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ATTAINING THE APPROPRIATE SIMULATION PROGRAM TOWARDS BETTER ENVIRONMENTAL DECISIONS

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Abstract

Global Warming is one of the greatest environmental threats of the 21st century. Many parties around the world like governments, corporations, and researchers, etc. are working hard to find solutions. Architectural education is concerned with global warming issues, and trying to achieve reliable design related solutions for a sustainable environment. Majority of the students use simulation programs to determine with accuracy some variables that can support designers to take decisions about the best strategies to apply for any type of building. These simulation programs are usually selected based on their straightforward and user-friendly interface. The most common programs among architecture students at the Beirut Arab University are Ecotect, DesignBuilder and CFD. However, not all the results are precise nor are they based on an accurate scientific basis. This paper will discuss the scientific background, interface, and capability of these programs. In addition compare them in order to establish their differences, besides a brief overview about energy simulation concepts. In addition the research will conduct a survey measuring the awareness and benefit of the three programs among students as a design decision supporting tool. Furthermore students that already implemented these programs in their design will be selected, to show how they dealt with these programs and how these programs interfered with their design decision making. The selection of the students will show the appropriate year to add this program as a supporting tool for architectural design studio.

Keywords

Architectural design studio. Building simulation programs, CFD, DesignBuilder, Ecotect

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A. SIDANI¹, O. MOH.OMAR²

ABSTRACT

Global Warming is one of the greatest environmental threats of the 21st century. Many parties around the world like governments, corporations, and researchers, etc. are working hard to find solutions. Architectural education is concerned with global warming issues, and trying to achieve reliable design related solutions for a sustainable environment. Majority of the students use simulation programs to determine with accuracy some variables that can support designers to take decisions about the best strategies to apply for any type of building. These simulation programs are usually selected based on their straightforward and user-friendly interface. The most common programs among architecture students at the Beirut Arab University are Ecotect, DesignBuilder and CFD.

However, not all the results are precise nor are they based on an accurate scientific basis. This paper will discuss the scientific background, interface, and capability of these programs. In addition compare them in order to establish their differences, besides a brief overview about energy simulation concepts. In addition the research will conduct a survey measuring the awareness and benefit of the three programs among students as a design decision supporting tool. Furthermore students that already implemented these programs in their design will be selected, to show how they dealt with these programs and how these programs interfered with their design decision making. The selection of the students will show the appropriate year to add this program as a supporting tool for architectural design studio.

KEYWORDS

Architectural design studio. Building simulation programs, CFD, DesignBuilder, Ecotect

1. INTRODUCTION

Energy performance simulation programs are powerful tools to analyze energy performance and thermal comfort during the building's life-cycle, such as energy use and demand, temperature, humidity, costs, daylighting, and ventilation (Rosenbaum, 2003). Hundreds of reliable building energy programs have been developed over the past 50 years. Building simulation is the process of using a computer to build a virtual replica of a building. Such tools differ in many ways; in their thermodynamic models, graphical user interfaces, life-cycle applicability, and compatibility with other programs. A simulation is performed by taking that building through the weather conditions in a specific time. In a way, building simulation is a way to quantitatively predict the future and thus has considerable value. Environmental simulation programs consist of an engine with complex algorithms which enables detailed thermal simulations based on simple text-based input and output files. Most important for the friendly use of these tools is the program interface that eases the generation of input and the evaluation of the output, and exposes the functionality of the engine to the user (California Commissioning Collaborative, 2012). These simulation software can determine

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conclusion the listed strategies will show the appropriate year to add this program as a supporting tool for architectural design studio, and in which design phase.

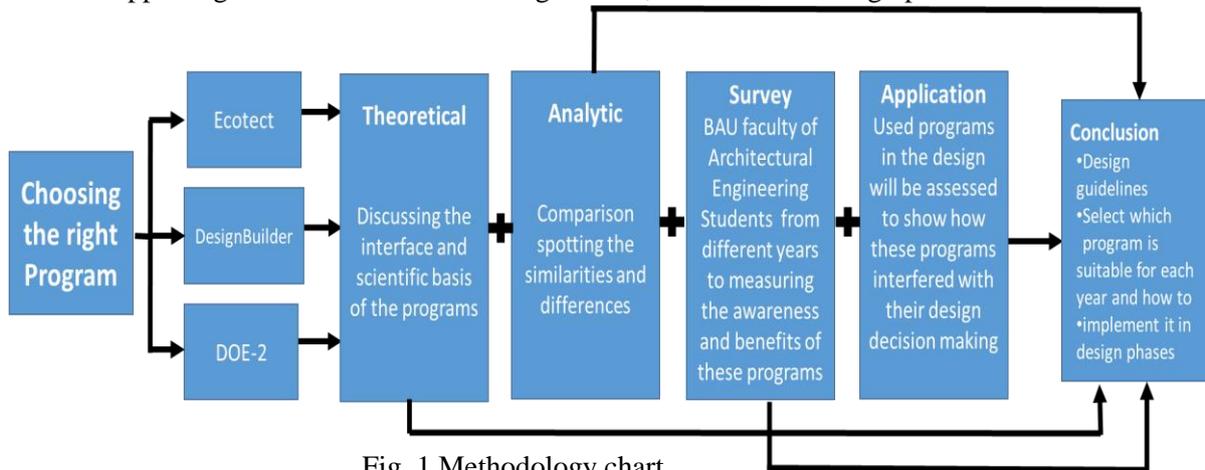


Fig. 1 Methodology chart
Reference: By Authors

2. THEORETICAL

The following programs were chosen based on their familiarity to the BAU students, in addition the Design Builder is being taught in a course named Environmental Design for fourth and fifth academic years 2014/2015. While students use Ecotect since it is fast to learn and dealt a lot with. DOE-2 was chosen since it has the same components and results of both Ecotect and Design Builder but more advanced with reliable data and scientific based, few students use this program. This part will identify the use of each program, including the compatibility with CAD and other geometry based software, nevertheless will show the interface of each program.

2.1 Ecotect

Autodesk Ecotect Analysis is an environmental analysis tool that allows designers to simulate building performance from the earliest stages of conceptual design. It combines analysis functions with an interactive display that presents analytical results directly within the context of the building model. Ecotect was acquired by Autodesk from Square One Research and adds to an array of tools that augment the Revit BIM environment including Sketchup, AutoCAD, 3D Max or Rhinoceros in DXF or 3ds format. Ecotect is different from other analysis tools in that it targets the earliest stages of design, a time when simple decisions can have far-reaching effects on the final project. (Autodesk, 2015)

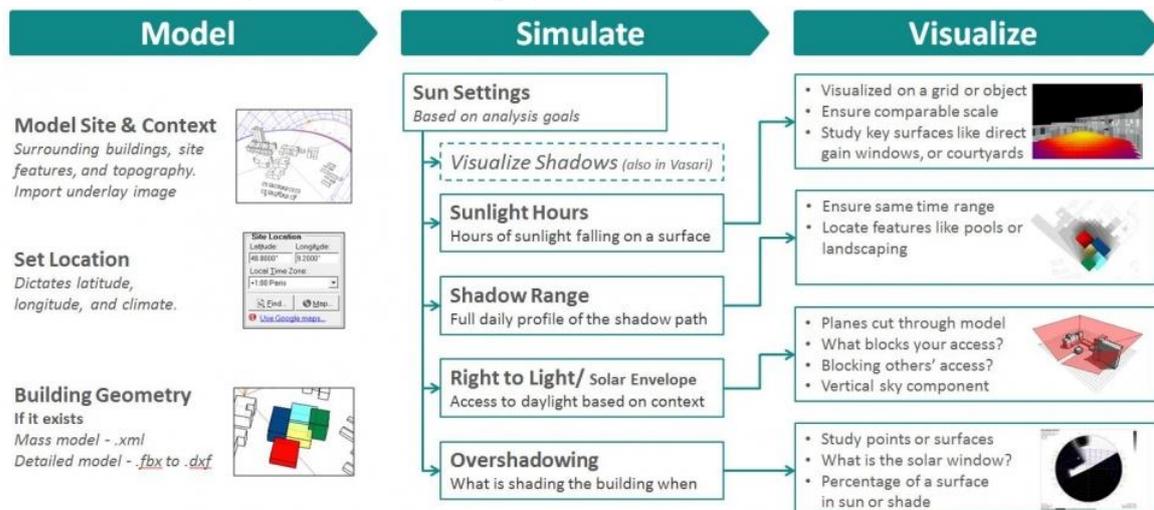


Fig. 2 Modeling, Simulation and Visualization Settings of Ecotect

Reference: <http://sustainabilityworkshop.autodesk.com/buildings/ecotect-shadows-sunlight-hours>

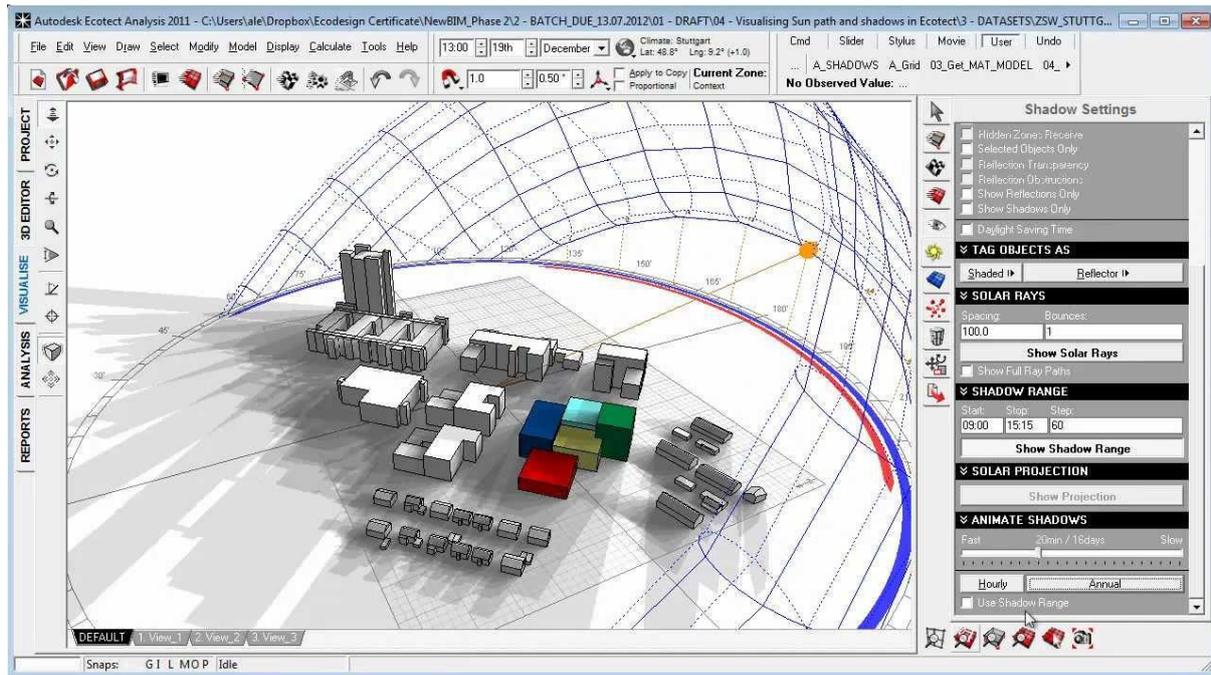


Fig. 3 Ecotect Interface, and Visualizing sun path and shadow

Reference: <http://sustainabilityworkshop.autodesk.com/buildings/ecotect-shadows-sunlight-hours>

2.2 DesignBuilder

Provides advanced modelling tools in an easy-to-use interface. This enables the whole design team to use the same software to develop comfortable and energy-efficient building designs from concept through to completion. allow you to link with BIM solutions, analyze solar shading, maximize the use of renewable technologies, test facade options and check the potential for natural ventilation to provide cooling all in one place, adjusting as you go according to client requirements. High quality technical and rendered outputs help communicate findings to clients in a way they can easily understand. Key performance indicators such as energy consumption, carbon emissions, thermal comfort, daylight availability and cost can be provided throughout the design process in both naturally ventilated and air-conditioned buildings. Some typical uses are:

- Calculating building energy consumption.
- Evaluating façade options for overheating and visual appearance.
- Thermal simulation of naturally ventilated buildings.
- Daylighting models lighting control systems and savings in electric lighting.
- Visualization of site layouts and solar shading.
- Calculating heating and cooling equipment sizes.
- Communication aid at design meetings.
- An educational tool (DesignBuilder, 2010)

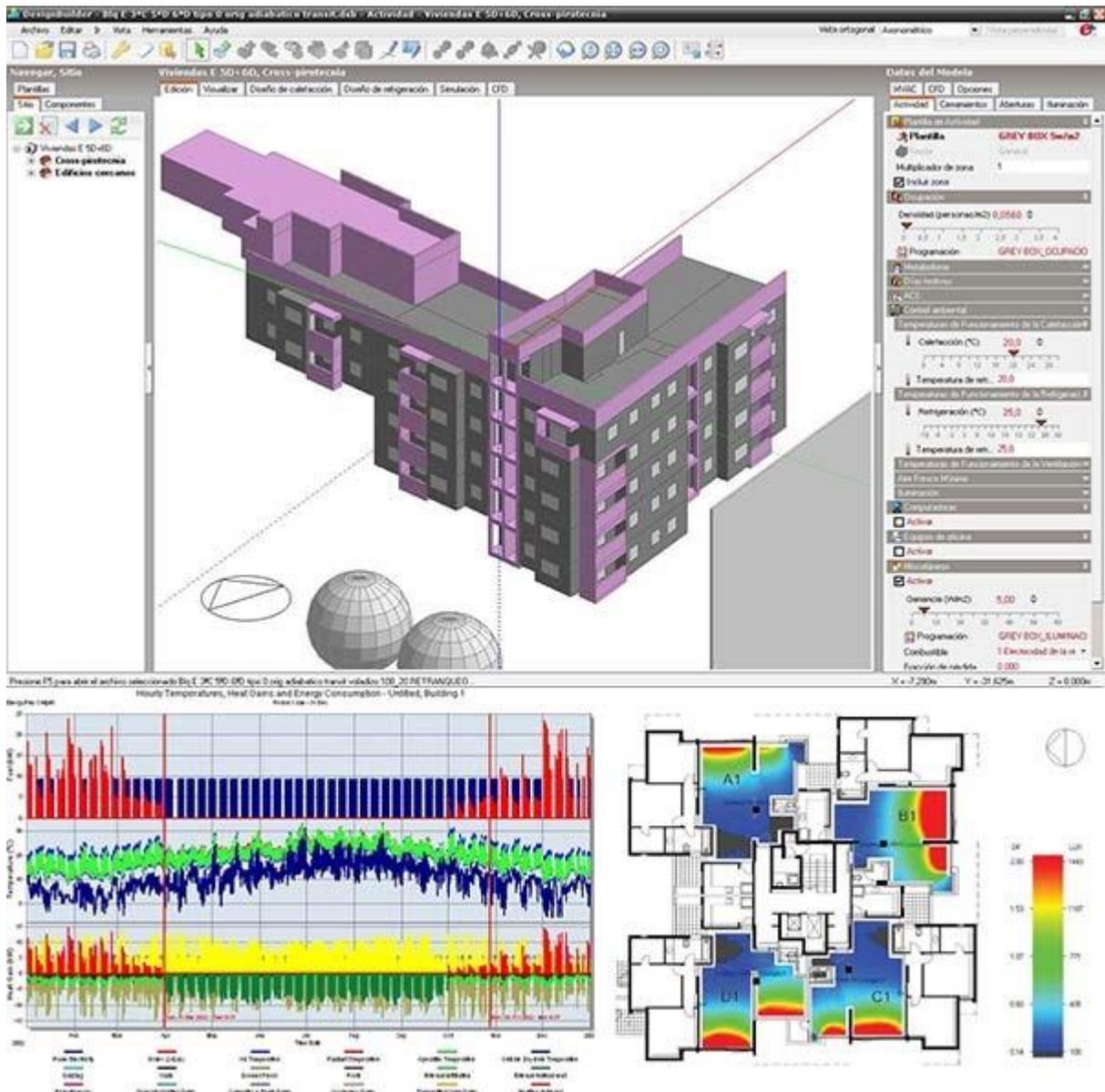


Fig. 4 Design Builder Interface Graphs and internal zones showing heat and lighting
 Reference: <http://www.designbuilder.co.uk/>

2.3 DOE-2

DOE-2 with the given building geometric, HVAC description and hourly weather information can predict the energy use and energy cost of a building. DOE-2 has one subprogram for translation of input (BDL Processor), and four simulation subprograms (SYSTEMS, LOADS, PLANT and ECON). SYSTEMS, LOADS and PLANT are executed in sequence, with the output of LOADS becoming the input of SYSTEMS, etc. The output then becomes the input to ECONOMICS. Each of the simulation subprograms also produces printed reports of the results of its calculations. DOE-2 has been used extensively for more than 25 years for both building design studies, analysis of retrofit opportunities, and for developing and testing building energy standards in the U.S. and around the world. The private sector has adapted DOE-2 by creating more than 20 interfaces that make the program easier to use. (Hirsch, 2012)

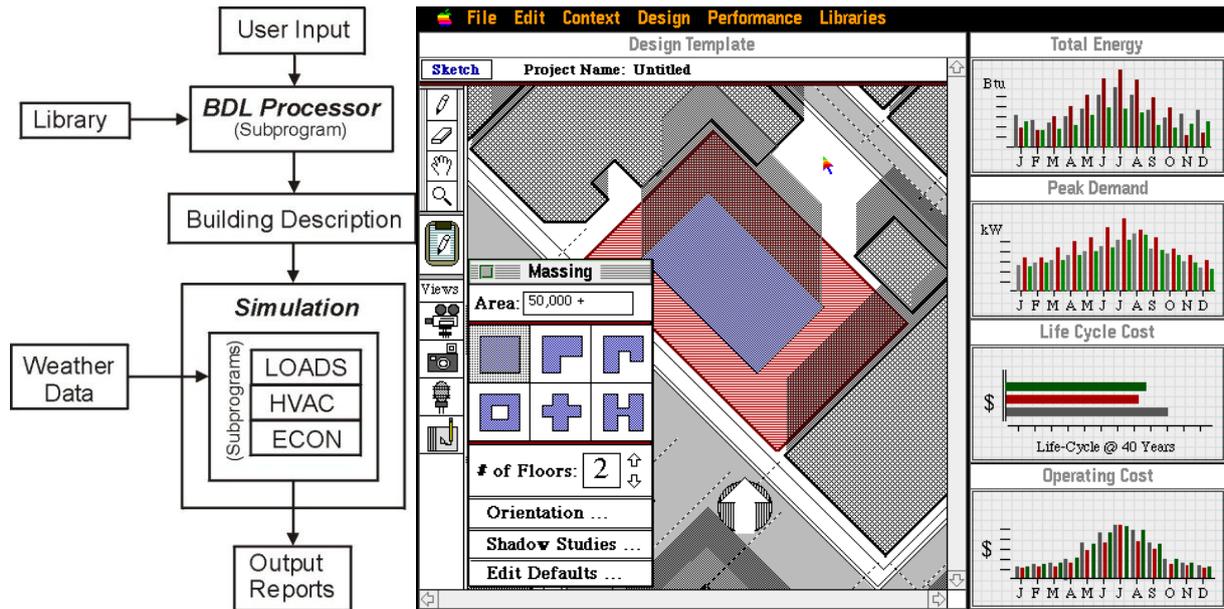


Fig. 5 Flowchart of DOE-2 (Left), DEO-2 Interface Geometry and Data Analysis (Right)
 Reference: www.electricianmath.com (Left), Reference: http://eetd.lbl.gov/ (Right)

3. ANALYTICAL

This part will be a comparison between the three programs that will give an overview of how the programs compute, deal with the air flows, handle the output and input, interact with renewable energy, and how they are affective interior and exterior wise, nevertheless the following will also cover the specialty of each program and the precision and accuracy of the outcome, and engines that help each one.

3.1 Comparison

Table 1. Comparison between DOE, Ecotect and DesignBuilder.
 Contrasting the Capabilities of Building Energy Performance
 Simulation Programs: Drury B. Crawley

Zone Loads	DOE-2	Ecotect	DesignBuilder
Interior Surface convection			
dependent on temperature			x
dependent on air flow			P
dependent on surface coefficient from CFD			E
User-defined coefficient (constants, equations or correlations)	x	x	x
internal thermal mass	x	x	x
Automatic design day calculation for sizing			
Dry bulb temperature	x	x	x
dew point temperature or relative humidity	x		x
User-specified minimum and maximum	x		x
user-specified steady-state-periodic or fully dynamic design conditions			
Building Envelope, Daylighting and solar			

outside surface convection algorithm			
BLAST/TARP			X
DOE-2	X		X
MoWiTT			X
ASHRAE Simple			X
Ito, Kimura and Oka correlation			
user-selectable			X
inside radiation view factors			X
			X
Radiation-to-air component separate from detailed convection (exterior)			X
Solar gain and daylighting calculations account for inter-reflections from external building components and other buildings		X	X
Infiltration, Ventilation, Room Air and Multizone Airflow			
Single zone infiltration	X	X	X
Automatic calculation of wind pressure coefficients			P
Natural ventilation (pressure, buoyancy driven)			X
Multizone airflow (via pressure network model)			X
Hybrid natural and mechanical ventilation			
Control window opening based on zone/external conditions			X
Displacement ventilation			X
Mix of flow networks and CFD domains			
Contaminants, mycotoxins (mold growth)			
Renewable Energy Systems			
Renewable Energy Systems (12 identified, X+O)	1	4	4
Idealized HVAC systems		X	X
User-configurable HVAC systems			X
Pre-configured systems (among 34 identified, X+O)	16	0	28
Discrete HVAC components (98 identified, X+O)	39	0	66
Economic Evaluation			
Simple energy and demand charges	X	X	X
Complex energy tariffs including fixed charges, block charges, demand charges, ratchets	X		X
Scheduled variation in all rate components	X		X
User selectable billing dates	X		X

P: partial, E: essential

3.2 Comparison results and discussion

The difficulty in the interphases of the three programs varies from the Ecotect being the most user friendly and the DOE-2 being the hardest they changed the interface over 20 times to make it easier for the users. The numerical input of each programs concerning the material

properties, reflectivity, heat transfer and resistance differ which is hard on some students to acquire as for DOE and DesignBuilder in case of Ecotect it is easier but not very accurate, according to the ASHRAE standards Ecotect isn't compatible on the other hand site location and climate condition is mostly the same in all programs.

Flexibility of the geometry for each program is a major difference in creating and editing the models, DesignBuilder is limited in this area which is hard to have a fluid shape or a complex design, while Ecotect is much easier when it comes to geometric forms, DOE is mainly friendly with the straight lines as the DesignBuilder, not good with fluid designs. As for the compatibility of CAD programs, it is also a big difference since design builder is only compatible with Revit, AutoCAD files will enter as a 2D drawing and should be traced to run the simulation, Ecotect is compatible with most of the design programs like Sketchup, AutoCAD, 3D Max or Rhinoceros in DXF or 3ds format and DOE is compatible with DWG formats after 2009 but should be traced as well.

The specialties of these programs are different, as for the Ecotect this program since it is compatible with most of the modeling and geometric programs and friendly interface it could be used and could support all design interphases. DesignBuilder on the other hand have accurate results and variety of computation that could be made easily, with a wide library for building materials to choose from so this could be used after the conceptual phase in the design process. The DOE-2 is the most accurate program with the most engines that gives a wide range of computes options and renewable energy implementation and computation, this program should be used in the final stages the design since it is the most accurate but isn't very flexible to use.

Since few years ago Autodesk is no longer giving new licenses for Ecotect, only people with old licenses can run the program and it is replacing it with a new program called Green Building Studio which is a Cloud-based energy-analysis software [4].

4. SURVEY

A group of people will be selected from level2 till postgraduate students. The aim of the survey I to measure the awareness of the students for these programs and in these levels for how important it is for the design and as a tool for decision making. In addition to categorize the programs according to the difficulty level of the interface and how the outcome was expressed. Finally, the students will be asked about how affective it is on their design.

4.1 Survey Results

The answer of Q1: what simulation program do you know?

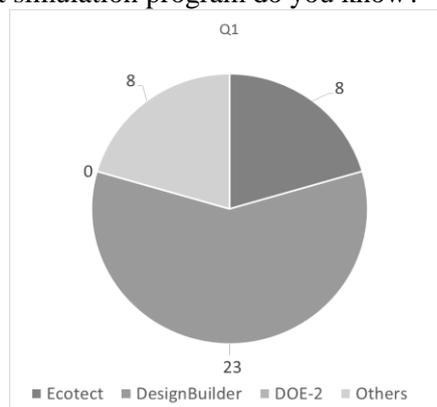


Fig. 6 Statistics of the first question in the survey
Reference: By Authors

The answer of Q2: Did you work on any simulation program or apply it to your project? If yes which program did?

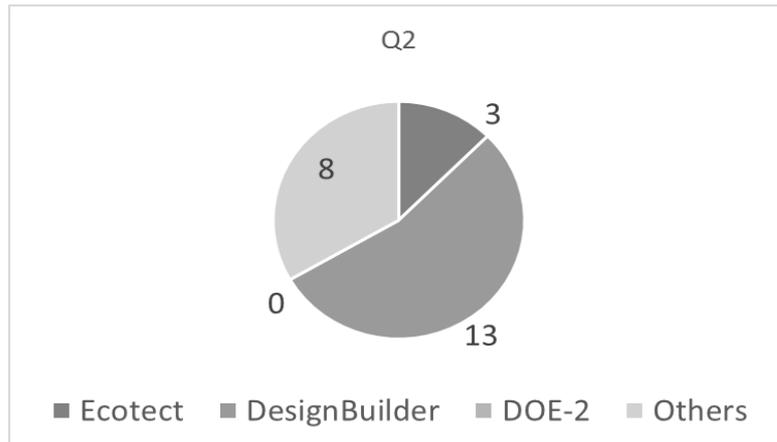


Fig. 7 Statistics of the second question in the survey
Reference: By Authors

The answer of Q3: How satisfied where you with the results you got?

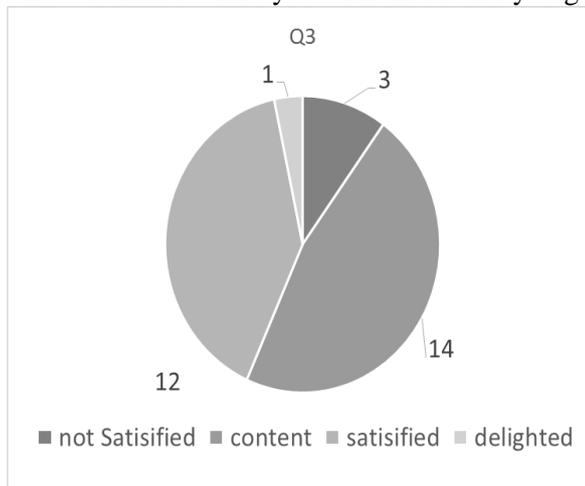


Fig. 8 Statistics of the third question in the survey
Reference: By Authors

The answer of Q4: How much time did it take to achieve the results of the simulation?

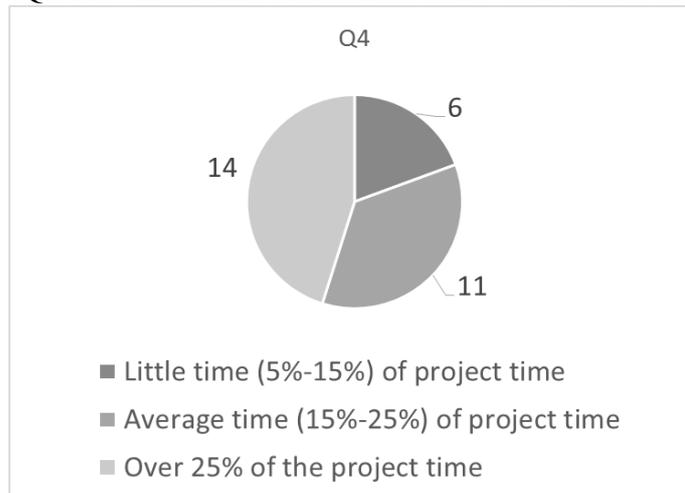


Fig. 9 Statistics of the fourth question in the survey
Reference: By Authors

5.1 Application Results

From the study of the application the following points were shown which are:

1. The implementation of the building on the given site in the right place according to the wind movement.
2. Choosing the appropriate place for wind turbines in the site selected (zone with no wind obstruction and the highest reaching speed)
3. The integration of the simulation program on the environmental diagram to allocate the project elements in the site.
4. The use of the simulation program only in the first stages (conceptual phase) is not the most effective way to acquire the ultimate solution.
5. The student had a difficulty in extracting the results from the program and expressing it in the poster presentation.

6. CONCLUSIONS

In the last decade architecture education was focusing on sustainability and environmental issues, the simulation programs are the ultimate tool to a better design decisions. The students only know the programs that are being taught to them in final years without any background about the simulation programs in the second and third year, this was shown in the survey, so we recommend to implement different simulation programs among different educational levels. The selection of the programs to suit the appropriate education level is due to the friendly inter phase and the complexity of the input data required example (Ecotect/ green studio energy for second year, design builder for third year and DOE-2 for fifth and graduate studies). Since according to the comparison results of the three programs DOE-2 cover most of the environmental studies and meets the approved standards, and it is the most satisfactory in its results, but it has the hardest interphase and the input is very advanced. In addition in different design stages we can encourage students to use different simulation programs to enhance their design decisions in their projects.

REFERENCES

- Autodesk (2015). "Autodesk Ecotect Analysis" Sustainable Building Design Software <http://usa.autodesk.com/ecotect-analysis/> visited on 12-11-2015
- California Commissioning Collaborative, (2012) "Spreadsheet Tool". http://www.cacx.org/resources/rcxtools/spreadsheet_tools.html visited on 08-12-2015
- DesignBuilder (2010) "DesignBuilder-flyer-v1a" <http://www.designbuilder.co.uk/> visited on 12-11-2015
- eQUEST (2010). "What is Energy Modeling & Building Simulation" <http://energy-models.com/what-is-energy-modeling-building-simulation> visited on 10-11-2015
- Gordon, Brett (2013). "Design Process Discover, Define, Design, Develop, and Deploy" <http://inbound.anchorstl.com/web-design-process.pdf> Visited on 15-10-2015
- Hayter, S., Torcellini, P., Hayter, R., Judkoff, R., (2000). "The Energy Design Process for designing and constructing High performance buildings".
- James J. Hirsch (1998-2012) "The home of DOE-2 based Building Energy Use and Cost Analysis" <http://www.doe2.com/> visited on 12-11-2015
- Rosenbaum, Marc (2003). "Understanding the Energy Modeling Process: Simulation Literacy 101". <http://www.buildinggreen.com/> visited on 10-11-2015

APPENDIX

Survey

Beirut Arab University

Faculty of Architectural Engineering
Debbieh



Beirut Arab University requests your help. Please complete the following Student Survey based on the research paper we are recently completing for your University. Thank you for your time.

Student Name:

Year:

Project Type:

1. What Simulation Programs Do You know?

- Ecotect DesignBuilder DOE-2 Other

2. Did you work on any simulation program or apply it to your project? If yes which program did you use?

- No Yes Name of the program

3. How satisfied were you with the results you got?

- Not Satisfied Content Satisfied Delighted

4. How much time did it take to achieve the results of the simulation?

- Little time (5%-15% of project time) Average time (15%-25% of project time) Over 25% of the project time

5. What were the difficulties you encountered while using the program?

- Difficult Interface Flexibility of the Geometry Compatibility Data input
 Expressing the Results Other

6. Do you recommend any simulation Program to be applied to your academic year? If yes which and why?

Thank you very much for taking the time to complete this survey. Your feedback is valued and very much appreciated!