ENERGY OPTIMISATION DURING AEC (ARCHITECTURAL, ENGINEERING, CONSTRUCTION) CONCEPTUAL DESIGN PHASE

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Dissertation by

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Abstract

This research aimed to investigate and analyse the problems of BIM technology and tools in energy optimisation, how to do energy optimisation in the conceptual design phase, which constraints are necessary and which to use and to find solutions to these problems. It also explains how energy optimisation can be integrated into the conceptual design phase on previously worked systems and how the system will be used. This research completed both quantitative and qualitative data collection and data collection with focus group expert participants. This research has analysed participants' opinions and interpretations in a statistical and non-statistical way and aimed to make improvements on the framework in which they participate. The results of the study show that; the proposed framework has been set up successfully, and a framework has been created to excite the participants and enables more in-depth research into the future.

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1. CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

The importance of the effect of passive conditioning facilities, the energy consumption of buildings and/or fully renewable energy sources to the Architectural, Engineering and Construction (AEC) sector are highlighted in the current literature. Along with these researches of energy, developed countries and some international institutions have begun to think broadly about this issue. Moreover, in recent years the European Union (EU) has developed new policies for the AEC sector, which are increasingly focused on energy efficiency and sustainability (Diakaki et al., 2010). One of the most critical issues concerning the control and regulation of energy used in buildings is the fact that; it constitutes 40% of the total energy need and demonstrates microeconomic and macroeconomic effects. For example, the European Union's energy dependency and high project implementation costs can be given as an example of this subject (Diakaki et al., 2010).

Energy consumption models and delivery processes have a significant impact on global climate change, and therefore the problem of energy pollution has become one of the major problems of the European Union’s. The primary source of this energy pollution is fossil fuels that pollute the air and produce high levels of emissions (Gaterel, 2005). In addition, much of the energy pollution comes from the construction sector. The fact that the gas emissions emitted by the housing sector are a significant environmental impact creates significant uncertainty about future climate conditions (Stern, 2006). Therefore, in recent years, the EU has been addressing energy pollution in the construction sector and has been implementing close work in this area. The EU's target in this regard is to reduce by 20% in 2020 compared to 1990 (Hamdy al, 2011). For this reason, it is believed that the future built with these envisaged policies will provide a significant environmental benefit. (Gaterell, 2005).

Due to these effects and problems in energy consumption, energy management is always on the agenda of developed countries. In all countries, including the UK, governments and researchers' construction regulations and energy policies have a visible effort to promote an energy efficient building environment to increase awareness among employers, designers and customers (Gaterell, 2005). However, conscious use and reduction of energy use are possible with the improvement of air quality and the development of new design guidelines

and technologies, including energy optimisation (Vine, 2003). One of these innovations is the research on optimising and implementing the results of the energy optimisation process. These researches are a method based on the energy methods needed in the conceptual design phase (Georgiadou et al., 2012).

The purpose of this research is to develop new methods/techniques for energy optimisation through the conceptual design phase. It provides to adaptation, which has a high potential for energy efficiency, cost savings and future value added. Due to the increasing interest in this area, there are many studies aimed at developing a framework for creating energy efficiency at the design stage, but the real issue is that most of the comprehensive frameworks work on designs that need to be optimised. This does not consider the design constraints and the requirements of the optimisation process. These frameworks do not serve as a supportive tool for designers during the conceptual design phase and therefore cannot respond to needs. (Attia et al., 2012). This research intends to develop new techniques and methods for these needs and prepare them for implementation.

1.2 Research Aims and Objectives

This research aims to establish some new methods and criteria for energy optimisation in the conceptual design phase of designers. In addition, some criteria must be used in the decision-making system of the conceptual design phase in order to find and optimise the most efficient energy performance result. Along with these criteria, the use of BIM software systems in a management framework designed to optimise energy during the conceptual design phase is one of the objectives of this research. For this reason, this research suggests to integrate an existing model, detailed energy optimisation data, and to provide findings that provide strong coordination.

Theoretical and experimental ways to achieve the targets are listed:

1. Identification of the effects and characteristics of actions at the conceptual design stage;

Until this research, many types of research have been completed on the definition and effects of energy on the conceptual design stage. Based on these completed surveys, a more detailed background study of the topic will be undertaken. In order to make this

research more effective and successful, the elements affecting the design criteria will be determined and controlled during the conceptual design phase. Furthermore, the definition of energy optimisation criteria and the definition of links will be made. In addition, the investigator should determine the optimum values of these criteria, the ways of evaluating them and their effectiveness during the conceptual design phase process. All these studies and studies have been assembled to form a framework for energy optimisation during the conceptual design phase.

2. Examination of restrictions of existing tools;

The investigator collects information about the framework, its management and process to understand the capabilities and limitations of the tools and methods concerned and how they are managed. To gain knowledge and awareness about the system, the researcher will create a discussion environment with the focus group on the prepared framework. It should be based on the feedback from the people at the target of the research to ensure that the research and criteria are consistent with the correct methods and results. The evaluation of these generated frameworks is useful for creating a new and most applicable framework for the researcher's focus group recommendations.

3. Incorporating energy optimisation criteria into the framework and defining their relationship to BIM;

Based on the data obtained in the previous steps, the investigator should establish a framework, together with the necessary criteria, so that the energy optimisation can work in the first stages of the conceptual design phase. Thus, this framework will affect the sustainability of all future academic and/or industry studies. However, when these criteria are included in the existing framework, a number of rules and regulations are required. The necessary conditions, criteria and applicability should be determined. The necessary arrangements will be made to use the research in a useful way in the future. With this framework, optimised designs for energy will be created. In addition, through this framework study, the researcher will determine the best integration path and strategy for use with BIM.

4. Development of a conceptual framework;

The researcher must transform the conceptual framework into an approved framework, with all the goals and objectives planned for the research being completed, together with feedback. In addition, the applicability and sustainability of the research should be controlled by BIM. The approved framework will provide solutions to problems arising from possible future developments. The researcher describes the most appropriate method and framework for collaboration in the BIM environment.

1.3 Research Questions

- How can the design energy optimisation be integrated during the conceptual design phase?
- What method should be applied to the energy optimisation that can be integrated into the design?
- How can designers use BIM for conceptual design and energy optimisation?
- What is the contribution of BIM to optimising energy in the early design phase?
- What are the results of integrating the BIM into an optimised energy model during the conceptual design phase?
- How can designers use BIM in the AEC sector for both energy optimisation and conceptual design?

1.4 Rationale

Recently, the concept of sustainability in the construction industry has become a necessity for the construction of the construction future. The most critical of these needs are increasing energy costs and environmental concerns. For this reason, it is imperative to make decisions on building energy consumption during the building's early design phase. This is one of the significant problems of energy saving. To calculate energy consumption and to preserve the proportions of buildings, management frameworks that manage the reliable design process and integrate with energy are required (Elbeltagi et al., 2017). What's more, designers need BIM tools and new technology developments to see the benefits of building performance and other energy values.

Architects are project employees who make conceptual design plans in the early design process and make important decisions in this regard. When taking these decisions, functional and technical data are critical factors for them. A significant number of these decisions are decisions about the energy performance of buildings in the process of making design decisions (Tian et al.,2015). In addition to the latest technological developments, these decisions can be made more precise, productive and more detailed. The parameters created in the light of these decisions are handled in the design process (Wang et al., 2005). The problem here is that it is difficult to work with the model of the energy parameters calculated using these tools and the model of their decisions.

It is tough to find the optimum value of such an entry because there are many elements that are most involved in the first stages of the design process. For this reason, the designer cannot be sure of their decisions or can decide later the change. This is damaging the project in many places. Making the design possibilities with the best-optimised energy decisions and making this decision with the manufactured technological tools makes the results reliable and fast. Thus, optimising energy decisions can be added together with decisions that affect the design. Energy decisions that are likely to change later are avoided.

1.5 Methodology Used

This study aims to examine and develop a framework for energy optimisation method and process in the conceptual design process.

Literature review

This study, which is the continuation of the literature review of the subject, is currently analysing a subject or filling a void. Problems in energy optimisation that are desired to be integrated into the early design phase are identified, evaluated, and new topics are developed in current findings. The efficiency and performance of the process in energy optimisation are supported by the literature sources examined during the early stage of the process. It will also be explored in the literature how the process of early design phase works and what this process involves.

Creation of conceptual energy optimisation framework

Supported by literature review and background work, the research will develop a new method and process by creating a conceptual framework for energy optimisation in the early design phase. The researcher summarises the methods to fill the gap in the current research and to achieve the criteria for the energy optimisation process in the energy efficiency and conceptual design phase.

Focus group

Focus groups are the most critical factor for research, for the validity of the research, the applicability, the suitability of the research and the resolution of user problems. As the focus group, opinions and feedback will be received about the framework established with the experienced people from the sector or academia. These feedbacks are essential for the sustainability of the conceptual framework.

İmproved Frame

The validated framework created by established methodology strategies is possible by developing feedback from the focus point on the needs of the focus group and the conceptual framework. Experienced in the field and developed a conceptual framework by those who have mastered the subject and will be validated framework.

1.6 Dissertation Structure

In terms of the readability of the research by the readers, the research is divided into different sections. The introduction section from these chapters; The study covers the reason for the research and the background information about the study. This first section also explains the requirements for doing the work, the reasons for the selection of the topic, and the goals of the work. The second part is the literature search and the literature search on the research topic. In this section, different findings, techniques, goals and objectives of previous studies on the research topic are explained. The current literature contains topics that explain the use of energy optimisation in the conceptual design phase. The third part explains the research method, research method and methodology. This section is also the most useful part of the research because it explains the shape of the chosen method and the process of

execution. The next section is about data collection and analysis of the research. The results section, which is the last section, evaluates the hypothesis or research objectives in the first section.

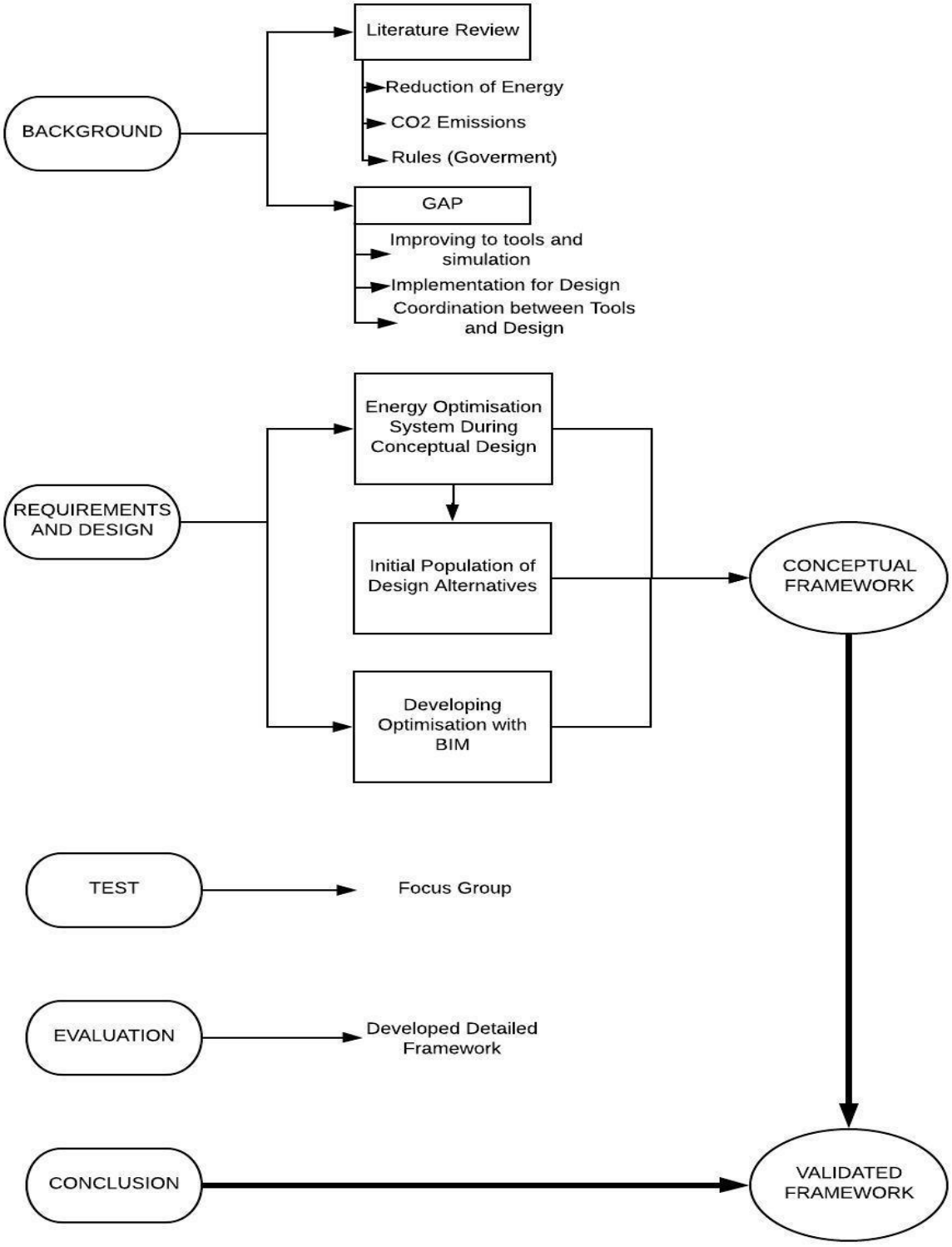

Figure1.1: Research Flowchart

2. CHAPTER TWO: BACKGROUND AND LITERATURE REVIEW

Energy efficiency and energy performance issues are the most contemplated and decided issues in the conceptual design phase that designers miss most. (Bogenstatter, 2000). Therefore, energy optimisation decisions have become a matter of designers' experience or a matter of decision making with a few calculation programs after a design decision has been made. (Tian et al., 2015). However, it should be known; all decisions about the energy topic belong to the designer. In addition, these decisions must be accompanied by building functions, the concept of the building and design decisions about the building during the early design phase. Examples include building orientation, efficient use of sunlight, natural heating and cooling. (Tian et., 2015). Today, due to similar reasons such as lack of expertise, lack of knowledge and skills, energy performance and optimisation are always lacking and uncertain. (Tian et al., 2015)

The purpose of this work is to integrate energy optimisation into the process of producing sustainable design alternatives in the conceptual design phase and to explain its parameters so that they can be useful. Each of these parameters consists of the end effector limits. These parameters can give the most efficient alternatives to the designer in the direction of the essential needs. Optimization for energy performance, for example, is aimed at achieving efficient use of energy in design and to derive this energy uses from solar or natural ventilation. (Yannas, 1993). In the current literal, conceptual design phase, the decisions on design alternatives addressed the share of energy and its needs as well as the problems.

2.1 Energy and Constructions

In recent years, increasing energy efficiency and saving in buildings around the world has become a significant priority (Diakaki et al., 2010). Energy production and consumption areas have a very high impact on the global climate (Gaterel, 2005). The source of this energy pollution is fossil fuels that pollute the air and produce a considerable amount of emissions. Moreover, the construction sector has a significant share of this energy pollution. When the effects of the construction sector on the global climate are investigated; the most

critical issue that creates uncertainty about future climate conditions is increasingly the environmental impact of gas emissions from buildings (Stern, 2006).

Today, the impact of energy consumption and energy resources on the Architectural, Engineering and Construction (AEC) sector in buildings has also become important (Diakaki et al., 2010). Developed countries and research institutes are therefore beginning to think broadly about energy efficiency and to produce solutions. Moreover, the European Union (EU) has declared that it has become a need to regulate energy efficiency and regulate energy efficiency to improve the energy performance in the building sector, which constitutes 40% of the energy needs of its members (Diakaki et al., 2010). Therefore, in recent years, the International Organization for Standardization (ISO), the European Standardization Committee (CEN) and the International Energy Agency (IEA), which are among the largest organizations in the world, have undertaken severe and extensive work on the development and implementation of energy efficiency in buildings (Hamdy al, 2011). The EU's target in this regard is to reduce by 20% in 2020 compared to 1990 (Hamdy al, 2011). For this reason, it is thought that these policies and actions will have a significant impact on the future built up (Gaterell, 2005).

According to the fifth evaluation meeting of the IPCC (Intergovernmental Panel on Climate Change in 2010, 32% of the energy used in the world and 19% of the energy-generated part of the greenhouse gases belong to the consumption of energy used in the buildings. These ratios have had a high impact on global warming and environmental problems that have been spoken over the last few years in the world. Therefore, the energy efficiency of the construction industry and its increasing need for it are not very surprising. (Bynum, Issa & Olbina, 2013)

2.2 Problems of During Conceptual Design Phase

Because of all the effects and problems related to energy efficiency, energy management is on the agenda of developed countries. Regulations and policies aim to promote awareness among employers, designers and customers and encourage energy efficient buildings (Gaterell, 2005). New design principles are also needed to provide energy optimisation to increase energy efficiency and reduce global impact. It is also essential for researchers to develop and effectively use these design principles and technologies (Vine, 2003). One of

these innovations is the research on optimising and implementing the results of the energy optimisation process. These researches are a method based on the energy methods needed in the conceptual design phase (Georgiadou et al., 2012).

The previous research and reviews show that the decisions in the early architectural design process for energy efficiency are the most critical process for efficient management and efficiency of energy. Nevertheless, it is inevitable for designers to make more useful and productive decisions about energy when this process is actively worked with energy-optimising programs. Another point is that designers are still using tools that are not very well developed or able to respond to needs because of the high probability of making use of all these programs and errors during calculations. These tools for building energy efficiency, which is used in industry, offer a limited number of variations and alternatives to designers (Al-Fahmawee, 2013).

In the conceptual design phase, decision-makers cannot observe any design change decision, feedback or immediate information problem. (Attia, Gratia, De Herde and Hensen, 2012). There is also a significant lack of coordination between the software used to model the techniques in the software and design process, and the many methods used in the energy optimisation process. The reason for this; There is no successful management framework for energy optimisation and design. For this reason, this causes many problems and energy fewer designs to emerge. For this reason, designers are far from producing an efficient energy-optimised design. (Elbeltagi, Wefki, Abdrabou, Dawood and Ramzy, 2017). Another reason for this fracture is that there is no effective coordination or process between the CAD programs used to build the building mass in the design process and the programs used for energy simulations, which are shown as the most critical obstacles to the parametric joints of the designers for efficient energy design (Elbeltagi, Wefki, Abdrabou, Dawood and Ramzy, 2017).

There are many ways in the buildings to manage and improve the efficiency of the energy. According to the International Energy Agency, the outer shell and top shell (roofs, windows, walls, etc.) that make up the building have critical effects on many aspects, including energy performance and the calculation of energy requirements and energy ratios required for installation. However, the insulation material and the types of materials used here are also influenced accordingly (Caldera, Corgnati & Filippi, 2008). Besides the materials used in the

buildings, the concept of the building has a considerable severe effect on the energy topic in the effects such as the size of the used areas, the types of heating and cooling systems, building user behaviour (Catalina, Virgone & Iordache). For example, the building's use of natural light and its associated materials, north-south orientation of the building, alternative ventilation and heating systems are among the most influential choices in energy efficiency. Moreover, according to Aksoy and Inalli, the concept of building and the optimisation of the orientation indicated that the building would benefit 36% of energy efficiency and saving.

2.3 Initial Population Design Alternatives

One of the critical and initial decisions of designers in the process of building design is to examine the shape of construction. However, these decisions can affect the constraints and needs, such as laws, land structure and site restrictions, depending on the requirements. (Yannas, 1993). The structure of the building differs by being influenced by these external factors that affect it, and energy performance is evaluated accordingly. (Granadeiro et al., 2013). In addition, these assessments also influence decisions on artificial lighting, energy efficiency and the use of natural resources. All of this will mislead designers or ignore them, which will increase the building's energy costs. (Pacheco et al., 2012).

Most of the designers working in the AEC sector often benefit from the final stages of design, from the visualisation and modelling techniques of their design. However, this process often causes the designer to lose design knowledge in the early conceptual design phase, even though the conceptual design phase in which significant decisions are made is a critical stage (Abrishami, Goulding, Rahimian, Ganah, & Sawhney, 2014). Despite the use of various tools or techniques to solve this problem with conventional CAD tools, CAD tools have not been able to support the designer in the conceptual design stage. Because CAD tools have only an external interface and are not intuitive. In order to solve this problem, it has been proposed by (Raudovski, 2009). That BIM and CAD systems can be integrated together to produce different design alternatives with specific restricted rules and mechanisms, regardless of the design or skill of the designs, and that new and different design alternatives can be offered, it has recommended the use of BIM applications' interfaces (Akintola Akintoye, Jack Goulding, 2012). This approach has increased the creativity of designers as a technique to produce new and different design alternatives and has played an essential role in improving the design by changing different design

alternatives, design parameters, and analysing designers during the conceptual design stage. (Kim & Kang, n.d.).

There are a number of constraints while preparing parameters that play a role in this process. These; **Orientation** is to optimise visual comfort, to control lights from the east and west directions, and to capture the right and comfortable light inside the building by minimising the artificial illumination inside the building (Yannas, 1993). Orientation also controls, and analyses wind angles and manage forms of artificial cooling and natural ventilation, assessing the orientation of the interior to the wind direction for more comfortable airflow (Yannas, 1993).

The second factor influencing the parameters is the design of the interior of the designed structure. Namely; **the arrangement of the interior of the buildings** is strictly dependent on the seating area and the layout of the building. However, the hours of use of the rooms are influenced by several factors, such as temperature needs, depending on the reasons for use and their function. (Yannas, 1993).

Another factor affecting the parameters is **the design of the outer shell space** (windows, doors, etc.). The most important design criteria in terms of energy optimisation or energy efficiency during the conceptual design phase are decisions about building glass and outer shell openings. The design and evaluation of open spaces have several purposes. These; to use the natural light source at the maximum level in the building, to balance the relationship between the building and the exterior, to provide a high-quality vision and to control the natural ventilation and heat transfer. (Yannas, 1993). The decisions of these openings vary depending on the climatic conditions, orientation, width and aspect ratios, and the need for these spaces, depending on the location of the location where the design is to be made. (Yannas, 1993).

2.4 Energy Tools

The complexity and amount of information of buildings designed with sophisticated technologies and methods make it difficult to understand the building performances of building owners and designers in a holistic way. The reason for this is that the integration tool does not remove or coordinate too much information and confusion problems between

building performance values and prepared design models. (Jaffery, 2016). According to Elbeltagi (2017), building performance simulations in buildings where high performance and energy efficiency are required show design alternatives as different and effective design alternatives as both environmental and energy calculations. Choosing the most efficient and comfortable one among the different design options is done with the evaluation of the conceptual design stage. Therefore the conceptual design stage is critical regarding the sustainable design of the buildings. The performance values of the buildings are directly related to these decisions. For example, during the conceptual design phase, choosing the right direction, appropriate models and spaces for the building and reducing energy consumption by 30-40% without spending additional money. All this is done only with effective decisions made in the design phase (Elbeltagi, Wefki, Abdrabou, Dawood and Ramzy, 2017).

Designers need decision support programs to design and analyse the best design idea they have chosen from design alternatives in the early design period, in a fast and practical way with energy performance (Attia, Gratia, De Herde and Hensen, 2012). These programs need to integrate energy simulations in the design process early in the design process. There are many simulation programs developed in recent years that have been developed or alleged, but these tools are often used to measure the efficiency of design after determined design ideas, rather than early design stages, and ignore the issue of informing decision-makers in the conceptual design phase (Attia, Gratia, De Herde and Hensen, 2012). In addition to this, more advanced research (G-BIM) has been developed in this regard, a successful system that facilitates designers in the conceptual design phase and produces design alternatives limited to parameters introduced into the system. According to this system, the designing criteria, constraints and factors constitute millions of design alternatives through parameters (Abrishami, Goulding, Rahimian, Ganah, & Sawhney, 2014).

2.5 Tools of Energy optimisation and BIM

Over the past 50 years, hundreds of building simulation programs have been developed by architects and professionals with knowledge of the subject, to help build and improve energy efficiency in buildings. On the website of the United States Department of Energy, there are a total of 417 programs used for energy performances in the buildings (Tian, Chen, Tang, Wang, & Shi, 2015). According to many types of research, only about 30% of architects use

these tools, although the energy simulations used at the premises reveal that the designer has a significant advantage and potential for the early architectural design phase (Weytjens & Verbeeck, 2010). However, it should be recognised that a proportion of design decisions are decisions taken early in the design phase, whereas these decisions have an 80% effect on building energy efficiency (Suh & Park, 2017). There is a need for simplified simulation programs for users to measure the accuracy of these decisions made by the Bender and to show the energy decisions made to the building during the early design phase.

Unfortunately, the impact of building energy efficiency on the energy efficiency used in the world is so substantial that the lack of information on the BIM or the lack of the BIM process, the opportunities and positive effects of BIM be overlooked. According to Rahmani Asl (2015), the decisions made about energy efficiency in the early design phase, using parametric Building Information Management / Modelling (BIM), and optimising algorithms result in maximum energy efficiency. Together with BIM, he also noted that designers could simplify the coordination between analysis programs, which they use to evaluate energy efficiency. Moreover, moreover, he explained that the confused design modelling simulations are potentially coordinated with architectural modelling (Rahmani Asl, Zarrinmehr, Bergin & Yan, 2015). This means; With the new parametric BIM technology optimisation algorithms, BIM can generally define the limits of sustainable designs and designs with maximum energy efficiency. However, the use of new optimisation algorithms with BIM creates new problems. As a simple example, when a BIM model is optimised to reach maximum energy efficiency, the designer's willingness to model can cause undesirable effects regarding visual or efficacy (Rahmani Asl, Zarrinmehr, Bergin & Yan, 2015).

This research simplifies energy-minded decision-making in the designer's decision-making process and enables the designer to find the best option for energy efficiency and energy use. Also, the key to working is to combine all these options with architectural requirements and other untransformed features. At the same time, the designer must use simulation tools on energy efficiency to ensure that the project understands energy better to do sustainable projects. Of course, high energy performance enhances the design, quality and comfort of the plant. In addition, these actions are encouraged by government and non-governmental organisations working on clean energy because of the regulation of zero CO2 and energy consumption. Thus, the project shown to be sensitive to energy efficiency will be a longer

life cycle, both technologically and economically. In this way, the project will become energy, quality and comfortable building with high performance and less costly work. It is expected that the use of irrational energy optimisation management framework, along with BIM, in the early architectural design phase will contribute to both the industry and the academic field.

3. CHAPTER THREE: DESIGN AND METHODOLOGY

The methodology section of a researcher is considered to be the most critical part of the research departments that informs the reader about the most likely approaches, how they are conducted and researched, how they are processed, and how the researcher can reach research results. (Lewis, 2015). The methodology section is the most focused and time-consuming part of an investigation. In this part of the research that explains the role and situation of energy optimisation in the conceptual design phase, different research approaches and designs, data collection methods and analyses have been studied, and the most appropriate ones have been shown as the most suitable reasons.

3.1 Research Design / Approach

There are several methods of explaining and selecting a research methodology. However, because they reflect the quality of the work, the method that best describes the research should be chosen. (Lewis, 2015). In addition, the researcher has three basic approaches that facilitate the selection of these methods. These are the numerical method (quantitative), the non-quantitative method (quantitative) and the method in which these two are used (Creswell, 2013). According to Bernard (2011), the research includes verbal research approaches such as numerical (qualitative) approach, reports, e-books, written sources and analyses, which is a rather simple approach for researchers.

Nonetheless, the non-quantitative method approach is shown as questionnaires, group discussions, numerical data and interviews, and this approach are time-consuming to analyse long tasks and information. However, it is beneficial in terms of numerical values and reliability. Moreover, sometimes these two method approaches are applied.

To increase the effectiveness of this research, the focus group method was selected from the numerical method approaches, and the recommendations of those interviewed in the focus group were applied. Thus, the feedbacks of the research frameworks mentioned at the beginning of the research on the academic and industrial field have been determined. The discussion environment with eleven people was done with the experts who talked about the subject of the development of the conceptual framework recommended in the research.

The reason for choosing the focus group in this research methodology is to ensure that the people who have mastered the subject in the academic and professional life are discussed with good or bad aspects of the conceptual framework in a corporate discussion environment and provide numerical data about the research at the end of the process. In this research, in addition to the purpose of the meeting with the focus group, the conceptual framework developed to integrate energy optimisation in the conceptual design phase into the process is to be improved according to the suggestions and needs of the members of the focus group.

3.2 Project Requirements

Since the purpose of this project is to provide a framework for energy optimisation during the conceptual design phase, the framing requirements will be specified. Project requirements are described in detail for the development of this project;

- In the conceptual design phase, the necessary information of the proposed framework for energy optimisation should be investigated, the constraints affecting the process should be determined, and the effects of these constraints should be analysed.
- Parts of the production system phase should be defined, and optimisation criteria for the energy optimisation system should be determined during the conceptual design phase. These criteria must be specified and ordered where the process is run.
- Optimization criteria for the first population of design alternatives should be determined. In addition, the energy optimisation system should be integrated into the process before this part.
- The most efficient design alternatives should be implemented with BIM tools, and process outputs should be controlled.

3.3 Design

a. Background Information

The first phase of the proposed framework (Figure 1.2) for energy optimisation is the background information phase. This phase is the first phase of the frame and the phase that

influences traditional design decisions that have existed for many years. In this phase, the first phase of the frame is completed with decisions such as design summaries, routines, site data, design requirements and other constraints. Other restrictions may include, for example, decisions made by the municipality, the client and the designer.

b. Generative System

The second stage in the conceptual design phase is the generative system in the framework (Figure 1.2) of energy optimisation. This stage is the most critical phase of the proposed framework and constitutes the main structure of the process. At this stage, a production system is described as the initial population of design alternatives mentioned in the literature review and successful in the previous years. In this system, designers can access millions of design alternatives depending on the constraints they enter and through the parameters entered. This system has already been worked on before. This framework demonstrates how to integrate the energy optimisation system into the system and which criteria to consider. Energy optimisation design criteria; building orientation, planning, design and dimensioning of building openings, and finally material selection. The design, energy optimisation criteria and constraints required to be created using the proposed framework are ready for the initial population design alternatives system. Thus, the energy efficient design and production system is completed.

c. BIM Environment

Energy optimisation studies have been completed at this stage, and the role of the BIM tools in the conceptual design phase has been demonstrated, using the energy efficient designs after the production system has been built. In this phase, the use of BIM programs and their place in the process are mentioned. (Figure 1.2)

At this stage of the rubric, the use of the Revit program and energy simulation programs is included. In the process, with the Revit program. Revit has benefited from the ability to remodel and modify the design. With the Revit program, the parameters will be used in a more healthy and error-free manner and will respond immediately to changes made to the

results. In addition, the Revit program offers designers the ability to display 3D models in the design phase, as well as view energy optimisation decisions instantly in their models.

The use of energy simulation tools provides designers with convenience by numerically analysing the effects of given decisions on design. In addition, it can further improve the energy decisions at the conceptual design stage and provide the best energy efficiency.

d. Output Information

The last phase of the proposed framework (Figure 1.2) for energy optimisation in the conceptual design phase is; constraints and criteria, and the use of Revit and energy simulation tools, the data presented to users of the framework will be disclosed. At the same time, this data is the final design of the design in which energy optimisation is integrated into the conceptual design phase. Along with the design that is created, users are presented with a set of data about energy.

This stage also shows the output of the system described in the frame and the output information that system users have at the end of the system. The outputs generated by the Revit program are; the 3D model of the energy optimised design, the management as the facility to be created, the cost and the cost management that will affect the structure of all aspects of the design and the design decisions as a result of the system.

Outputs generated by energy simulation tools need to be evaluated in 2 steps; Analyzes and information output. As analyses, artificial lighting projects, wind analysis reports and usage areas of the building and window, the best sizing analyses of door gaps are provided by the system as output. Another stage is the output of the energy performance appraisals, the best material to choose from for the structure, the orientation and insulation decisions, and finally, the energy optimised the best design project system, which is the most important output of the system.

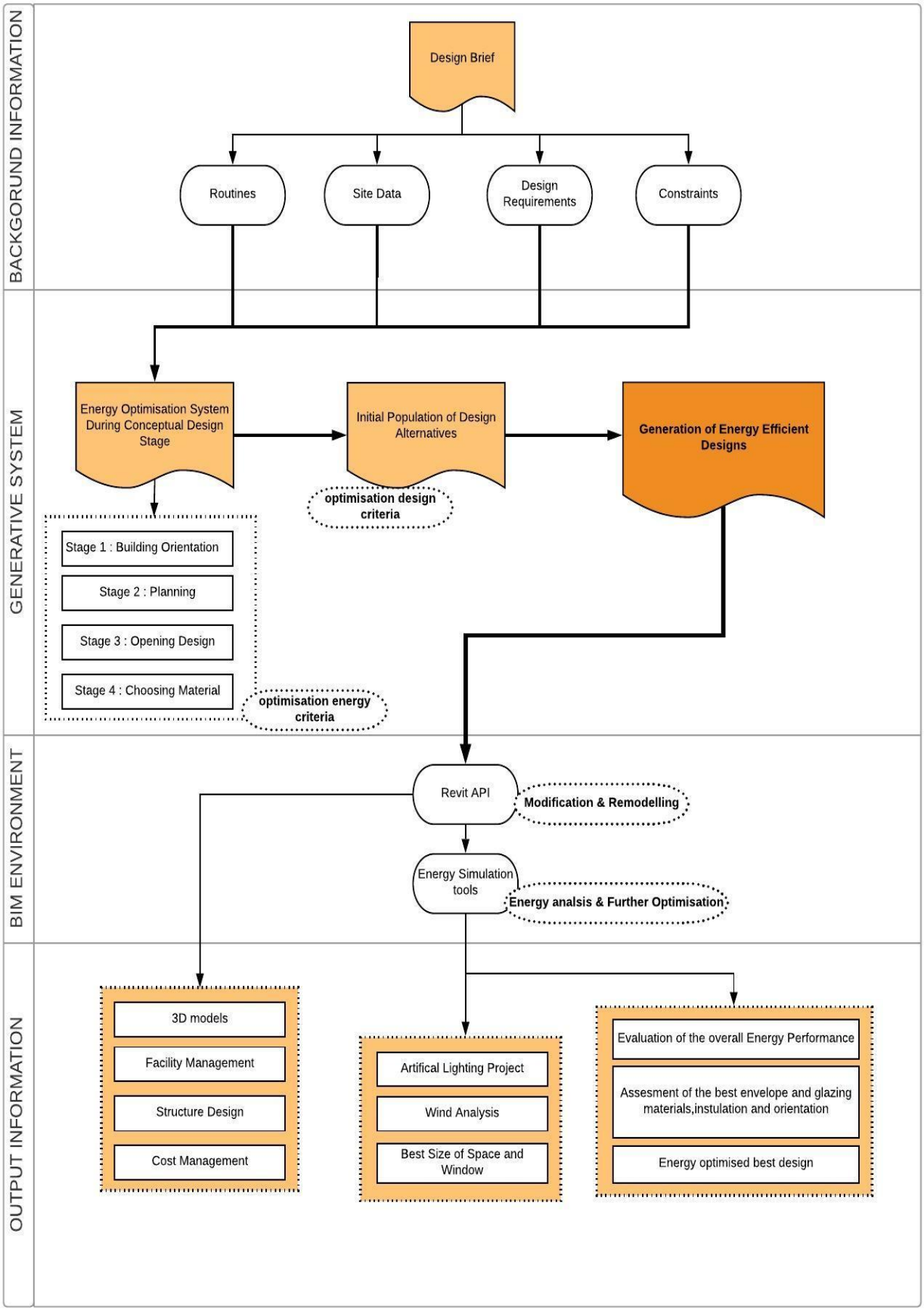

Figure1.2: Concept Framework for Energy Optimisation

4. CHAPTER FOUR: DATA COLLECTION

In this section, information collected for the analysis of the presented framework for energy optimisation will be presented during the conceptual design phase. The gathering of information is done to ensure the reliability of the work and the flow of information coming and going. According to the criteria set by the researchers, data are collected in two ways, mostly primary and secondary data source methods. The primary data source includes data generated by the participating direct participant. These data are obtained using different techniques, such as questionnaires or interviews, taking into account the design, the design, and the approach being investigated. (Lewis, 2015). The secondary data source method, which is another data source method, is collected using studies completed or executed by other researchers. (Creswell 2013). It contains printed documents such as reports, reports, books, etc., often used by researchers. For this study, we use both primary and secondary data collection methods by using focus group participants. In addition, this research on energy optimisation in the conceptual design stage has been completed based on the research framework, in line with the opinions of eleven experts in the field, from academic and sectoral perspectives on ethical rules. This flow of information with the focus group was made on the conceptual framework. If changes are made in the conceptual framework after the experts' view, these changes will be processed in the framework, and an approved framework will be established.

This data collection method has been collected using both qualitative and quantitative methods. In addition, primary data is used for this. In the analysis of data collected in the research, non-statistical tools were used both statistically and interpretively. In addition, for this study, data were collected directly with the focus group and participants. The focus group work was conducted with expert participation, and eight questions were asked. All these questions were asked about the conceptual framework of energy optimisation in the conceptual design phase. Participants in the focus group were asked some questions to present the framework of the discussion of the frame in a transparent manner. At the same time as all the participants, these questions were administered in the meeting environment. Questions asked by participants;

• How do you evaluate the process of the energy optimisation framework that will be integrated into the conceptual design phase?

• What is the contribution of BIM to optimising energy in the early design phase?
• Are there optimisation criteria for energy optimisation, building orientation, planning, openness designs, sufficient material selection stages to limit the information?
• Do you find success in the framework of integrating energy optimisation in the conceptual design phase of the research?
• What parameters should be used when creating design alternatives?
• What are the points to be considered when integrating energy optimised output designs into production?
• What are the expectations of the academic or industrial area in this area?
• What methods should be applied to integrate energy optimisation during the conceptual design phase?

These questions were asked by the participants to get an idea of the framework and to ask each question to be developed by the experts of the frame. Participants were asked about the proposed framework process for energy optimisation to be integrated during the conceptual design phase. In addition, energy optimisation of the frame is added; planning, openness designs, information constraints and material selection stages. In addition, when constructing the design alternatives, the frame is asked which of the parameters to ask, and if so, which methods can be used to combine them. In addition, all these processes and inter-sectoral expectations and the needs of academic and industrial areas were concluded with the views of the participants. The BIM tools, which are used to easily integrate the framework into the system and take advantage of the technology, have benefited from optimising energy and contributing to the conceptual design phase.

The answers to the questions asked by the participants in the research were analysed and compiled by the researcher. According to this; In the future, the framework has been agreed on in the exciting way for the construction industry to use energy optimisation in the conceptual design phase and make it easier for designers. It has contributed to the evaluation and development of the research by the broad audience, which is the participation of people from different nations and business fields. For this reason, the reliability of the research and the sustainability for future use are provided. For this reason, the questions asked by the participants were addressed to every person in the construction area, and common questions were asked from experts in each area. No specific and specialised questions were asked in the field.

Explanations and questions were made about the design and parts of the conceptual framework of the participants. In the framework of the ethical rules presented in the research, it is aimed to take the approved framework decision after this meeting by the privacy principles. It is expected that the AEC sector experts meeting and academic field will provide safe feedback in this regard. The final version of the frame that is created and revised by the focus group recommendation will lead to the creation of new ideas and research areas about the research.

Different approaches and methods have been chosen for the purposes and purposes of the study and for data collection as mentioned above. However, this research should be systematically followed by the procedures so that the researcher can obtain useful results after using these methods. For this reason, previous studies have been analyzed, and the collected data are presented in the literature review. In the conceptual design process, energy optimisation data are collected from academic reports, books and websites. In addition, a specific framework has been presented to the Sahara to improve the framework, reach its goal, and facilitate readers' understanding. For example, the main themes of the research were integrated between the issues of energy efficiency, BIM tools and conceptual design stage, and the topics were related. The energy optimisation presented in this study was based on information gathering and ethical rules. In the appendix of the research, all documents related to ethical limits and permits are available.

As a result, in the conceptual design stage, which was built on the basis of the literature survey and developed with the participants' opinions, the framework of energy optimisation was closed with the information gathering phase and the literature was closed for research and findings not obtained from the secondary sources were obtained. This is why it is essential that the stage of information gathering is the stage that has been proven in terms of positive-negative or value.

5. CHAPTER FİVE: ANALYSIS AND DISCUSSION

This section deals with analysing and responding to what you have accomplished to achieve the objectives of the research. It also intended to explain in detail the main findings of the research participants and to present this data with the secondary knowledge and evidence mentioned in the literature section. In other words, in a consensus on the work already completed by the researchers, this research is to respond concisely to the results from the questionnaire, to obtain a more detailed benefit of the topic. As discussed above, this chapter in this research should be concerned with how to integrate energy optimisation into the conceptual design phase, how to integrate it, what frameworks can be built based on previously completed research, what are the boundaries of this framework and how should it be integrated into the System? The AEC plays a role based on both quantitative and qualitative analysis with questions such as whether the industry needs such a system or framework. The results of the study, the questions asked of the focus group participants and their answers were analysed, and the results were presented.

The primary findings of the work were a system that produces design alternatives about the initial of populations of design, using a number of constraints and parameters in the conceptual design phase throughout the AEC sector and worldwide. This system has been produced using qualitative and quantitative data or methods. For this reason, AEC provides convenience at a significant point in the sector. The necessity of this system is due to the prevention of wastage in the construction area, and the increase in productivity in the researches carried out by academia, industry and most non-governmental organisations around the world. This completed and literalized system is described as requiring a system for energy optimisation and a production framework that can be integrated into design alternatives and work well with BIM tools. On the other hand, BIM technology is intended to be used in the system as new technology because it is more active by changing the benefits of sustainability and traditional methods with technology. (Lu & Li, 2011).

The focus was collected by 11 participants, including the findings gathered by the focus group participants, countries from 4 different countries Europe and non-European countries. The average age of these participants is 32. In addition, approximately one-fourth of the participants are more than six years old, either in the AEC sector or academic work. In

addition, there are architects, mechanical engineers, construction engineers, building engineers and architectural office directors in the participants.

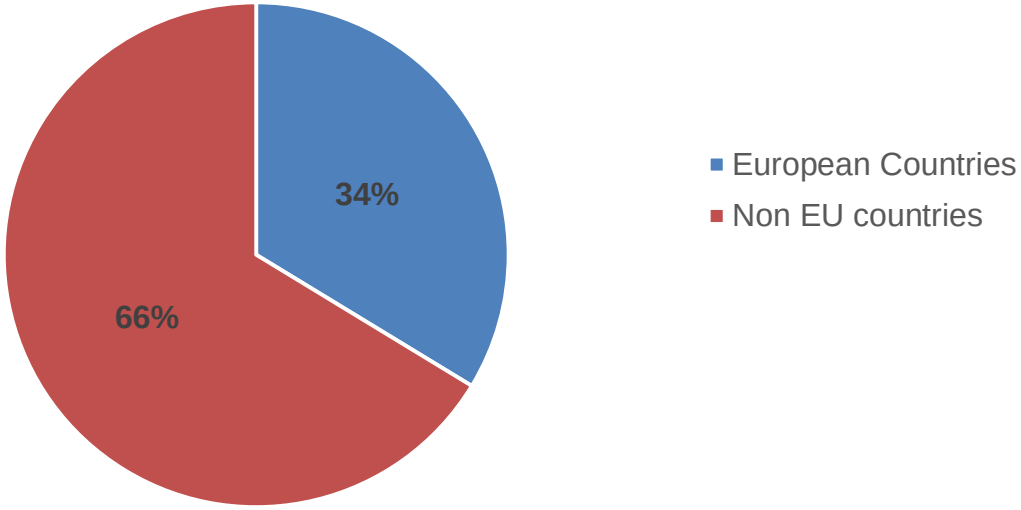

Figure2.1: The nation of participants

Since this research aims to use energy optimisation in the conceptual design phase with the BIM tools, and because it forms the framework for this, the analysis of the BIM usage information of the selected participants is also made. In this study, the use of BIM was also analysed. 88% of the specialists from sector or academia who are in focus are aware of BIM tools and actively use BIM technologies. In contrast, 12% of participants used BIM tools.

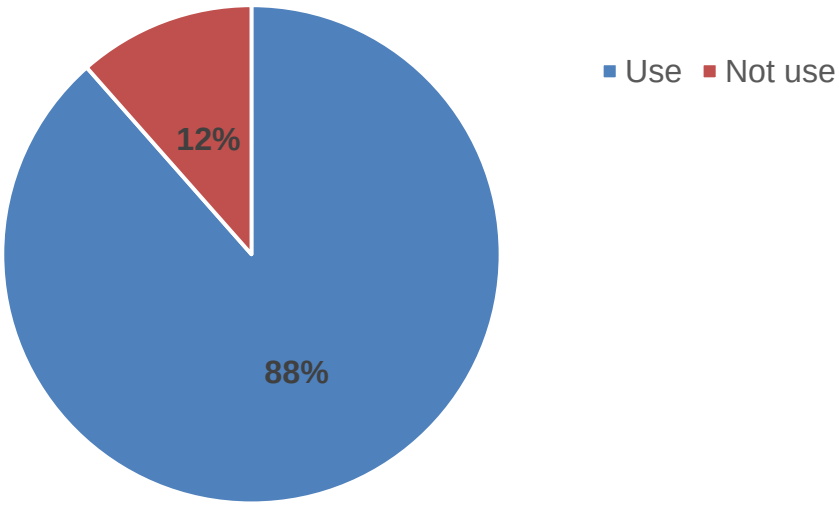

Figure2.2: BIM users of participants

According to Attia 2012, there are many problems encountered in the implementation of design changes at the conceptual design stage, which brings many errors. Hence,

integration at this stage requires energy optimisation, systems that produce design alternatives, and BIM technology. As a result of qualitative and quantitative analyses in the present study, the framework presented for energy optimisation during the conceptual design phase received positive feedback from the AEC industry and the academic community. The frame has the best energy-optimised design alternatives, along with an initial system (initial populations of design alternatives) and constraints developed for energy optimisation. With the resulting data in the frame result, a conceptual design phase was designed to be fast, reliable, returnable and able to work with other tools due to BIM technology.

According to the focus group meeting reports with participants, the participants finalised the framework with recommendations and considerations on whether the energy optimisation system on the frame should be before or after the design alternatives system. Participants have indicated that the coordination with the design alternatives production system can improve and improve the criteria for the optimisation criteria of the targeted energy optimisation system. However, this framework also focuses on how the system works and how it can be integrated. Therefore, the conceptual framework remains unchanged as a result of the participants' views and analyses. This framework, which participants state as a need for industry and academics, can work with programs other than those specified in the framework because they can work integrated with BIM tools.

According to the analyses and researches already completed by the researchers, it is stated that energy management in the conceptual design phase is essential for energy efficiency. This topic has also been mentioned in the literature review. However, for more efficiency and active work in energy management, it is inevitable to integrate and optimise energy optimisation in the conceptual design phase (Al-Fahmawee, 2013). These decisions will help designers make more accurate, efficient, and revisable decisions about energy. It is inevitable that this framework, approved by the participants in this research and afterwards, will answer the need in this regard when comparing literary survey and information gathering stages. In other words, a different perspective and technique have been shown to energy efficiency in industry or designers who have previously limited variations and alternatives in limited numbers.

This research suggests a solution to the problem of limited decision-making abilities that designers already have in the conceptual design phase, along with the proposed framework.

In addition, this research has solved the lack of coordination with communication between conceptual design phase software and many energy efficiency methods using BIM technology. (Attia, Gratia, De Herde and Hensen, 2012). The main reason for this lack of coordination is the lack of a framework for energy optimisation management at the conceptual design stage. For this reason, designers are far from designing energy efficiency in the conceptual design phase. (Elbeltagi, Wefki, Abdrabou, Dawood and Ramzy, 2017). This research, with contributions in participants, has been completed in separate studies in the literature; energy optimisation, BIM technologies, and systems that generate design alternatives at the conceptual design stage.

Optimization criteria are also included in the framework so that energy optimisation can be done healthily in the research. These criteria govern space constraints in the system when optimised. Since there are many ways to achieve energy efficiency in the buildings, the framework also includes the most important of these criteria. These criteria are also included in the analysis of energy performance and calculations. However, since the energy values of the materials used in the design are expected to affect the energy optimisation, the material selection is also considered as the optimisation criteria. The orientation of the buildings is the planning phase of design and other energy optimisation criteria in the design of window-door openings.

The last phase of the proposed framework for this research is the system outputs, designers, Revit, and some simulation tools, as well as a presentation on the design. If the generated data changes the designers' decisions, the system provides flexibility to the designers if they come back to the previous stage and make changes afterwards. The 3D model in the system outputs presented in the frame covers all decisions that can be made about facility management, cost and design. Since these decisions affect all aspects of the design, the frame has been developed so that the designer can make decisions at this stage. However, the effect of the designer's designing decision changes led to a number of problems in previous research and the literature. This problem has been solved with this research. Participants also agreed on the same idea. The outputs of the last stages of data output are analysis and calculations. Here, the designer can arrive at the numerical data on the analysis and calculations he wants to see, such as the design of the wind, wind analysis, direction, insulation decisions, material selection and efficient use of the gaps in the structure.

6. CHAPTER SİX: CONCLUSIONS

This research on energy optimisation in the conceptual design phase compiles the field in the literature search of all the problems mentioned above and topics in the system framework proposal and collects the data about the area that has been completed today. They are given with the support of participants and eventually analyse them. As a result, exciting solutions for the AEC sector and academic work are presented. These solutions are welcomed by the experts in the industry and the academy. For this reason, the purpose of this research is to develop a system that can integrate energy optimisation using BIM tools in the conceptual design phase. However, designers will now start designing with a significant number of designers, which are essential in a few ways. The framework proposed in this study gives the designers flexibility in design decisions, which are described in the literature and at the design stage.

An essential part of the litter presented in the research focuses on the problems of designers in energy optimisation, the use of auxiliary tools and general issues in the conceptual design phase. Also, the effects of the design process of BIM tools are emphasised. Also, attention has been drawn to the lack of coordination among the many devices in the construction sector and therefore the influences of design. Finally, many difficulties arise from all the problems, such as time loss, poor quality designs, ignorance of the business people, and so on. However, together with this study, a framework for solving the issues such as how to optimise the energy in the conceptual design phase and how to conduct the process jointly with the lack of coordination is suggested. For this reason, with this research, awareness of energy will be increased in the field of construction, and a significant phase in energy efficiency will be completed.

The research was carried out as planned as indicated in the appendices. A long period to understand a system which is a conceptual design stage system, called the initial population of design alternatives and which can give designers millions of design alternatives through programmed parameters, did not affect the duration of this research. Also, the arrangement of the energy optimisation framework during literal translation and conceptual design constitutes a large part of the study and has been completed as scheduled. The meeting with the participants was completed successfully with the number of people planned and the

number anticipated. Thus, framework research based on actual data and monitored by enthusiastic enthusiasm was developed.

In recent years, energy has become an essential part of the world when it comes to studies, analyses and reasons for climate change. It is also seen that the energy problem is on the agenda of the developed countries and researches and reports are made about energy saving and productivity. It is stated that a large part of this energy, which is on the agenda of the world, belongs to the construction sector. (Gaterell, 2005). This framework, developed and approved by taking into consideration the views of the participants, is considered to be of great benefit to this research, which has been on the agenda of developed countries in recent years.

This research solves the problems encountered during the conceptual design phase and eliminates the lack of coordination related to energy optimisation. Also, this analysis has also used BIM technologies, which have benefited from many designs and industry perspectives in recent years. In this way, models can be created that can create decisions flexibly in a short period, analyse energy criteria during the conceptual design phase, and create the best energy-optimised design alternatives. In short, the framework proposed in this survey, which introduced a new method to the designers in the construction sector, has been a solution to many problems in the field of construction lately.

This research is gathered through the participation of all participants, who have expertise in their focus areas, are knowledgeable in BIM and have experience in different building sites. All this information gathering was carried out within the framework of all ethics rules provided by the University of Portsmouth. However, the reliability of the data presented in the study is also ensured.

The results of the study emphasise that the proposed framework for energy optimisation at the conceptual design stage is a significant step for energy efficiency. It explains the many advantages of this framework and how it will be useful to the designer when used with BIM tools. Here, the most critical point is that the system must be constrained to be able to optimise the desired constraints, design, and energy. The main reason for this is determining the decision-making optimisation criteria for the energy of the design or data to be generated. This may vary in different projects or designs at different levels. At the same

time, it is desirable to be knowledgeable about BIM to be able to use this framework and to be sufficiently informed to use the tools.

6.1 Recommendations

This research suggests a framework for energy optimisation in the conceptual design phase. However, in order to conduct further research on this subject in the future and to be able to conduct further research on the subject, it is recommended that we do more research than this research. There are also many different ways to integrate the energy optimisation system into the system that offers the design alternatives. Therefore, as different methods can be tried for the conceptual design phase integration of energy optimisation, it is suggested that the researcher analyse these methods. Finally, these methods will contribute to the development of lithologies in energy optimisation. As more detailed information on the role of energy optimisation in design is needed, future researchers are advised to conduct surveys and interviews in the industry and academic settings if it is too early. Thus, more information will be gathered, and the views of a larger body will be taken.

6.2 Limitation

The most significant limitation of the study is that there is not enough time to conduct further research. Therefore, only the focus group met in the survey. The most significant limitation of the study is that there is not enough time to conduct further research. Therefore, only the focus group met in the survey. Moreover, due to the limited time of the study and the fact that the researcher arrived in the summer season, i.e. the holiday season, no more participants were found.

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Appendix 1 : Ethics Review of Project

Statement of Originality:

This Independent Project/Dissertation is submitted in partial fulfilment of the requirements for the degree of MSc.

I, the undersigned, declare that this Independent Project/Dissertation is my own original work.

Where I have taken ideas and/or wording from another source this is explicitly referenced in the text.

I give permission that this Independent Project/Dissertation may be photocopied and made available for interlibrary loan for the purpose of research.

I give my permission for this Independent Project/Dissertation, and the electronic source, to be used in any manner considered necessary to fulfil the requirements of the University of Portsmouth Regulations, Procedures and Codes of Practice.

Course:

Name: Mehmet Arif AK706

Student ID: 869068

Signed:

Date: 01.06.2018

ish

University of Portsmouth

Certificate of Ethics Review

Project Title:	Energy Optimisation During AEC Conceptual Design Phase
User ID:	869068
Name:	Mehmet Arif Aktog
Application Date:	31/05/2018 19:08:28

You must download your referral certificate, print a copy and keep it as a record of this review.

The FEC representatives for the School of Civil Engineering & Surveying are Tim Whitehead and John Williams

It is your responsibility to follow the University Code of Practice on Ethical Standards and any Department/School or professional guidelines in the conduct of your study including relevant guidelines regarding health and safety of researchers including the following:

- University Policy
- Safety on Geological Fieldwork

All projects involving human participants need to offer sufficient information to potential participants to enable them to make a decision. Template participant information sheets are available from the:

- Univeristy's Ethics Site (Participant information template).

It is also your responsibility to follow University guidance on Data Protection Policy:

- General guidance for all data protection issues
- University Data Protection Policy

SchoolOrDepartment: SCES
PrimaryRole: PostgraduateStudent
SupervisorName: Sepehr Abrishami Shokooh
HumanParticipants: Yes
ParticipationLimitedToAnsweringQuestionsOrInterviews: Yes
HumanParticipantsWarning
ParticipantInformationSheets: Graphs, charts, bars or tables will be used.
ParticipantConfidentiality: No names, age, gender, addresses, a telephone number will be taken.
InvolvesNHSPatientsOrStaff: No
NoConsentOrDeception: No
CollectingOrAnalysingPersonalInfoWithoutConsent: No
InvolvesUninformedOrDependents: No
DrugsPlacebosOrOtherSubstances: No
BloodOrTissueSamples: No
PainOrMildDiscomfort: No

Certificate Code: 6E95-34D3-467F-268D-E760-8049-6583-51C3 **Page 1**

PsychologicalStressOrAnxiety: No
ProlongedOrRepetitiveTesting: No
FinancialInducements: No
PhysicalEcologicalDamage: No
HistoricalOrCulturalDamage: No
InvolvesAnimals: No
HarmfulToThirdParties: No
OutputsPotentiallyAdaptedAndMisused: No
HasSecurityImplications: No
Confirmation-ConsideredDataUse: Confirmed
Confirmation-ConsideredImpactAndMitigationOfPontentialMisuse: Confirmed
Confirmation-ActingEthicallyAndHonestly: Confirmed

Supervisor Review

As supervisor, I will ensure that this work will be conducted in an ethical manner in line with the University Ethics Policy.

Supervisor signature: Sepehr Abrishami

Date: 01/06/2018

Appendix **2 : Project Plan**