can acquire real-time information re-garding the flow of traffic and transportation frameworks, thus facilitating the renovation of the transport agency networks according to the valuable statistics provided through ITS (Radwan, 2015).

Through an increase in efficiency of transportation systems, this system can increase the mobility and effectiveness of drivers, reduce emissions and increase commute performance (Radwan, 2015).

IRAN

There have been attempts in metropolitan areas of Iran to lessen the in-tensity of Transportation problem's impacts. The most noticeable activi-ties have been done while the population of cities increased and trans-portation systems became a serious concern. It was a reform in energy subsidies in 2010 in which a new rule was legislated to increase the price of gas to modify the consumption patterns and decrease the traffic and pollutants. This reform is still on its initial stages to be accomplished and reach sufficient goals (Dominique Guillaume, 2011) and (Moshiri, 2014).

Another important action to alleviate the heavy traffic impact on the busi-ness district of Tehran was imposing a restricting scheme to limit car en-trance to that area. Drivers who intend to get into the specific territory should pay its price. Also, there is a scheme that has been implemented for a few years in Tehran and some other metropolitan areas, cars can enter to an area just in specific days and are being distinguished by their numbers.

Drivers who want to access the area, in which they are monitored through automatic cameras, have to pay a fee for some time. Although the schemes have been successful to some extent, the increasing number of cars makes cities more crowded every day.

Some commitments have been made in large cities, especially in Mash-had and Tehran, to enhance their public transportation systems. To reach that bus and taxi fleets are going to be renewed to a level to lower the average age of the vehicles, also some buses have been replaced to run by natural gas instead of less efficient fuels. Besides, an annual inspec-tion has been compulsory for all of the active cars to be checked for their fuel efficiency and safety.

Investing in infrastructures especially mass transit public transport sys-tems like metro and electrical trains over the country has been a noticea-ble issue to both increase in the quality of

life in cities and lower traffic volume by moving it from roads to railways. To do this, New Towns De-velopment Company and Islamic Republic of Iran Railways company are two of the main engaged governmental companies in Iran and have sup-ported the global targets regarding protecting the environment as well as providing necessary facilities for the society.

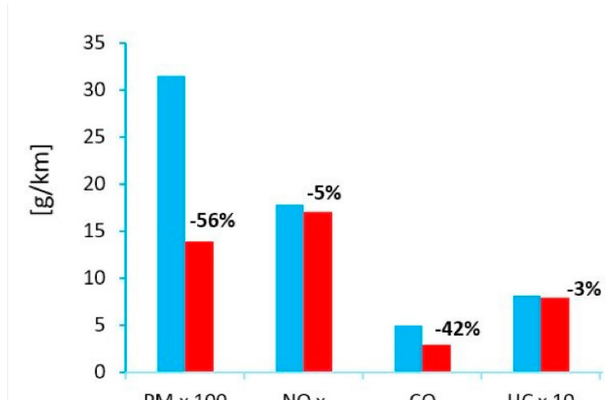
Historically, the first railway line in Iran was inaugurat-ed in 1888 by cov-ering an 8.7 km path since then around 13600 km of railways has been constructed, but from this figure, almost 300 km is electrified. One of the important pro-jects that will have a prominent impact on suburban traffic of Tehran is the “Hashtgerd Electrified Railway project”, which connects Hashtgerd’s new town to Karaj metropolitan area and Tehran’s metro system. In the following section, this pro-ject and its consequences will be described in more detail.

SIGNIFICANT PROGRESS FROM AROUND THE GLOBE

Many developed and developing nations have contributed their part to sustainable transportation systems. A few of the key learnings from differ-ent countries around the planet have been mentioned in this section.

SHANGHAI, CHINA

The Italian Ministry of the Environment and Territory, Gloria VISCONTI introduced a Sino-Italian environmental collabora-tion project. One of the ventures which began in April 2003 is the Shanghai GECAM (white die-sel) program. The goal was to boost air quality in major Chinese cities through the use of GECAM, a liquid diesel emulsion stabilized with addi-tives that yields significantly lower PM, NOX, CO and HC emissions rela-ti-ve to ordinary diesel fuels (Wiederkehr, 2003).



	PM x 100	NO x	CO	HC x 10
Diesel	31.5	17.862	4.948	8.15
Gecam	13.9	17.036	2.891	7.94

Figure 5-1: Comparison of emissions with vehicles using Diesel and Gecam. Adapted from: (Wiederkehr, 2003)

Figure 5-1 shows the performance comparison between die-sel and GECAM. There has been a significant decrease in the number of emis-sions resulted from the use of Gecam when compared to the emissions released by the use of Diesel.

As a pilot project, 500 buses with GECAM were introduced in Shanghai. Also, the municipality of Beijing agreed to consider launching several cooperation programmes on mobility (Wieder-kehr, 2003).

BOGOTA, COLOMBIA

With a current population of approximately 9 million, Bogota, the capital of Colombia, lacked infrastructure and did not have idealism for the fu-ture. The nation best known for its famed drug trafficker, Pablo Escobar is, in fact, a progressively sustainable city and has been doing several im-pressive things which not many nations on this planet can probably ac-complish (Hosey, 2017).

In the 1990s, Bogota’s infrastructure system was not up to the mark. Traf-fic was the major problem as it caused a huge number of accidents. For-mer Mayor of Bogota, Colombia, Enrique Peña-losa revolutionized one of the world’s most disorganized cities into a sustainable urban planning model (Hosey, 2017).

In 2000, Transmilenio, Bogota's Bus Rapid Transport (BRT) System was officiated. With a fleet of 6000 buses, an average of 2.4 million passen-gers are shuttled every day (Hosey, 2017). Dedicated lanes have been allocated to the buses in the middle of the streets with elevated platforms. This makes it easier for people with disabilities, people using strollers and the elderly (Guevara-Stone, 2014).

In addition to making the transit system open to a wider range of resi-dents of the city, Transmilenio operates free feeder buses for minimal-income neighbourhoods. The system has a fixed ticket price regardless of the distance travelled from the outskirts of the city to the major stations so that people with lower income can still be able to afford their travel ex-penses (Guevara-Stone, 2014).

The government began building over three hundred kilometres of bike lanes, which increased the number of cyclists in the city by five times. To encourage sustainability, the bike lanes stretch through both the low-income and the affluent neighbourhoods, and an approximate of 300,000-400,000 rides are made by the bicyclists every day in Bogota (Guevara-Stone, 2014).

The parking fee was increased. Based on the last number on the car's license plate, forty percent of the cars could not drive around the city dur-ing the peak hours from Monday to Friday. Every year on one day, the citizens of the city function without a car (Guevara-Stone, 2014).

These improvements have made a massive difference in the city's living standards. Carbon dioxide emissions were decreased by more than sixty thousand tonnes per annum. Deaths and injuries due to traffic were down by 89%. To travel 18 miles, the 2 hours plus ride now requires only 55 minutes to travel. In 2012, the Transmilenio study revealed a correspond-ing reduction in crime by 85% and there has been an appreciable amount of growth in the property values and employment opportunities (Guevara-Stone, 2014)

ELLICOTT, USA

Appling ITS (Intelligent Transportation Systems), Ellicott has been equipped with a smart parking system for the city centre. The reasons behind this action were to increase the rate of turnover in parking slots in the street and decrease the time needed from drivers to find an empty parking space.

This was done through using sensors emplaced on different parking places to keep an eye on occupancy, then associated data were sent to dedicated processing centres who in turn exchanged parking information with car drivers using a mobile software application.

As a result, the system was responsible for a nearly ten percent growth in parking efficiency and the same growth in the local business's revenue was also noted, as well, carbon footprint produced from the vehicles was reduced since drivers spent less amount of time looking for available parking space (Streetline, Inc, 2012).

LOS ANGELES, USA

In the city of Los Angeles, traffic lights are synchronized to ensure the op-timum smooth flow of traffic. This act led to reduced commuting times, more fuel economy and emissions have been reduced. In the first phase, LA County implemented traffic signals, tracking the movement of vehicles through a radar system at about seven hundred various intersections (Radwan, 2015).

This act has led to millions of hours' worth commute time being saved, over thirty million gallons of petrol saved and over three hundred thou-sand tons of carbon dioxide emissions being reduced. The second phase will observe the incorporation of thousands of more intersections (Radwan, 2015).

HASHTGERD NEW TOWN ELECTRICAL RAILWAY, IRAN

In the 1980s Iran encountered a prompt population growth, during those years many people migrated to cities, especially to the capital Tehran. As a result of that phenomenon, an unintended, disordered expansion around the big cities took place. There was a tremendous demand for housing, also preventing

sprawl around the cities was enough to per-suade Iranian officials for providing a new housing scheme to control the challenging situation.

Therefore, developing new towns was considered as one of the strate-gies of urban development in Iran. For that, the ministry of roads and ur-ban development of Iran did feasibility studies to construct 17 new towns in the vicinity of metropolitan areas.

One of the preliminary and biggest new towns in Iran is Hashtgerd's new town which is located 25 km north-west side of "Karaj". The whole ap-proved area of the town is 4300 hectares and is estimated to accommo-date 500'000 people in 2040. It's accessibility to the capital is by line 5 of Tehran metro. (Falahat, 2013)

Traffic volume of the artery between Hashtgerd-Karaj-Tehran, which acts as a connection of north-west of the country to the capital, is considerable and annually millions of cars commute through that path. As a conse-quence of consuming fossil fuels, a huge amount of emissions spread to the atmosphere. Because of this mass traffic that hampers the life of sur-rounding citizens, engaged authorities have decided to devise a sustain-able means of transport and build a 25 km electrical railway to lessen the congestion and transfer some part of the commuters from private cars to the mass transport railway system (Falahat, 2013).

This project uses the double-deck trains and will be able to transport al-most 16,000 people per hour. Also, it has been designed to have 7 minutes headway for trains and can be upgraded depending on the fu-ture demand (Falahat, 2013).

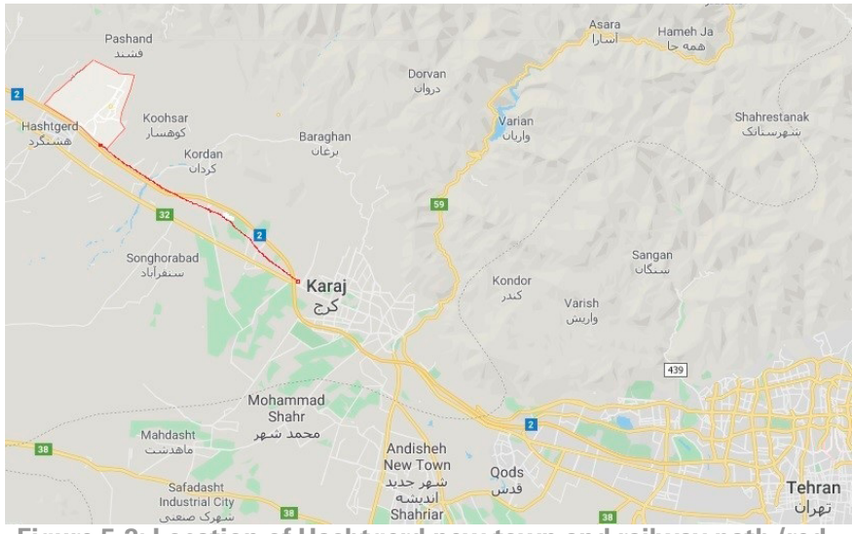


Figure 5-2: Location of Hashtgerd new town and railway path (red line). (Maps, 2019)

In figure 5-2, the location of Hashtgerd's new town and railway path is shown. This project brings many benefits to the whole society as well as the people who live in the surrounding region in terms of environmental and economic aspects (Iranian Fuel Conservation Company, 2015).

ECONOMIC AND ENVIRONMENTAL IMPACTS

Although in terms of technical aspects, railway projects are not considered economically justified all over the world, but as a long-term investment, the following effects on the economic and built environment can be noticeable:

- Conserving fossil fuel resources.
- Reduction of greenhouse emissions.
- Saving the costs of treating air pollution diseases.
- Save on depreciation and spare parts for suburban cars.
- Reducing the number of accidents and increasing the safety of citizens.

SOCIAL AND CULTURAL EFFECTS

It is of great importance to plan urban developments based on ac-cessibility to public transportation modes. In other words, these roads and railways are the core of

CONCLUSIONS AND RECOMMENDATIONS

Considering the current traffic situation of Egypt, specifically greater Cai-ro, it is hard to implement a single cure to the problem. However, it is possible to improve Egypt's transportation system efficiency. The problem of Cairo's congestion issues can be approached by two perspectives, inadequate transportation infrastructure elements coupled with insuffi-cient driving etiquette culture and awareness.

Looking at the advantages that can be achieved by using BIM technology in transportation system facilities, it would be strongly advised to use BIM in the current and future infrastructure construction and maintenance pro-jects in the developing countries. This usage will help dramatically in avoiding poor road quality mistakes made in the past and would provide higher quality road facilities in the future.

The driving culture issue can be addressed by applying strict rules for using the roads. These rules must be a part of a complete traffic control ideology that includes instructions, rules, fines, and most importantly, a visible clear mechanism of applying the fines and the rules. By doing so, the drivers will be obligated to follow the road instructions carefully moti-vated by the fear of paying strict fines when violating these rules. For in-stance, the road users will not park in a non-parking area because the parking fine will be relatively expensive compared to the current traffic violation system.

Another way to address the driving etiquette would be to adopt an ITS project across the country. This system will be useful in two ways, one way will include the on-going collection of traffic data for the transporta-tion systems in Cairo. These data would require a big-data analysis sys-tem to interpret the information and transform them into useful information for future transportation studies for Cairo's traffic issue. The second out-come of ITS would include environmental aspects. Proper ITS applica-tions can help greatly in reducing traffic jams which will lead to fuel econ-omy and reduced carbon footprint.

Nations like Iran can achieve these sustainability goals by making in-vestments in infrastructures especially in public transportation systems like buses, BRT, and metro lines. The money that is being spent on the fuel subsidies must be diverted to the public transport sector so that the entire society benefits through it. While car ownership cannot be limited in a short period, but measures can be taken to restrict auto-use in crowded pedestrian areas in cities. To ensure easy accessibility, it is im-portant to implement the right land use and urban planning.

India still has a lot to do to develop safe and efficient public transportation systems. Public infrastructure would boost people's flexibility and open the door to the country's new economic opportunities. Sustainable public fleet systems provide a safer environment for women. They are highly accessible to the elderly and disabled people. Investment in public trans-portation would have a positive effect on the economy.

The governments of developing nations should encourage people to purchase environmentally friendly vehicles. The use of bicycles can ease congestion and also reduce the journey time of other users of the road. Plans from other sustainable cities around the globe to restrict the use of automobiles should be developed.

For nations with mixed traffic systems, it will be challenging to achieve the sustainable transportation system, but, the minor changes mentioned above can act as a steppingstone for obtaining sustainable mobility. The responsibility lies not only in the hands of the Governments of the nations but also its citizens. Citizens should also take the responsibility of making their nation a sustainable nation.

The developing countries are required to formulate the framework for ur-ban transportation with a suitable combination of enhanced transit ser-vices which are rail or bus oriented. Strategies to reduce private vehicle usage should include parking levers, increase in congestion pricing, land usage improvements and traffic-free travel. To control the preference of automobile infrastructure, behaviour and modes of travel, taxes should be designed.

To conclude, any developing country can achieve these goals with im-proved integrated urban planning, use of BIM in road pro-

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LIST OF FIGURES

OUR SUSTAINABLE FUTURE: A CONCLUSION

Eric Pollock, Ana Reinbold

We are currently faced with finding a solution for one of the most urgent issues of today's world; climate change. One of the reasons behind global warming and carbon emissions is the increase of global energy consumption. Therefore, the solution for the climate dilemma is decreasing the amount of energy consumption on a worldwide scale. The construction industry is responsible for 40% of energy consumption and 36% CO2 emissions in the EU. One-third of modern energy consumption is used for heating buildings. To reduce this high percentage of carbon emissions, we need to rethink how we construct our cities. Special attention has been given to the correct use of sources for both text and photographs, as well as working in a research team with a similar format.

The Sustainable construction chapter presents zero-energy buildings, the role of quality precast units, recycled materials, recycled demolition waste and eco-friendly bricks. They all decrease the negative impacts on the environment by saving natural resources, preventing distractive effects of global warming. To have a smart zero-energy building in the future, energy optimization and integrated active and passive solar systems are a must. To develop waste management systems, such as creating an online platform to connect all involved parties, minimize waste and making the whole process faster, easier and more controlled. Reducing waste can also be achieved by implementing precast construction in developing countries. Eco-bricks have unique benefits such as better building performance, cost-efficiency, high strength, water resistance, carbon-neutrality and low amount of mortar.

The passive house chapter shows how sustainable, energy-efficient construction can provide a high-level of comfort to its residents while being affordable. The carbon footprint of a passive house is close to zero and renewable energy sources are used to produce energy for the house. They reduce environmental pollution, increase indoor air quality and improve ventilation. Passive Houses must have a super-insulated building envelope, be airtight, have energy-efficient windows, have good ventilation and few thermal bridges. Many EU countries have initiated government policies and regulations to promote the construction of passive houses.

The sustainable transportation chapter has shown how nations have made investments in infrastructure, especially in public transportation systems like buses, rail and metro lines. Improved public infrastructure offers flexibility and opens the door to new economic opportunities; cases in India, Iran and Egypt show this. Sustainable public transport systems provide a safer environment for women, and they are highly accessible to the elderly and disabled people. Investment in public transportation would have a positive effect on the economy. The use of bicycles can ease congestion and also reduce the journey time.

The research presented in the urban planning chapter shows how to achieve sustainable urban planning, social and economic development goals. Brownfield regeneration can fulfil some of the need for growing demands on housing, as shown in Finland and Germany. Waste management, including plastics, must be supported by the concepts of source reduction, reuse, recycling, composting and combustion.

South Korea's waterfront renovation is a prime example of urban and cultural transformation. The same values should be applied so that the social and environmental dimensions stay in harmony. Similarly, Egypt is promoting the use of renewable energies. The use of solar and wind energy cannot only help reduce the impacts on the atmosphere but also conserve energy for future generations. Other countries must recognize their capacity and invest more in renewable energy sources based on available resources and geographical conditions.

Urban planning concepts for the utilization of renewable energy sources, plastic waste management, brownfield redevelopment,

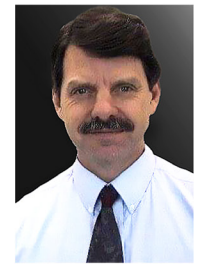
waterfront regeneration and elderly care facilities need solid support both from the general public and their government. To create a better future in the context of sustainable cities, consideration should be given to adopting the philosophy of sustainable urban planning, purposeful collaboration, a clearer understanding of environmental goals and their economic and social implications.

The Sustainable design chapter presented how architecture and engineering can have a significant positive effect on our lives. The aim is to reduce the negative environmental impacts by improving balance and efficiency in the way we use materials, energy and space. Traditional architecture in hot and dry regions was based on sustainability to create a balance between buildings and nature. Traditional architects paid careful attention to natural energy sources like water, wind and sun to give indoor comfort. They understood that buildings are connected to their environment. Nigeria is developing rapidly, but large investments are lost due to the collapse of buildings. Several studies show that the use of unauthorized materials and faulty construction performed by amateurs etc., are the reasons for building collapse in Nigeria. Policymakers should institutionalize suitable planning, supervision and control of construction work to ensure that all buildings are designed, specified and properly built. In other developing countries, case studies prove that the documentation in construction business and sustainability are connected and changes in documentation will affect the construction project which in turn will affect the sustainability.

The students finalize this work with a broader knowledge that sustainability encompasses construction projects from different perspectives, the design phase, the choice of construction material, the constructability analysis, the good use of technology and consistent documentation. They show in this book that they have acquired a holistic thinking about sustainability and they are able to develop work being part of a multicultural team, aggregating knowledge and experience to be problem solving professionals ready to face the challenges of the today’s world.

Given the authors' suggestions and findings based on the numerous case studies and examples from different parts of the world, the planet will certainly progress towards sustainable urban targets if they are accepted, applied and genuinely practiced.

Eric Pollock, Editor, Lecturer, Construction and Architecture



This third book on Sustainable Cities presents solutions for a sustainable built environment. Equally important was the work of the five research groups in working together to produce this publication. Teamwork was the key, and the results are encouraging, we can build sustainable Cities.

Ana Reinbold, Editor, Lecturer, Construction and Architecture

This third book of Sustainable Cities series is the result of the student work, dedication and continuous improvement. I am very glad to have participation in confection of the three books and be able to follow how the students dedicate and improve as teams, researchers and professionals during the process.

Riikka Wallin, Publications Coordinator, Metropolia UAS

This publication is an inspiring example of how learning about a topic that is crucial for our society and creating something tangible like a publication can be combined into the same process. I am sure Sustainable Cities III will inspire its readers. This is a unique project and it's been a joy to cooperate with the writers and other creators that are dedicated to sustainability and their own learning whether they are students or teaching staff.

Marika Antikainen, project manager, SIMHE

Co-writing such an interesting and topical publication as part of the studies is an excellent example of developing important expert level skills for work life. Jointly conducted research definitely increases both students' team work and analytical abilities and also subject specific knowledge.

Homa Javadi, illustrator, Student of ConREM

I would like to express my sincere gratitude to my instructors Eric Pollock and Ana Reinbold for their kind supports and expertise and also for providing me with the opportunity of taking part in this amazing Sustainable Construction III project.

Helsinki Metropolia University of Applied Sciences

SUSTAINABLE CITIES III

INTERNATIONAL STUDENTS IN OUR CONREM MASTER'S PROGRAMME BEGIN THEIR STUDIES IN HELSINKI, SOME LEARNING ABOUT SUSTAINABILITY FOR THE FIRST TIME. THE GOAL OF THIS THIRD RESEARCH BOOK IS TO STUDY THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (SDGS). THE RESEARCH CONTAINS FIVE CHAPTERS FOCUSING ON THE DESIGN CONSTRUCTION OF THE BUILT ENVIRONMENT. THE STUDENTS, CIVIL ENGINEERS, ARCHITECTS AND BUSINESS GRADUATES, CHOSE THE TOPICS, FORMED THE WORKING GROUPS AND RESEARCHED THE CASES FROM DIFFERENT CITIES AROUND THE WORLD TOGETHER. THE CHALLENGE IS CLEAR. OUR SOCIETIES NEED MORE PROFESSIONALS WITH SUSTAINABLE MANAGEMENT AND SOFTWARE TOOLS FOR FUTURE PROJECTS TO SUCCEED ENVIRONMENTALLY. USING THE SDGS AS GUIDELINES, PROGRESS CAN BE MADE IF WE TAKE SUSTAINABILITY SERIOUSLY NOW.

Eric Pollock, Anna Reinbold (EDS.)

Lecturers,Metropolia UAS

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