MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF CONSTRUCTION

VIETNAM INSTITUTE OF ARCHITECTURE

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THE SOLUTIONS OF BUILDING ENVELOPE INTEGRATED DESIGN TO IMPROVE ENERGY EFFICIENCY FOR HIGH-RISE OFFICES IN THE SOUTH CENTRAL COAST AREA OF VIETNAM

Major: Architecture

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SUMMARY OF DOCTORAL THESIS

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The project was completed at:
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The thesis can be found at:
1. Vietnam National Library.
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PREAMBLE

1. Lý do chọn đề tài

The architecture and construction industry is the largest contributor to energy-related carbon emissions (with about 37% of global emissions). Building design and construction are the main agents that create negative changes to the ecological environment and therefore need to be controlled and limited to the lowest level. All countries (including Vietnam) are required to join hands in efforts to reduce CO2 emissions to protect our common home, earth.

As a country blessed with natural conditions and climate, Vietnam has many advantages in applying passive design solutions to buildings, especially coverings to improve efficiency. energy consumption results. In recent times, the Party, State, and Government of Vietnam have had many guidelines and policies to promote the economical and efficient use of energy and resources, protect the environment, and reduce greenhouse gas emissions in industries. socio-economic activities, including the construction sector; This is a very good premise for researching and applying passive design solutions to improve energy efficiency for buildings.

Therefore, the thesis chooses to research integrated design solutions for the envelope to improve energy efficiency for high-rise office buildings in the South Central coastal region - an area where Many favorable advantages in natural climatic conditions to reduce energy consumption for this type of project, contributing to protecting the ecological environment and ensuring sustainable development in the future.

2. Research objectives

The topic identifies the goals to be achieved as follows:

Objective 1: Evaluate energy efficiency for high-rise office buildings under the simultaneous impact of three factors: Natural ventilation - Natural lighting - Air conditioning.

Objective 2: Provide design solutions to improve energy efficiency through the impact of the envelope;

Objective 3: Develop a toolkit to quickly assess the current status of existing or under - designed projects, from which to evaluate the level of energy efficiency achieved by the project, then provide solutions to improve it. Energy efficiency for buildings.

3. Research methods

The project uses the following research methods:

- Collection - synthesis - evaluation method, Theoretical analysis and synthesis method, Simulation method, evaluation and comparison of results, Case study method.

4. Scope of research

- Scope of research climate zoning: The research scope of the climate project is the South Central coastal climate region of Vietnam, this is the area in the southern climate region. Among them, the typical projects selected are located in Da Nang city.

- Scope of the research problem: The project chose to research the solution to design the cover based on the simultaneous impact of three factors: Natural rubber - Natural rubber - Air conditioning

- Scope of impact and influence factors: The impact and influence factors included in the study are natural physical factors, minimizing artificial factors because these will be Factors that greatly influence the increase in energy consumption.

- Scope of survey and assessment: The project will survey and evaluate typical high-rise office buildings in some large cities in the study area including: Da Nang city, Nha Trang city (Khanh

Hoa province), Quy Nhon city (Binh Dinh province). At the same time, the topic also uses survey results and assessments of previously researched authors to make inferences and comparisons to increase objectivity.

5. New contributions of the thesis

- Orienting energy efficient design solutions for projects based on integrating the impact of 3 factors: natural environment - TGTN - air conditioning.
- Provide tools to quickly assess building energy efficiency
- Expanded to other climate regions in Vietnam
- An approach to green architecture through energy efficiency criteria
- Towards sustainable architecture in Vietnam

6. Concepts and terms used in the thesis

- Integrated design of the envelope: is a design method that applies multiple solutions at the same time to the envelope of the building.
- Other terms: High-rise office, energy efficiency, envelope, South Central coastal area, bio-climate, sun shading effectiveness,...

7. Structure of the thesis

In addition to the introduction (10 pages), conclusion (02 pages), references (04 pages), appendices (33 pages), the thesis content is presented in 3 chapters:

Chapter 1: Overview of energy efficient envelope design solutions for high-rise offices

Chapter 2: Scientific basis for designing energy efficient envelopes for high-rise offices

Chapter 3: Integrated design solutions for envelopes to improve energy efficiency for high-rise offices in the South Central coastal region of Vietnam.

CHAPTER 1: OVERVIEW OF ENERGY EFFICIENT ENVIRONMENT DESIGN SOLUTIONS FOR HIGH RISE OFFICE

1.1. Meaning and importance of energy efficient buildings

1.1.1. Current status of energy consumption in the world and Vietnam

The very strong socio-economic development in the world in the second half of the 20th century did not go hand in hand with corresponding environmental protection and sustainable development solutions, leading to the consequence that energy resources are increasingly exhausted. Among the many factors involved in that process, the architecture and construction industry "contributes" a very large proportion: construction - architecture consumes about 70% of the total use of natural materials, about 37% total electrical energy consumption, and produces about 30% of all "greenhouse gases" worldwide.

1.1.2. Current status of energy efficient building design and construction

Effective energy use for construction projects depends on the following three main factors: (1) Passive architectural solutions help the building have the ability to prevent heat from transferring from outside to inside the house and Take advantage of natural ventilation and natural light to ensure comfortable micro-climate conditions in the building; (2) Design technical systems such as ventilation equipment systems, air conditioning systems, electric lighting and other equipment systems to ensure comfortable microclimate environmental conditions and meet energy use targets efficient and economical; (3) Management behavior of building users.

1.1.3. Evaluate the energy efficiency of construction works

In the world today, there are many methods and indicators that have been proposed to monitor and evaluate energy use efficiency in construction projects. Typical indicators are the following:

- Energy efficiency index - EEI (Energy Efficency Index) or Building Energy Index - BEI (Building Energy Index) - compares the level of energy consumption between different buildings.

- Standards of the Federal Republic of Germany categorize the energy efficiency of construction projects with 05 levels: Low energy buildings, Energy efficient buildings, Passive energy buildings, Energy neutral buildings , Additional energy works

- Energy Star Label of the US: The Energy Star Label is a program implemented by the US Environmental Protection Agency (EPA) from 1992 to present, with the goal of helping businesses and individuals save costs and protect the ecological environment through the use of highly energy efficient appliances.

In Vietnam, QCVN 09:2017/BXD "National technical regulation on energy efficient construction works" issued by the Institute of Construction Engineering (Vietnam Association of Structures and Construction Technology) Updating regulations on scope and level of application is the latest legal tool related to the issue of energy efficiency in construction projects.

1.2. Situation of energy efficient building design and construction in the world and Vietnam

1.2.1. World situation

In the last decades of the 20th century, the United Nations had to organize World Summits to discuss environmental protection, sustainable development,... Countries around the world had to sign named in the "International Conventions" on limiting climate change and protecting the ozone layer.

Next is the development of different architectural trends, we can mention typical trends such as: Environmental Architecture, Ecological Architecture, Energy Efficient Architecture, Architecture (biology) climate,...

After that, these trends in architectural research in many different directions are collectively called GREEN ARCHITECTURE or Sustainable Architecture. And green and sustainable issues in architecture have become a guideline for design solutions of architects around the world.

1.2.2. Situation of some countries in the region

In Asia and Southeast Asia, many countries have been achieving many achievements in green building development such as Singapore with the set of criteria for evaluating and recognizing green buildings (Green Mark), Taiwan (with Green architecture assessment system EEWWH, Malaysia with activities to improve energy efficiency in Malaysian housing construction started in the 80s through energy audit activities,...

1.2.3. Situation of energy efficient building development in Vietnam

Starting in 2007, Vietnam has introduced and approached green architecture with support from the government and coordination and support from international organizations. Although it has been nearly two decades, along with a large number of new projects being built, the number of projects certified as green/sustainable buildings is very modest with only nearly 100. In addition to incentive policies and investors' concerns about increased investment costs, the lack of foundational construction regulations and standards and binding policies when licensing are the reasons. hindering the development of green buildings in Vietnam.

1.3. Situation of energy efficient high-rise office design and construction in the South Central Coast region (Taking Da Nang as a case study)

1.3.1. Overview of high-rise office construction situation

Currently, Da Nang has more than 60 high-rise offices that have been put into lease and use, and the number of works and projects under construction in this field is rapidly increasing. High-rise offices can be divided into 2 types:

- Independent office format.
- Complex office format.

Regarding architectural form: Most of the shell area of these buildings is covered by glass material.

1.3.2. Evaluation of energy efficient buildings in Vietnam and the South Central Coast region

In recent years, the Vietnamese construction market has also been embracing the trend of green building design and construction and making efforts to create sustainable green building projects.

In our country, according to the Vietnam Green Building Council, Vietnam currently has about 100 standard green buildings. According to statistics, Vietnam is slower than other countries both in the number of green buildings and in training and awareness. The number of projects achieving international certification so far is less than 3%.

1.4. Overview of building envelope design solutions suitable for climate conditions and energy efficiency in the world and Vietnam

1.4.1. Types of energy efficient enclosures around the world

Through the process of research and development, up to now in the world there are a number of solutions for designing highly energy efficient envelopes as follows:

- The shell uses green trees; The shell integrates environmental protection technology; The building envelope adapts to the local climate.

1.4.2. Overview of building envelope design solutions suitable for climate conditions and energy efficiency in Vietnam

- Requirements for building envelope design in Vietnam towards energy efficiency: The building envelope is understood as the part that divides indoor and outdoor space. The functions of the house shell in our country include: Sunshade, Heat and noise insulation, Lighting, Ventilation (and also shielding from hot wind, cold wind, storm wind), Waterproofing, Welcoming beneficial elements. inside the construction.

- Design lessons learned from traditional architecture: Traditional architecture solves these problems well through solutions in the style of "open architecture" including: Sun shading, natural ventilation, Natural light, heat insulation,...

1.5. Research status of related topics

- There have been many domestic authors with in-depth research on many different issues and aspects with the goal of providing energy efficient design solutions. Typical authors can be mentioned such as: Hoang Manh Nguyen, Pham Ngoc Dang, Le Thi Bich Thuan, Nguyen Quang Minh, etc.

- Besides, there are cooperative research projects in the form of protocols between Vietnam and countries such as Russia, Bulgaria, China,...

Along with that, many doctoral theses also research issues related to energy efficiency such as authors: Pham Thi Hai Ha, Nguyen Anh Tuan, Le Thi Hong Na,...

1.6. Research problem posed for the topic

The topic aims to solve the problem through the following contents:

- Research the factors that affect the energy consumption level of three individual factors, then put the three factors CSTN-TGTN-DHKK into a multidimensional relationship (2 or 3 dimensions) to come up with a solution most optimal;

- Provide a toolkit to quickly assess energy efficiency for projects through specific criteria;

- Orient specific solutions and instructions in the design of high - rise office buildings for architects based on the research results obtained.

CHAPTER 2. SCIENTIFIC BASIS OF ENERGY EFFICIENT ENCLOSURE DESIGN FOR HIGH RISE OFFICE

2.1. Theoretical basis

2.1.1. Theory of high-rise office buildings

According to the classification of many countries in the world today, high-rise buildings are divided according to the number of floors: 9-15 floors, 15-25 floors, 25-40 floors, and over 40 floors (called skyscrapers). God).

The International High-Rise Building Committee, based on criteria of height and number of floors, has divided high-rise buildings into 4 groups:

- Group 1: Houses with floors from 9 to 16 floors (no more than 50m high);
- Group 2: Houses with floors from 17 to 25 floors (no more than 75m high);
- Group 3: Houses with floors from 26 to 40 floors (no more than 100m high);
- Group 4: Buildings with 40 floors or more (called super high-rise buildings).

Thus, through some of the above classification methods, the author chooses high-rise offices as buildings with a number of floors from 9 to 40 floors.

2.1.2. Theory of the envelope covering architectural works

The building envelope includes the following components: External walls (including windows), roof and foundation (this component is in direct contact with the ground so is not part of the research of the project).

For high-rise office buildings, the glass area on the surface of the wall covers a very large proportion compared to the total area of the cover. Therefore, climate-adaptive design solutions for shell walls are of the most importance in general solution systems.

2.1.3. Basis for assessing energy efficiency of high-rise offices

There are many methods to evaluate the energy efficiency of buildings, of which currently the evaluation method based on energy efficiency index is the most commonly applied.

Energy efficiency index or Building Energy Index is used in many countries by comparing energy consumption levels between different buildings. The usual unit of measurement for the Energy Efficiency Index is kWhm2/year.

2.1.4. Improve energy efficiency in architectural design

Improving energy efficiency, therefore, instead of just being done independently in each individual component, should be done holistically from the basic design steps, with the perspective that each design solution This part will affect the ability to increase/decrease energy consumption in other systems.

2.2. Practical basis

2.2.1. Current status of envelope design of high-rise buildings in our country

The design and construction have achieved many significant achievements in terms of functionality, construction level, convenience for users, etc. However, it seems that the design element of the house shell is being overlooked; Specifically, many envelope projects have only one very simple layer, which is not sustainable against complex climatic factors, or they also have many layers but are "structural layers" and have not been effectively treated. ; Along with that is the use of inappropriate materials, especially using glass materials without reasonable support components, or focusing too much on aesthetic and economic factors and forgetting the main function of the glass. The housing shell and the structural components that the housing shell must have.

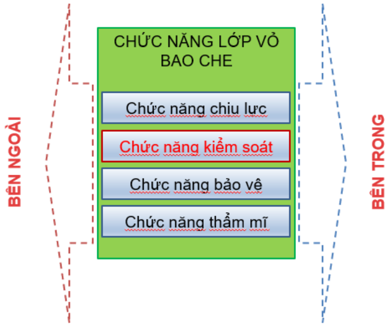

Figure 2.1. The required function of the building's envelope.

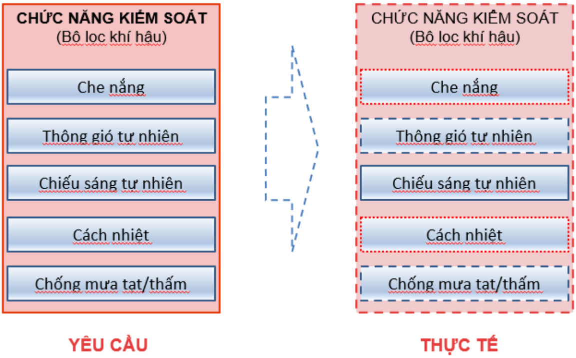

Figure 2.2. The actual control function of the current cover.

The role of the shell in our country's architecture is evaluated according to the table below:

Table 2.1. Current status of the role of the cover

No.	REQUEST	TRADITIONAL CRUST	CURRENT SHELL
1	Sun protection, rain protection	✓	
2	Insulation	✓	
3	Get natural light	✓	✓
4	Natural ventilation	✓	
5	Waterproofing		✓
6	Create views that look	✓	

	good		
7	Beauty	✓	✓

It can be seen that more and more the cover is ignoring its functional requirements.

- Characteristics of spatial organization:

Currently, most buildings used as offices have closed spaces (no windows) and use full-time air conditioning, while the building envelope uses a very large glass area. . Typical examples include Lotte Tower (Hanoi), Bitexco Financial Tower (HCMC), City Administrative Center. Danang, …

Table 2.2. Statistics on the number of high-rise buildings in Vietnamese urban areas (as of 2021)

No.	City	Height **36m-199m**	Height **+200m**	Height **+300m**	Height **+400m**	Total number of buildings
1	Hanoi	1,380	5	1	-	1,384
2	Ho Chi Minh City	1,336	2	-	1	1,339
3	Danang	166	–	-	-	166
4	Nha Trang	160	-	-	-	160
5	Vinh	75	-	-	-	75
6	Vung Tau	56	-	-	-	56
7	Ha Long	54	-	-	-	54
8	Bac Ninh	32	-	-	-	32
9	Hai Phong	29	-	-	-	29
10	Thai Nguyen	26	-	-	-	26

- Characteristics of using materials on facades:

Similar to other types of high-rise buildings, the office facade consists of two parts: a solid brick wall and a glass wall.

However, unlike other types of buildings, the proportion of glass walls on the facade of this building is often higher, due to high lighting requirements, creating specific architectural highlights, and the need to expand the horizon. look outside and the user's surrounding space.

Figure 2.3. Typical examples of modern high-rise buildings in Vietnam use glass in a very large proportion on the facade (Lotte Hanoi, VP Bank Hanoi, TTHC Da Nang and SHB Da Nang).

2.2.2. Results of surveys and evaluations of actual projects

Field survey of all 23 office buildings and recording of building types (mainly architectural plans and facades) for the purpose of classifying and evaluating the proportions of building types. The content is classified as follows:

- Type A: Rectangular plan and rectangular box shape;
- Type B: Circular and cylindrical plan;
- Type C: Elliptical and cylindrical elliptical plan;
- Type D: Mixed plan and mixed block type.

According to survey information of high-rise office buildings in Da Nang, the following comments can be drawn:

- (1) Regarding the number of floors: High-rise office buildings in Da Nang have a number of floors that are not too high, most are under 20 floors;

- (2) Regarding the direction of the project: The entire project faces the main roads, not paying attention to choosing a good direction compared to the climate;

- (3) Regarding block shape: The proportion of works with rectangular shapes accounts for the majority of surveyed works (83%), works with other shapes only account for a very small proportion.

- (4) Regarding the organization of natural ventilation: Most high-rise offices do not organize natural ventilation but use air conditioning all the time, this is a huge waste of energy, in climate conditions. The exterior has a very high level of comfort (over 60%).

- (5) Regarding sun shading solutions: Among the surveyed projects, only 1/23 projects (Phi Long Plaza building) have a specific sun shading solution for the cover.

- (6) Regarding the glass/wall ratio: This ratio is very large for survey projects, many projects even use 100% glass for the covering wall.

- (7) Regarding the layer of insulation material for the cover: 100% of projects do not have a layer of insulation material for the cover.

- (8) Regarding clean energy use (roof energy): Most buildings do not use rooftop energy to improve energy efficiency.

Through surveying the amenities of some office buildings in Da Nang, we have the following assessments:

- The climate in offices using air conditioning for cooling mainly depends on the working mode of the air conditioning equipment system, almost independent of the high floor of the house and the direction of the house.

- Regarding lighting quality: In general, the lighting quality in rooms is poor because the illumination (illumination) is unevenly distributed on the working surface.

- Regarding air quality in offices using central air conditioning systems, it shows that the concentration of CO2 and bacteria in the air is higher than the TCCP.

2.2.3. Properties and typical data of materials

Before deciding to choose insulation materials for a building, the following factors need to be considered:

- Thermal efficiency – Thermal resistance value R
- Fire safety
- Humidity
- Control air leaks
- Analyze the life cycle of materials

2.2.4. Characteristic properties and data of light sources

The natural light that illuminates the room is taken from the sun's light outside the house.

The initially scattered light is inherently direct, but after being refracted and reflected through the atmosphere, it forms scattered light from the sky. With appropriate characteristics, scattered light is the main light source used for artificial lighting of interior spaces.

2.2.5. Characteristics, data, and typical technology of air conditioning systems

Air conditioning has the role of creating and maintaining a comfortable microclimate for users during the building's operation time (time of air conditioning use). Air conditioning, also known as air regulation, does not depend on conditions from outside or inside the building. It always maintains stable microclimate parameters of the air in the room to reach a comfortable state. according to user's request.

2.3. Climate facility for the South Central Coast region

Vietnam's coastal territory is directly influenced by the monsoon circulation with the conflict of the 5 main wind blocks, so the coastal climate has many characteristics that are not found elsewhere.

Our country stretches along the coast, is located in an area affected by weather and climate change, and is directly affected by many different types of monsoons (5 types of monsoons with different blowing directions and properties). , creating a distinct characteristic compared to other areas, especially coastal areas close to the sea.

However, there are many climatic advantages in this area that other places do not have. It is necessary to take advantage of them and put them into projects to increase the value of amenities, ensure energy efficiency and protect the ecological environment. . Specifically:

(1) Air blowing from the sea is almost not polluted, always ensuring cleanliness and hygiene for humans.

(2) The sea is considered an artificial "air conditioner", contributing to significantly reducing the temperature of nearby areas.

(3) Land breeze - sea breeze (also known as Breeze wind) blows daily from the sea in the hot season, bringing cool, pleasant air from the sea, can create quite large wind speeds, can organize TGTN is effective, replacing artificial cooling devices such as fans and air conditioners in high humidity tropical areas.

2.4. Legal basis

2.4.1. International Conventions on Sustainable Development

Currently, the world is facing two big problems: The depletion of fossil energy sources (the main energy source still in use today) and the warming of the Earth. These two problems have the same common cause: the use and consumption of fossil energy is increasing and no alternative energy source has been found. Besides, people still do not have a solution to limit waste products. from these raw materials.

2.4.2. National target program on energy saving

“Deploy all Program activities in depth, remove barriers, create a breakthrough in improving final energy use efficiency, focusing on the fields of: Industrial production; projects that use a lot of energy; Transportation; service activities; family; popularize high-performance, energy-saving vehicles and equipment".

2.4.3. National Technical Regulation 09/2017 on energy efficient buildings

In Vietnam, QCVN 09:2017/BXD "National Technical Regulations on energy efficient construction works" issued by the Institute of Construction Engineering (Vietnam Association of Structures and Construction Technology) Updating regulations on scope and level of application is the latest legal tool related to the issue of energy efficiency in construction projects.

2.4.4. Construction standards and regulations related to high-rise buildings

- Quality standards;
- Standards for safety and sustainability;
- Aesthetic high-rise office design standards;
- For lighting standards;
- High-rise office design standards.

2.4.5. Law on economical and efficient use of energy

The Law "Effective and Economical Use of Energy" passed and promulgated by the National Assembly, No. 50/2010/QH12 dated June 17, 2010, has introduced the basic concept of economical and efficient use of energy. The results are as follows:

"Effective and economical use of energy is the application of management and technical measures to reduce losses, reduce energy consumption of vehicles and equipment while still ensuring demand, goals set for the production process and life".

2.4.6. Some other legal documents

- Circular No. 02/2022/TT-BXD of the Ministry of Construction: Promulgating QCVN 02:2022/BXD National technical regulations on natural condition data used in construction.
- Decree on Urban Development Investment Management issued by the Government, No. 11/2013/NDCP dated January 14, 2013

2.5. Socio-economic factors

2.5.1. Economic factors

Architectural design activities have many achievements in composition, theory, and criticism, with many works and projects winning high prizes in domestic and international competitions. Construction capacity has had a breakthrough development, Vietnamese construction enterprises have gradually upgraded, equipped and mastered science and technology, enough to compete successfully in the domestic and international construction market. gradually expanding into the international market. Production of construction materials develops strongly in both quantity and quality, ensuring supply for domestic and export requirements. Our country's construction industry has enough capacity to build large-scale national key projects with very high technical requirements in all fields of civil, industrial and infrastructure.

2.5.2. Social factors

With a starting point as a purely wet rice agricultural country and a relatively comfortable climate compared to many other regions in the world, Vietnamese people in general tend to integrate with nature as much as possible. , including during work as well as rest and daily activities. Therefore, the most noticeable characteristic in Vietnamese culture in general is friendliness and harmony, not only in social relationships between people but also in the relationships between elements in life. humans and nature, including architecture.

CHAPTER 3. INTEGRATED ENVIRONMENT DESIGN SOLUTION TO IMPROVE ENERGY EFFICIENCY FOR HIGH RISE OFFICE IN THE SOUTH CENTRAL COASTAL AREA OF VIETNAM

3.1. Proposing design principles and processes for integrating envelopes to improve energy efficiency for high-rise offices

3.1.1. General principles

- Construction space planning;
- Selecting the building shape;
- Organize the space;
- Structure of the covering shell;
- Principles of sun shading for different directions of the building;
- Principles for selecting materials used for the building envelope;
- Use clean energy to supplement energy consumption for building cooling.

3.1.2. Principles of integrating elements to improve building energy efficiency

During the research process, there were 3 groups of factors that directly and clearly affected the energy efficiency of the building: natural ventilation - natural lighting - air conditioning. The project will seek solutions to improve energy efficiency for high-rise office buildings under the simultaneous influence and influence of three factors: NATURAL VENTILATION - NATURAL LIGHTING - AIR CONDITIONING. And the results will be the new contribution of this research.

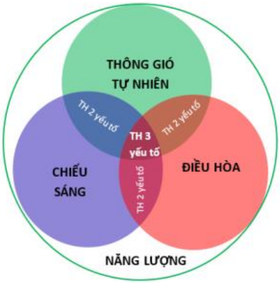

Figure 3.1. The model illustrates solutions to improve energy efficiency through integration of the project.

3.1.3. The design process integrates the envelope to improve energy efficiency

Steps to design an integrated enclosure to improve energy efficiency include:

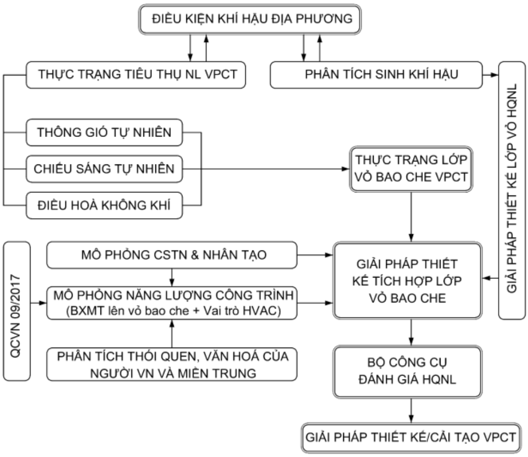

Figure 3.2. Diagram of design steps to integrate the cover to improve the energy efficiency of the building

3.2. Integrated design solution for high-rise office buildings

3.2.1. Natural ventilation organizational solutions ensure energy efficiency

- Construction direction and wind direction

- Cubic design ensures enhanced natural ventilation
- Space design ensures natural ventilation
- Solution for designing and arranging ventilation doors
- Solutions to control and increase ventilation efficiency

3.2.2. Natural lighting solutions ensure energy efficiency

- Solutions for choosing natural light sources
- Lighting direction for high-rise offices
- Solutions for space organization
- Solution for light door design
- Solutions for using materials for the cover

3.2.3. Air conditioning solutions ensure energy efficiency

- Reduce the volume of space used for air conditioning
- Reduce heat impact on the cover
- Solution to reduce air conditioning energy loss through the cover structure
- Combine the use of controlled natural ventilation
- Efficient use of clean energy to cool buildings

3.2.4. Integrate the simultaneous impact of three elements of natural ventilation - natural lighting - air conditioning

From the solutions synthesized in the 3 groups above, this section will analyze the synergistic (+) and mutually exclusive (-) relationships between factors in terms of the actual impact process on the industry. submit. This is a very important issue, because designers need to consider multi-dimensional relationships before coming up with the most reasonable solution. The diagram below will clearly show the relationship and interaction between three groups of factors: natural ventilation - natural lighting - air conditioning.

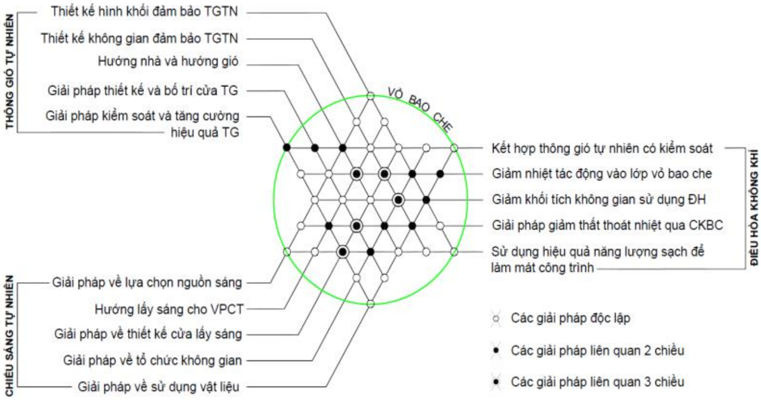

Figure 3.3. Diagram integrating 3 elements: TGTN-CSTN-DHKK

3.3. The tool evaluates the energy efficiency of the envelope through the integration of 3 factors

3.3.1. The basis proposes a tool to evaluate the energy efficiency of the envelope through integrating 3 factors

From the principles of envelope design, in order to have a basis for quantifying the energy efficiency of specific solutions, the author uses simulation solutions using the Energy Plus tool version 8.8.0 according to the following principles: following steps:

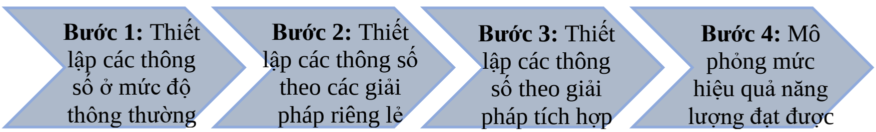

Figure 3.4. Diagram of energy efficiency simulation steps

The building model used for simulation is based on three basic shapes: (1) Rectangular block, (2) Circular cylinder, (3) Triangular prism with an equivalent floor area of 600m2.

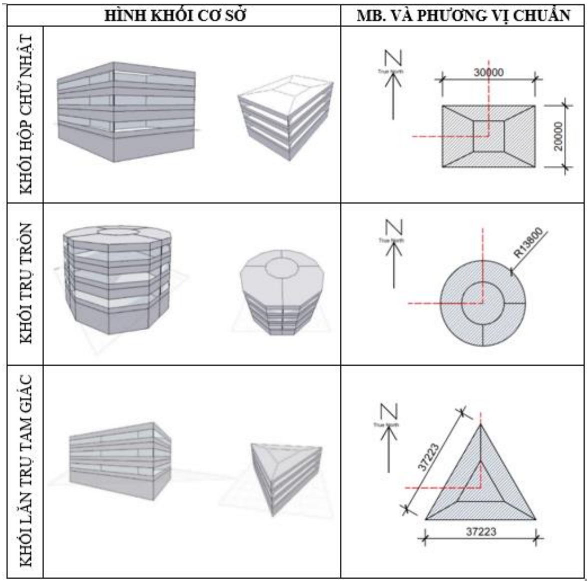

Figure 3.5. Models of works used for simulation

Table 3.1. Table of results of simulation of achieved energy efficiency.

No.	STRATEGY	RESULTS OF ENERGY CONSUMPTION (J)		RESULTS OF ENERGY CONSUMPTION (W)		EFFICIENCY ACHIEVED (%) COMPARED TO ORIGINAL MODEL
		Total energy consumption/year (GJ)	*Energy consumed/m2 of floor (MJ/m2)*	*Total consumption (kWh)*	*Energy consumed/m2 of floor (kWh/m2/year)*	
1	**ORIGINAL MODEL (According to common practice)**					
	Circular prism	2,847.1	430.9	790,916.0	119.68	100%
	Rectangular box	2,916.1	441.8	810,095.4	122.73	100%
	Prism block TG	2,861.8	413.8	795,019.2	114.94	100%
2	**ROTATE THE WORK CORNER**					
	2.1 Rotate the angle 30°					
	Circular prism	2,830.4	428.4	786,274.0	118.99	99.4%
	Rectangular box	2,922.9	442.9	811,992.7	123.02	100.2%
	Prism block TG	2,900.1	419.3	805,636.7	116.48	101.3%
	2.1 Rotate the angle 45°					
	Circular prism	2,823.1	427.3	784,246.1	118.68	99%
	Rectangular box	2,936.6	444.9	815,790.3	123.60	101%

	Prism block TG	2,977.5	430.5	827,135.6	119.59	104%
	2.1 Rotate the angle 60º					
	Circular prism	2,823.8	427.4	784,451.6	118.71	99%
	Rectangular box	2,898.3	439.1	805,133.9	121.98	99%
	Prism block TG	2,940.7	425.2	816,932.0	118.11	103%
3	**EXTERIOR SUNSHADE**					
	3.1 L=900					
	Circular prism	2,742.9	415.1	761,977.6	115.31	96%
	Rectangular box	2,809.9	425.7	780,590.2	118.25	96%
	Prism block TG	2,824.5	408.4	784,643.3	113.45	99%
	3.2 L=1200					
	Circular prism	2,708.2	409.9	752,349.1	113.85	95%
	Rectangular box	2,809.4	425.7	780,459.7	118.24	96%
	Prism block TG	2,807.8	406.0	780,006.8	112.77	98%
	3.3 L=1500					
	Circular prism	2,676.0	405.0	743,395.6	112.50	94%
	Rectangular box	2,809.0	425.6	780,345.8	118.23	96%
	Prism block TG	2,790.8	403.5	775,284.2	112.09	98%
4	**USE COVERING MATERIALS**					
	4.1 1-layer brick wall + Low E glass					
	Circular prism	2,636.6	399.0	732,436.4	110.84	93%
	Rectangular box	2,680.7	406.2	744,687.3	112.82	92%
	Prism block TG	2,689.1	388.8	747,020.9	108.00	94%
	4.2 Double-layer brick wall + Low E glass					
	Circular prism	2,608.4	394.8	724,619.1	109.66	92%
	Rectangular box	2,653.9	402.1	737,261.8	111.70	91%
	Prism block TG	2,673.7	386.6	742,742.7	107.39	93%
	4.3 Metal panel wall with insulation in the middle + Low E glass					
	Circular prism	2,636.3	399.0	732,353.0	110.83	93%
	Rectangular box	2,697.7	408.8	749,432.2	113.54	93%
	Prism block TG	2,702.2	390.7	750,657.3	108.53	94%
5	**CONTROLLED TRADING ORGANIZATION**					
	5.1 Ventilate 50% of the time					
	Circular prism	2,277.9	344.8	632,806.2	95.76	80%
	Rectangular box	2,287.3	346.6	635,423.1	96.27	78%
	Prism block TG	2,273.5	328.7	631,570.0	91.31	79%
	5.2 Ventilate 70% of the time					
	Circular prism	2,290.6	346.7	636,314.8	96.30	80%
	Rectangular box	2,296.5	348.0	637,953.8	96.65	79%
	Prism block TG	2,286.7	330.6	635,248.0	91.85	80%
	5.3 Ventilate 100% of the time					
	Circular prism	2,305.0	348.9	640,340.1	96.90	81%
	Rectangular box	2,313.9	350.6	642,812.5	97.39	79%
	Prism block TG	2,303.9	333.1	640,017.9	92.53	81%
6	**GLASS/COVERING WALL RATIO**					
	6.1 Glass area accounts for 30%					
	Circular prism	2,779.3	420.6	772,092.3	116.84	98%
	Rectangular box	2,794.4	423.4	776,292.7	117.61	96%

	Prism block TG	2,846.9	411.6	790,877.2	114.35	99%
	6.2 Glass area accounts for 50%					
	Circular prism	2,847.1	430.9	790,916.0	119.69	100%
	Rectangular box	2,916.1	441.8	810,095.4	122.73	100%
	Prism block TG	2,861.8	413.8	795,019.2	114.95	100%
	6.3 Glass area accounts for 70%					
	Circular prism	2,993.9	453.1	831,702.6	125.86	105%
	Rectangular box	2,983.0	452.0	828,666.3	125.55	102%
	Prism block TG	2,871.5	415.2	797,691.6	115.33	100%
7	**USING CLEAN ENERGY (Photovoltaic batteries)**					
	Circular prism	2,621.8	397.2	728,336.0	110.35	92%
	Rectangular box	2,621.8	397.2	728,336.0	110.35	90%
	Prism block TG	2,621.8	397.2	728,336.0	110.35	92%
8	**INTEGRATION OF SOLUTIONS**					
	Circular prism	2,213.1	334.9	614,799.2	93.04	78%
	Rectangular box	2,200.6	333.4	611,335.0	92.62	75%
	Prism block TG	2,148.2	310.6	596,767.2	86.28	75%

3.3.2. The tool's process evaluates the envelope through the integration of three factors

The evaluation process will include 4 steps:

Step 1: Consider the scale and conditions of the project

Step 2: Consider the applicability of the tool

Step 3: Evaluate the energy efficiency of the building's envelope

Step 4: Orient design or renovation solutions to improve energy efficiency for the project.

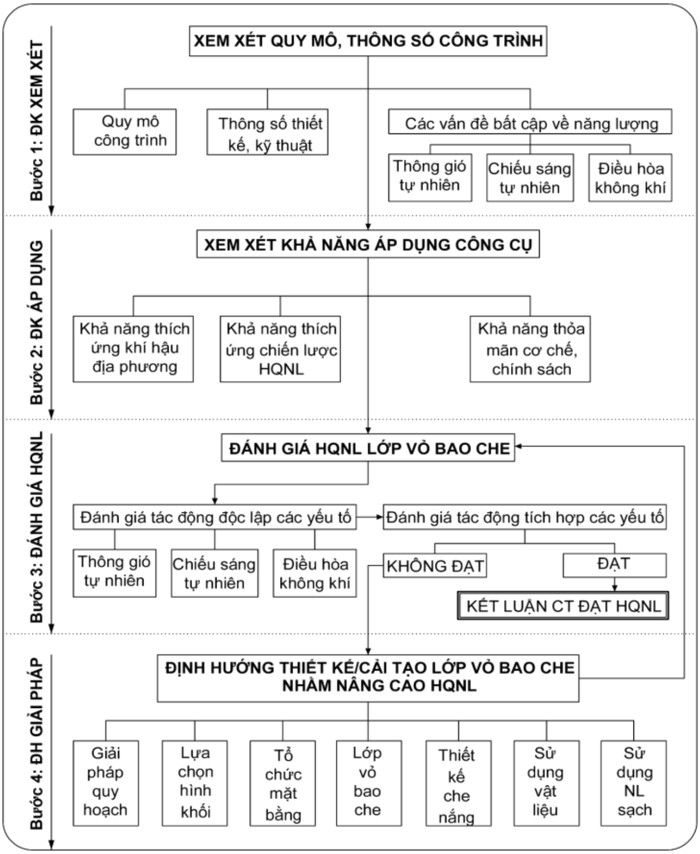

Figure 3.6. Process diagram of the envelope energy efficiency assessment tool through integration of 3 elements

3.3.3. Conditions apply

- Necessary conditions: This is a group of requirements related to the scale and technical specifications of the project being evaluated, in addition to any inadequacies affecting energy efficiency. This condition ensures the most effective evaluation project selection process, limiting the selection of projects outside the research scope of the topic.

In this section, there will be 20 contents belonging to three groups of evaluation criteria, each criterion is evaluated according to points 1 (corresponding to the case true or present) and 0 (corresponding to the case false or absent).

After that, the survey projects will be divided into three levels 1, 2, 3 corresponding to the percentage of total points as follows:

- Level 1: Achieve over 75% of total points;
- Level 2: Achieve 50-75% of total points;
- Level 3: Below 50% of the score.

The most effective assessment tool set will be applied to the project when it reaches level 2 or higher, but if it is at level 3, it cannot be applied because it does not meet the necessary requirements.

- Review conditions: This condition helps the evaluator have a preliminary survey of the actual situation (construction after construction, for new designs) before applying the evaluation tool.

In this condition, there will be 20 contents belonging to three groups of evaluation criteria, each criterion is evaluated according to points 1 (corresponding to the case of true or present) and 0 (corresponding to the case of false or absent).

After that, the survey works will be divided into three levels A, B, C corresponding to the percentage of total points as follows:

- Level A: Achieve over 75% of total points;
- Level B: Achieve 50-75% of total points;
- Level C: Below 50% of the score.

The most effective assessment tool set will be applied to a project when it reaches level B or lower. If it has reached level A, it cannot be applied because the project has achieved high energy efficiency.

3.3.4. Energy efficiency assessment tool based on integrating three factors

Three integrated elements: Natural ventilation - Natural lighting - Air conditioning with specific design requirements and solutions will be evaluated through integration scores. Each solution will be evaluated through 3 levels of integration: 1 (independent impact), 2 (2-way impact), 3 (3-way impact) between health centers. Each impact dimension is evaluated with a maximum of 1 point (corresponding to the case of yes/good/reasonable), a minimum of 0 (corresponding to the case of no/bad/unreasonable).

Table 3.2. The score evaluation table integrates 3 factors

YT TH	**REQUEST**	**No.**	**SPECIFIC SOLUTIONS**	**POINT INTEGRATED**			**Total**
				1	**2**	**3**	**6**
NATURAL VENTILATION	The cubic design ensures optimal natural ventilation	1	The block shape ensures good natural ventilation	1	2	0	**3**
		2	Increase the exposed area of the building with good wind direction	1	2	0	**3**
	Space design ensures natural ventilation	3	Space organization ensures traffic flow across the room	1	1	2	**4**
		4	Reasonable space division solution	1	1	2	**4**
	House direction and wind direction	5	The building faces a good wind direction	1	2	1	**4**
		6	There are solutions to limit the impact of adverse wind directions	1	2	1	**4**
	Solution for designing and arranging ventilation doors	7	Solution for arranging air intake and exhaust doors	1	2	1	**4**
		8	Door area ensures natural ventilation	1	2	2	**5**
	Solutions to control and increase ventilation efficiency	9	Natural ventilation control solution	1	1	1	**3**
		10	Solution to increase ventilation efficiency	1	1	1	**3**

YT TH	REQUEST	No.	SPECIFIC SOLUTIONS	POINT INTEGRATED			Total
				1	**2**	**3**	**6**
NATURAL LIGHTING	Solutions for choosing light sources	11	Use diffused light for natural lighting	1	1	0	**2**
		12	Requirements for light quality in lighting	1	1	0	**2**
	Lighting direction for high-rise offices	13	Choose the main lighting direction	1	0	1	**2**
		14	Lighting solutions for unfavorable directions	1	0	1	**2**
	Solution for light door design	15	Light door design solution	1	1	3	**5**
		16	Door height for natural light	1	1	3	**5**
	Solutions for space organization	17	Prioritize the arrangement of main spaces in good locations for natural infrastructure	1	1	1	**3**
		18	Organize more open spaces to enhance natural infrastructure	1	1	1	**3**
	Solutions for using materials	19	Glass material for natural lighting	1	2	0	**3**
		20	Ratio of glass to working floor area	1	2	0	**3**
AIR CONDITIONER	Combine controlled natural ventilation	21	Organize natural ventilation at appropriate times	1	3	0	**4**
		22	Use additional fans to increase wind speed during university use	1	3	0	**4**
	Reduce heat impact on the cover	23	Reduce the area of the cover in contact with the outside	1	2	3	**6**
		24	Shade the shell from the sun	1	2	3	**6**
	Reduce the volume of space used for air conditioning	25	Design space with optimal size	1	1	1	**3**
		26	Limit the use of air conditioning in some secondary spaces	1	1	1	**3**
	Solution to reduce heat loss	27	Control air leakage through the enclosure	1	1	0	**2**

YT TH	REQUEST	No.	SPECIFIC SOLUTIONS	POINT INTEGRATED			Total
				1	2	3	6
	through the cover structure	28	There are insulation solutions for the cover	1	1	0	**2**
	Use clean energy effectively to cool buildings	29	Combine the use of rooftop energy to cool the building	1	0	1	**2**
		30	There are solutions to increase the use of fresh air periodically	1	0	1	**2**
TỔNG CỘNG				**30**	**40**	**31**	**101**

The maximum total score that a project can achieve is 101 (in case it fully meets the evaluation criteria in the toolkit). From the results of the integration score, we will compare the energy reduction brought by the cover, then convert it to the energy efficiency level for the buildings according to the table below:

Table 3.3. The score evaluation table integrates 3 factors

No.	RESULT (Score)	RATIO (%)	CONCLUDE (Rating level)	Note
1	0-50	Below 50%	Not achieved	
2	51	50%	Obtain	
3	51-65	50-under 65%	Medium	
4	66-80	65-under 80%	Rather	

Table 3.11. Energy efficiency assessment table for the building envelope

No.	**RESULT (Score)**	**RATIO (%)**	**LEVEL OF ENERGY REDUCTION (kWh/m2/year) Based on simulated results**	**HQNL LEVEL**
1	0-50	Below 50%	Under 35	Did not meet HQNL
2	51	50%	35	**Achieved HQNL**
3	51-65	50-under 65%	From 35 to under 45	Achieved silver level HQNL **(Silver)**
4	66-80	65-under 80%	From 45 to under 56	Achieved gold level HQNL **(Gold)**
5	81-101	80-100%	From 56-70	Achieved Platinum level HQNL **(Platium)**

After receiving the evaluation results, based on the level of efficiency achieved, the designer and investor will consider the possibility of new design/renovation of unscored items according to the actual ability to increase/decrease. Energy efficiency for buildings.

Table 3.4. Orienting solutions to design/renovate the cover to improve the energy efficiency of high-rise offices.

YT TH	**REQUEST**	**No.**	**EVALUATION CRITERIA**	**Evaluation POINT**		**RENOVATION SOLUTIONS**
				OLD	**NEW**	
NATURAL VENTILATION	The cubic design ensures optimal natural ventilation	1	The block shape ensures good natural ventilation			
		2	Increase the exposed area of the building with good wind direction			
	Space design ensures natural ventilation	3	Solution for arranging air intake and exhaust doors			
		4	Space division solution			

	House direction and wind direction	5	The building faces a good wind direction			
		6	There are solutions to limit the impact of adverse wind directions			
	Solution for designing and arranging ventilation doors	7	Solution for arranging air intake and exhaust doors			
		8	Door area ensures natural ventilation			
	Solutions to control and increase ventilation efficiency	9	Natural ventilation control solution			
		10	Solution to increase ventilation efficiency			
NATURAL LIGHTING	Solutions for choosing light sources	11	Use diffused light for natural lighting			
		12	Requirements for light quality in lighting			
	Lighting direction for high-rise offices	13	Choose the main lighting direction			
		14	Lighting solutions for unfavorable directions			
	Solution for light door design	15	Light door design solution			
		16	Door height for natural light			
	Solutions for space organization	17	Prioritize the arrangement of main spaces in good locations for natural infrastructure			
		18	Organize more open spaces to enhance natural infrastructure			
	Solutions for using materials	19	Glass material for natural lighting			
		20	Ratio of glass to working floor area			
AIR CONDITIONER	Combine controlled natural ventilation	21	Organize natural ventilation at appropriate times			
		22	Use additional fans to			

			increase wind speed during university use			
	Reduce heat impact on the cover	23	Reduce the area of the cover in contact with the outside			
		24	Shade the shell from the sun			
	Reduce the volume of space used for air conditioning	25	Design space with optimal size			
		26	Limit the use of air conditioning in some secondary spaces			
	Solution to reduce heat loss through the cover structure	27	Control air leakage through the enclosure			
		28	There are insulation solutions for the cover			
	Use clean energy effectively to cool buildings	29	Combine the use of rooftop energy to cool the building			
		30	There are solutions to increase the use of fresh air periodically			
	TOTAL			**0**	**0**	

After adding design/renovation solutions, the building will be re-evaluated for energy efficiency again to produce the final results. Whether this result is high or low will depend on the level of investment in related criteria. This is also an important basis for investors and designers to base their implementation on.

3.4. Pilot application on some projects

3.4.1. Basis for selecting pilot projects

The selection of pilot projects is based on the following criteria:

- The building's block shape and typical floor plan are different (according to the classification of house types A, B, C, D;
- Different construction directions;
- Use a lot of glass for the cover;

- There are many shortcomings in terms of thermal comfort, natural lighting as well as the internal working environment;

- High energy consumption/m2 of floor.

3.4.2. DTU Office Building (Building Type A)

According to the assessment results, the Duy Tan University office building does not achieve energy efficiency (less than 50% of the requirements). This is an existing project, so some evaluation criteria will not change the results (for example, building direction, sun direction, wind direction, etc.), however many criteria can be achieved through through renovation or addition.

After changing a number of solutions to improve energy efficiency and re-evaluating the level of effectiveness according to the criteria, the score has improved significantly.

It can be seen that with just some renovation and addition solutions for this project, the evaluation score has increased by 17 points, bringing the total score to 61 points. With this score, the DTU office building has achieved an average level of integration results and a silver level of energy efficiency.

3.4.3. Da Nang City Administrative Center Building (Building Type B)

According to the assessment results, the Da Nang City Administrative Center building does not achieve energy efficiency (less than 50% of the requirements). This is an existing project, so some evaluation criteria will not change the results (for example, building direction, sun direction, wind direction, etc.), however many criteria can be achieved through through renovation or addition.

After changing a number of solutions to improve energy efficiency and re-evaluating the level of effectiveness according to the criteria, the score has improved quite a lot.

It can be seen that with just some renovation and addition solutions for this project, the evaluation score has increased by 35 points, bringing the total score to 79 points. With this score, the building has achieved a good level in terms of integration results and a gold level in terms of energy efficiency.

3.4.4. Phi Long Technology Building (Building Type D)

According to the evaluation results, the Phi Long Technology building has achieved an average level of energy efficiency and silver level of integration (over 50% compared to requirements). However, if more integrated solutions are applied, it will further improve energy efficiency.

After changing a number of solutions to improve energy efficiency and re-evaluating the level of effectiveness according to the criteria, the score has improved quite a lot.

It can be seen that with just some renovation and addition solutions for this project, the evaluation score has increased by 20 points, bringing the total score to 83 points. With this score, the DTU office building has achieved a good level of integration results and a platinum level of energy efficiency.

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS:

The contributions of the thesis are expressed through the following contents:

- Offer a new approach in designing the envelope: The envelope is the component that has a decisive impact on the energy efficiency of the building, at the same time taking on many functions (even some functions are contradictory). contradict each other). Therefore, when designing the cover, it needs to be evaluated through the impact of many factors and requirements at the same time. Only then can the highest energy efficiency be achieved.

- Point out groups of factors that interact with each other in 2 or 3 dimensions in reality, thereby providing a basis for proposing solutions to handle the cover appropriately: For groups of criteria belonging to 3 factors: TGTN-CSTN-DHKK, architects need to clearly understand the interrelationship between them, to balance the criteria with each other to create the most optimal design solution.

- Provide a set of tools to evaluate building energy efficiency: Although there have been many studies as well as simulation tools that can evaluate the energy efficiency of buildings in general and high-rise offices in particular, However, the practice faces many difficulties and has not been widely popularized, the most important reasons being the complexity of use as well as copyright costs. Therefore, the project has researched and proposed a set of tools that can quickly assess energy efficiency through solutions. If the toolkit is widely used, it will certainly encourage architects to focus on research and come up with much better solutions for the envelope than currently available.

- Propose some specific design solutions that can be applied directly to the research site: In addition to synthesizing design solutions, the project also proposes some specific solutions that can be applied directly. into localities for pilot research. These solutions will be a very good reference for architects during their practice.

And within the topic, the author has not evaluated the impact of other factors that also affect energy efficiency such as operational management, user behavior, and technical-related factors. , air conditioning equipment technology, ... However, the results from the project may open up further research directions, while also providing a useful tool in design, from which to More and more projects achieve high energy efficiency, in accordance with the national strategic orientation of energy safety and sustainable development.

2. RECOMMENDATIONS

With the research results of this topic, the author proposes the following recommendations:

a) Regarding mechanisms and policies:

The practice of energy efficient architectural design in general and high-rise offices in particular requires specific requirements and regulations for design projects before being approved for construction. Only then can we create synchronization in research and application of necessary solutions to achieve energy efficiency goals for projects.

There needs to be encouragement and further development of topics like this into design handbooks or guidance documents and widely promulgated to promote the research results of the projects.

There are preferential policies and additional support for highly energy efficient building designs to recognize and encourage architects to pay more attention and invest more in solutions that bring the best results.

b) Propose further research directions

Continue to research in this direction and apply it to other types of projects other than offices and at different scales to have uniformity and diversity of results; thereby providing complete research and reference materials for future designers.

Continue to research other issues in the project on the basis of integrating elements to contribute to promoting passive design and synchronization of elements to ensure energy efficiency issues, and further is sustainable architecture/green architecture.

Develop the quantity and quality of research, survey, and measurement information and data topics to have a solid and better basis for research project leaders.

LIST OF AUTHOR'S PUBLISHED WORKS

No.	Implementation content	Time	Participation role
1	Heat protection solutions for houses in the Central region, Vietnam Architecture Magazine, No. 11 - 2015, ISSN 0868-3768, pages 80-83.	2015	Author
2	Building energy norms: The first step towards energy-saving architecture, Architecture Magazine, No. 7 - 2017, ISSN 0866-8617, pages 62-67.	2017	Same author
3	Building shell - An element that needs more attention in current architecture in our country, Workshop: Technology & Engineering Solutions for Green Building and Green Urban Development in Vietnam, Vietnam Built Environment Association & Vietnam Association of Refrigeration Science and Air Conditioning, Hanoi December 14, 2019, pages 56-66.	2019	Author
4	Envelope integrated design solution to improve high-rise office energy efficiency, under the Workshop Topic: Architectural design and smart technology engineering solutions for public works in urban areas, Magazine Construction Magazine, December 2023 issue, ISSN 2734-9888, pages 52-57.	2023	Same author