Feasibility Study of Adopting Passive Energy Saving Concepts in The Design of Modern Building Supply Stores

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Abstract

According to the economic forecasts of the Krungsri Research Center, the trend of retail construction and home decoration materials in 2019-2021 has a high potential for growth due to the purchasing power of consumers. Therefore, modern building material stores have been continuously expanding amidst high competition. To reduce the cost of buildings, the big operators adopt various strategies such as adjusting branch expansion with a smaller business model. Despite the high competition, the big operators still experience continuous growth. Hence, applying the concept of energy-saving as a model for designing the local building material store through the passive design system can increase competitiveness with the big operators. This concept can reduce building management costs in the long term, increase business confidence, and enhance the organization's image. The research results show that many factors can be applied appropriately by using the energy-saving concept through the passive design system in this project. However, the designer must understand the essence of designing for energy saving in various issues to have a positive impact on local building material traders.

Keywords: *Modern Building Supply Store, Energy Saving Building, Passive Design System*

1. Introduction

1.1 Statement of the problems

The economic forecast by the Government Savings Bank Economic Research Center for 2018-2019 suggests that modern retailers, or modern trade, are continuously renovating their old branches and expanding new ones due to the government's efforts to stimulate spending. This will lead to an increase in overall demand for construction materials in the country, which will positively impact the growth of modern trade building supply stores. According to the Krungsri Research Center, the outlook for construction materials and home furnishings retail businesses in 2019-2021 has a high growth potential due to consumer purchasing power and a growing real estate sector. Despite increasing competition, modern trade building materials stores continue to expand their branches, and large operators have implemented various strategies such as adjusting branch expansion with a smaller business model, providing Home Service and One Stop Shopping Center services, and using a robotic system or modern management system to reduce costs and increase efficiency (Tumwongsa, 2018).

However, the large operators of modern trade building supplies still maintain continuous growth due to important supporting factors from government policies such as the Million House Project, economic stimulus measures, tax reductions for first home buyers in the real estate sector, and measures to reduce fees and mortgages (Chalong, 2019). By applying the energy-saving concept as a model for designing modern building materials stores that rely on nature, local business entrepreneurs can increase their competitiveness with major modern building supply traders. By recognizing the importance of energy efficiency and reducing energy consumption in the building sector, the building materials trade can reduce building management costs in the long run and help create a good quality of life for building occupants. This, in turn, will enhance the organization's image, increase business confidence, and encourage investment.

1.2. Hypothesis

The concept of energy-saving through a passive design approach can be appropriately applied to the design of modern building supply stores.

1.3. Terms of definition

Modern Trade refers to a building supply store that is systematically managed with the use of modern technology, offering a wide variety of construction materials, including basic construction materials, home decoration and repair materials, and furniture. Most of these stores are operated by major traders who are expanding their branches to serve new customers in Bangkok and other provinces, and are increasingly competing in after-sales services, such as repair and installation services both inside and outside buildings.

Energy conservation refers to the act of saving or reducing unnecessary energy use, while also increasing the efficiency of energy consumption. This includes reducing energy consumption for lighting, heating-cooling systems, transportation, and production machinery, resulting in less energy consumption for the same results. Energy conservation is an important part of enhancing the country's energy security, reducing household expenses, manufacturing and service costs, and reducing emissions of pollution and greenhouse gases that contribute to global warming.

Passive design refers to an architectural design approach for buildings that relies on nature to save energy. It involves applying knowledge about the environment, such as setting the building in a direction that receives natural wind and ventilation, planting trees around the building to provide shade, or positioning the building near a water source, among others. This approach can effectively reduce building management costs in the long run, while also creating a good quality of life for building occupants and enhancing the organization's image, leading to increased business confidence and investment.

2. Objectives

The objective of this study is to create a prototype model project of a local building supply store (Local Business) for energy saving.

3. Materials and Methods

3.1Study the concept of building design concept for energy saving about the theory of heat gain and heat loss theory of materials, which should also be consider.

- The four external impact factors in building design, which are Sun path, Natural vegetation, Topography, and Climate, these factors play a crucial role in energy-saving building design (Albatayneh et al., 2018)

- The six internal impact factors in building design, such as Solid wall, Translucent walls, Roof, External shading device, Air conditioning system and Lighting system. By paying attention to these factors, we can develop energy-efficient building designs that are sustainable and eco-friendly (Department of Alternative Energy Development and Efficiency, online).

3.2 Study the information of building supply stores on the Asian Highway No.1 (AH1), Wang Chao District, Tak Province, we should collect the data from government policy documents, regarding the infrastructure and transportation networks in the area. After that, analyzing the orientation and physical environment of the area, such as its climate, topography, and natural resources. Include the position of the land relative to the sun and prevailing winds. This information can help us understand the potential for passive solar heating and cooling, natural ventilation, as well as opportunities for sustainable building practices and understand the challenges and opportunities for building supply stores in the area.

4. Results and Discussion

4.1 Results

4.1.1 The design concept for energy-saving buildings involves the integration of various design methods, with each system working in harmony to achieve the highest energy efficiency at low design and building costs. The primary focus is on utilizing natural factors to prevent heat from entering the building structure (Passive Design) and incorporating high-efficiency equipment systems within the building (Active Design), as they directly impact energy consumption, particularly in the air conditioning and lighting systems. According to the Ministry of Energy's Department of Alternative Energy Development and Efficiency (online), the energy-saving building design concept, which relies on nature (Passive Design) and machines (Active Design), is divided into two factors:

4.1.1.1) External factors in building design

4.1.1.2) Internal factors affecting building design

4.1.2 The energy saving concept of external factors in building design is divided into 4 factors as follows:

4.1.2.1) Sun path

The building should be designed so that the narrow side faces east-west, allowing the side with less wall area to receive heat from the sunbeam, particularly in the afternoon when the sunbeam is the hottest (refer to Figure 1). This design will minimize heat entering the building and decrease electricity consumption in the air conditioning system.

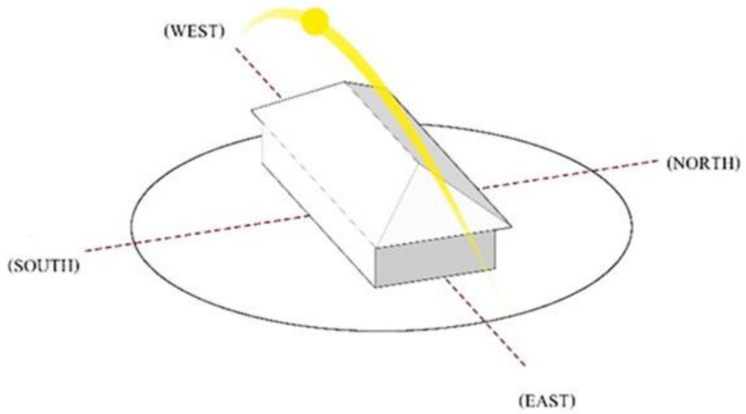

Figure 1 shows the orientation of the building corresponding to the orbit of the sun to reduce heat radiation in the east and west

4.1.2.2) Natural vegetation

Planting large shade trees around the building can reduce the heat generated by direct sun rays. Alternatively, planting shrubs, grass, and ground cover can prevent the sun's rays from heating the ground.

4.1.2.3) Topography

In order to fully save energy in building design, the improvement of the topography including the building area and the environment around the building is a critical factor that needs to be taken into account. Adapting the terrain to the construction of buildings can make the environment around the outside of the building lower than the normal climate, reducing the heat from the sunrays during the day, and thus reducing the cooling load on the building. There are several variables to consider, including trees, shrubs, ground cover, water sources, wind currents, and the slope of the ground facing north for less sunlight or creating a large pond to allow the wind to blow through and cool the environment (Department of Alternative Energy Development and Efficiency, online).

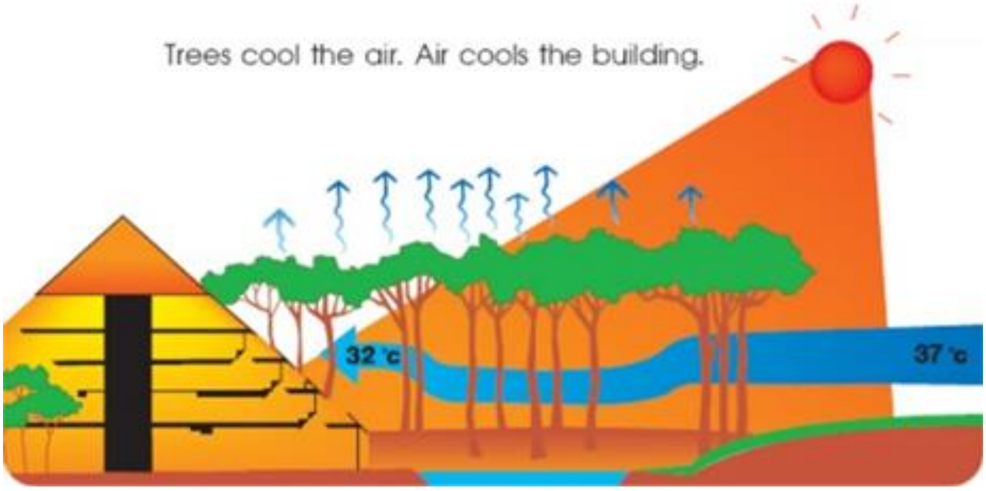

Figure 2 The use of natural factors to adjust the ambient temperature of the building to be cool.
Source: Publication of Business Building Sector building features Energy-saving building design [Online]. Retrieved from http://www2.dede.go.th/bhrd/old/web_display/commercial_buildings.html.

4.1.2.4) Climate

Building construction should take into account the local climatic conditions, whether it is tropical or cold, to reduce energy consumption. For example, it is possible to take advantage of local winds by placing the building and openings to block the wind direction. In Thailand, there are local winds such as the summer wind blowing from the south or southwest and the winter winds blowing from the north or northeast.

4.1.3 The concept of energy saving of internal factors in building design is divided into 6 factors as follows.

4.1.3.1) Solid wall

Solid walls play a crucial role in making buildings energy efficient as a significant portion of the energy in the building is consumed by the air conditioning system to regulate the temperature for building occupants' activities. Thus, selecting the appropriate solid wall is a crucial factor in reducing heat entry into the building and decreasing energy consumption by the air conditioning system.

Solid wall design guidelines encourage to increase the heat resistance (R-value) by installing insulation on the exterior wall or using a double wall with air gaps between the layers to insulate outside heat (Figure 3 and Figure 4).

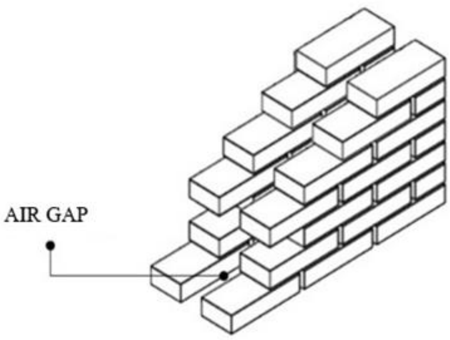

Figure 3 The brick wall in 2 layers with a gap in the middle (preferably more than 10 cm)

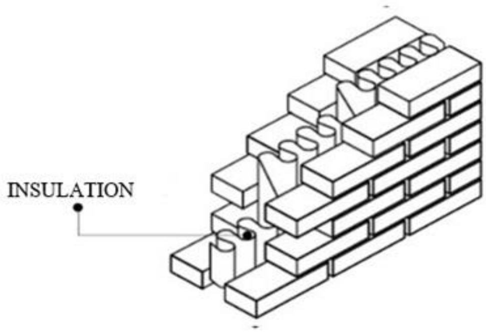

Figure 4 The brick wall in two layers with insulation in the middle

The exterior wall color should be of light tones, such as white or cream, as they have lower solar radiation absorption properties than dark colors. However, if you prefer to use darker tones, you should paint the solid wall in a location that receives less sunlight or install additional insulation.

4.1.3.2) Translucent walls

Translucent walls or glass are components of a building that significantly affect the building's energy consumption. This is because they receive and transfer heat from sunlight into the building, up to 5-10 times more than a solid wall. Therefore, the selection of the type of glass and installation technique is crucial in reducing the energy consumption of the building.

4.1.3.3) Roof

The roof should be insulated to improve the building's ability to resist heat. This can be achieved through the use of materials such as fiberglass insulation, PU insulation, gypsum board, and aluminum foil (Figure 5).

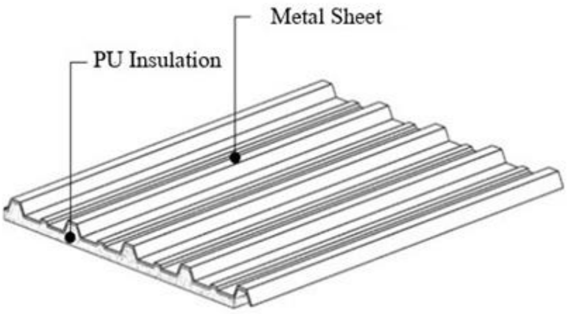

Figure 5 The metal sheet roof with PU foam insulation

4.1.3.4) External shading device

Exterior shading devices are more effective in reducing heat entering the building compared to internal ones, so the design of building openings and translucent walls should always include shading devices. When designing and installing outdoor shading devices, many factors should be taken into account, such as the building's orientation, the size of the opening, and the gap between the shading device and the building wall.

Guidelines for the installation of external shading device are shown in Figure 6 and 7

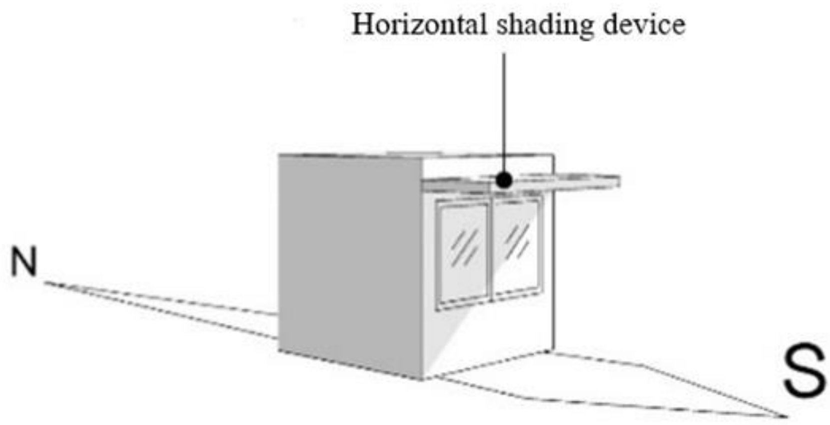

Figure 6 The south and north facades should be horizontal shading device

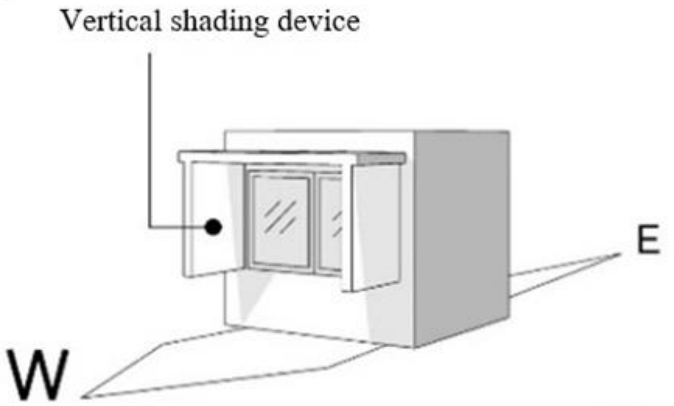

Figure 7 The buildings on the east and west sides should be vertical shading device

4.1.3.5) Air conditioning system

The air conditioning system must take into account various factors such as choosing an air conditioner that has a suitable cooling size for the cooling load and is highly efficient, or is a model that has an energy-saving label number 5, etc.

4.1.3.6) Lighting system

To reduce energy consumption in lighting systems, it is important to use bulbs that are as energy-efficient as possible while still providing sufficient brightness according to design guidelines for lighting systems include choosing high-efficiency lamps or LED lamps and taking advantage of natural daylight by installing separate on-off switches for areas along the building's perimeter where there is external light (Department of Alternative Energy Development and Efficiency, online).

4.1.4 Study the information of building supply stores in the sample area

Location of building supply stores in the sample area is on the Asian Highway No.1 (AH1), Wang Chao District, Tak Province (Figure 8). It is located in the government's investment plan with infrastructure, which will benefit dealers and produce manufacturers, by choosing a location with educational institutions tourist attraction, convenient transportation and not many building supply stores to avoid competition. The project location has a total area of 11 rai with the following details:

- North- adjacent to other people's land It is now cultivated with no building.

- South- adjacent to other people's land It is divided into small residential houses and areas because they are planted.
- East - adjacent to the mine to supply water for agriculture
- West is the Asian Road 1 (AH1)

Figure 8 The project location from Google satellite imagery

4.2 Discussion of results

The research findings were used as a guide for designing modern building supply stores with an energy-saving concept, aiming to make the building more energy-efficient and suitable for the local hot and humid climate. Thus, the building's form and composition were designed based on the demands of use and land constraints, with the front of the building facing southwest and the narrow side facing west-east, as shown in Figure 9. Consequently, the building needed to be protected from solar heat, and the outdoor environment enhanced to reduce heat entering the building, which was achieved by planting horizontal trees and vertical gardens to prevent pollution from reflections, noise, odors, dust, and adding a water garden to absorb rain and maintain soil moisture or a pond to collect rainwater, as shown in Figure 10, etc.

The interior of the building was planned to have open spaces and green areas, serving as a connection between the exterior and interior. These open spaces and green areas could also be used for promotional events, such as workshops, playgrounds, sharing spaces to meet, exchange, and share needs and help from new friends or designers, and an area for selling local products or community products to encourage people in the community to earn more.

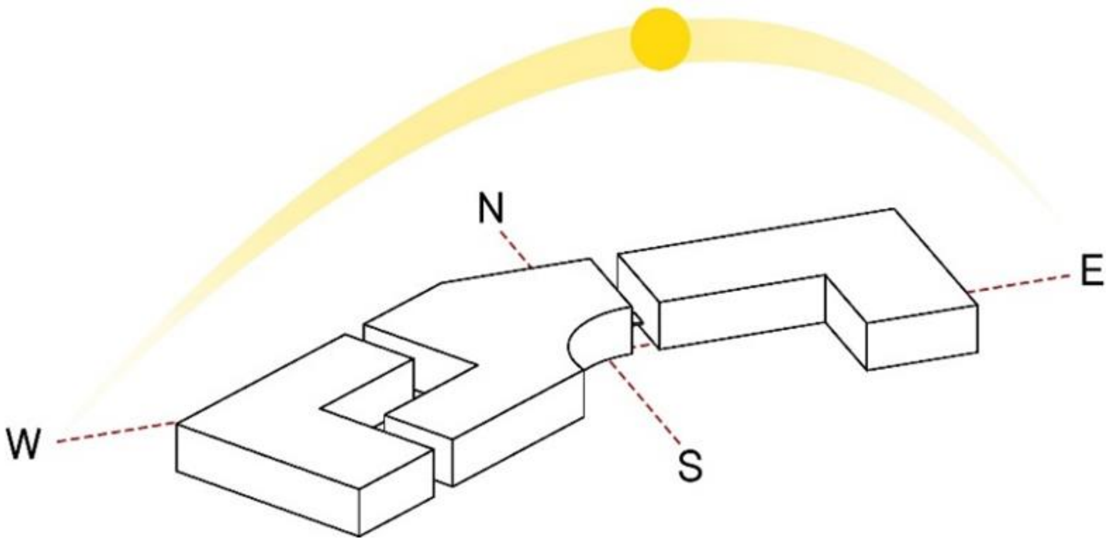

Figure 9 The narrow side of the building facing west-east

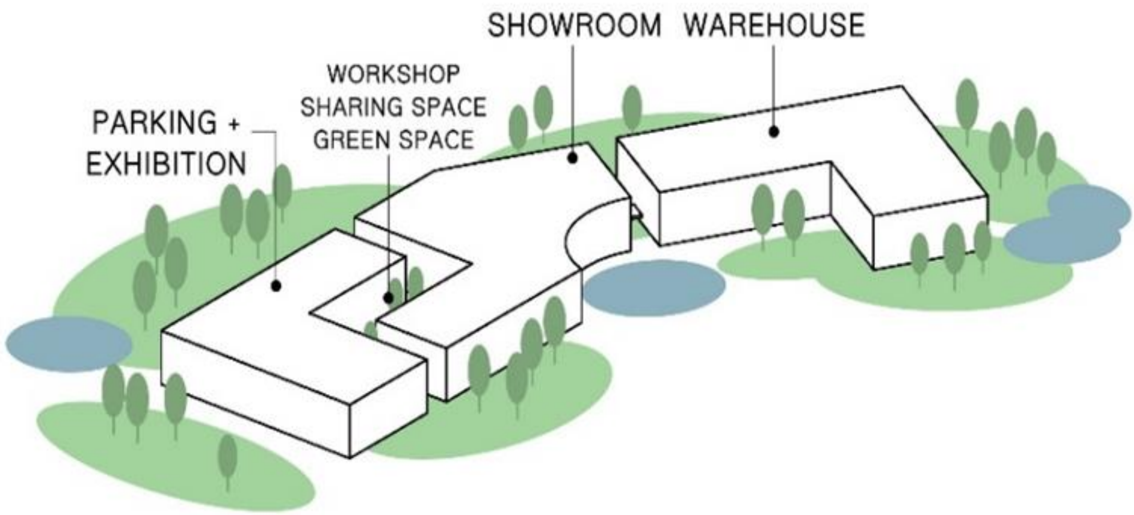

Figure 10 The external environment enhancements to reduce heat entering the building

The building is divided into different functional areas, and the usable area must be adjusted to reduce the building's opacity and allow sufficient natural light to brighten almost all areas, following the energy-saving concept of using passive design to promote a better quality of life. In addition to utilizing natural light, there is also the utilization of wind for natural ventilation in relation to the open spaces inside the building, which will absorb outside air for ventilation and help reduce heat radiation around the building, as shown in Figure 11.

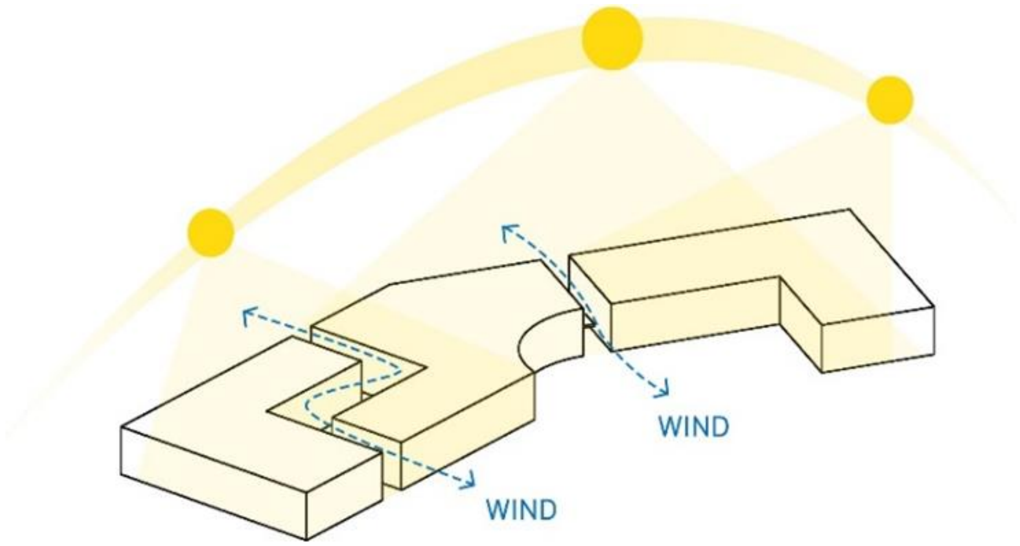

Figure 11 The utilization of natural light and wind

To increase the building's ability to resist heat, a masonry wall system with 2 layers of air-gap is used between the layers of the wall, and a light-colored exterior wall color is chosen to reflect heat. The interior layout of the building is separated into warehouse and sales areas to control air conditioning and logistics systems. Various building systems are selected according to the concept of building design that combines all design methods and systems to work consistently, including:

1. The lighting control system uses LED lamps, which are more efficient and energy-saving than other types of lamps. It can control the light on and off in each area, especially when there is sufficient natural light.
2. The automated warehouse management system is a computer robot-controlled system that manages goods, such as picking, putting, and stacking. This helps to reduce the use of horizontal space.
3. The water recycling system is divided into semi-waste water and waste water. Once treated, it is reused for watering the garden through a perforated pipe that allows water to seep into the soil.
4. The rainwater sequestration system filters and collects rainwater from the roof in tanks, which is then used to flush the urinal.

After studying the possibilities of using energy-saving design concepts by combining various factors studied and using high performance energy saving material, it was possible to apply them to the design of modern construction material stores appropriately, as show in Figure 12.

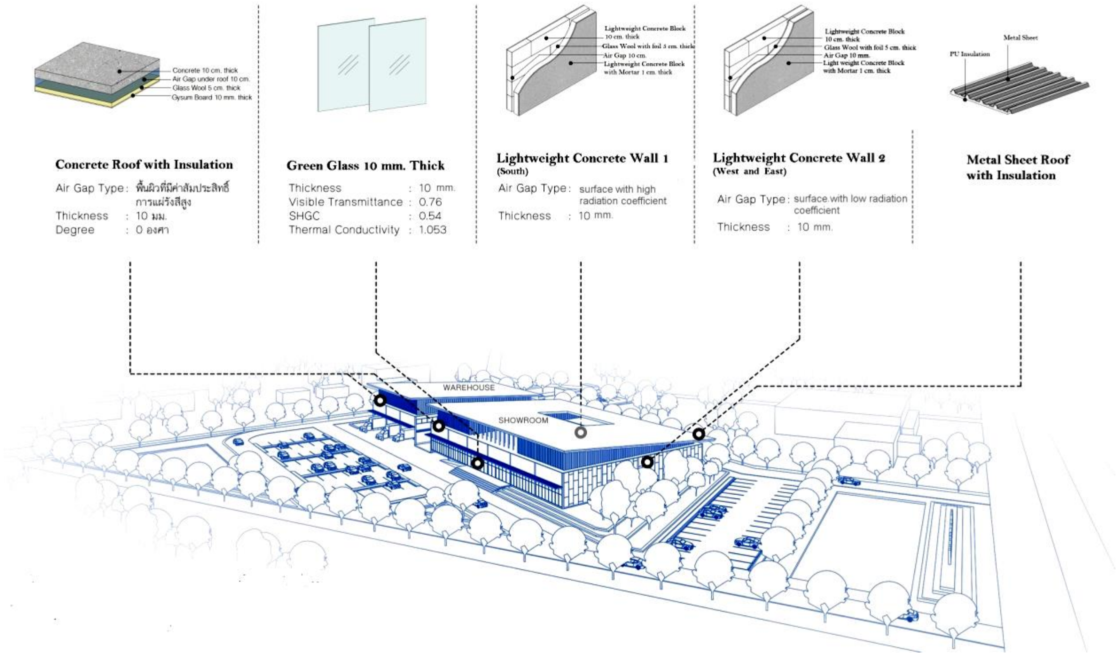

Figure12 High performance energy saving material

Table 1 Result of Evaluating OTTV and RTTV using BEC V1.0.6 Building Energy Code

SHOWROOM

Table: Whole Building Energy Report			
Building Energy Consumption	0.00	kWh/Year	
Energy from PV System	0	kWh/Year	Building Energy Code Compliance
Net Energy Consumption (Evaluated Building)	0.00	kWh/Year	Passed
Net Energy Consumption (Reference Building)	173,448.00	kWh/Year	

Energy by Floor

	Floor	Floor Area (m^2)	Wall Area (m^2)	Roof Area (m^2)	OTTV (W/m^2)	RTTV (W/m^2)	COP	LPD (W/m	EPD (W/m^2)	OCCU (Head/m^2)	VENT (l/s/m^2)	Total Energy Consumptio
1	1	2,000.00	1,160.00	2,000.00	42.94	9.16	0.00	0.00	0.00	0.10	0.25	0.00

Energy by Building Zone

	Zone Name	Zone Floo	Zone Area (m^2)	Wall Area (m^2)	Roof Area (m^2)	OTTV (W/m^2)	RTTV (W/m^2)	COP	LPD (W/m	EPD (W/m^2)	OCCU (Head/m ^2)	VENT (l/s/m^2)	Heat Gain Through Exterior Wall (W)	Heat Gain Through Roof (W)	Interior Heat Gain (W)	Energy Consumption of A/C System (kWhr/Year)	Energy Consumption of Lighting System (kWhr/Year)	Energy Consumption of Equipment (kWhr/Year)	Total Energy Consumption (kWhr/Year)
1	SHOWROOM	1	1,800.00	910.00	1,900.00	41.04	9.16	0.00	0.00	0.00		0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	WORKSHOP&SHARING SPACE EXHIBITION	1	400.00	300.00	300.00	55.67	9.16	0.00	0.00	0.00		0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00

WAREHOUSE

Table: Whole Building Energy Report			
Building Energy Consumption	0.00	kWh/Year	
Energy from PV System	0	kWh/Year	Building Energy Code Compliance
Net Energy Consumption (Evaluated Building)	0.00	kWh/Year	Passed
Net Energy Consumption (Reference Building)	110,376.00	kWh/Year	

Energy by Floor

	Floor	Floor Area (m^2)	Wall Area (m^2)	Roof Area (m^2)	OTTV (W/m^2)	RTTV (W/m^2)	COP	LPD (W/m^2	EPD (W/m^2)	OCCU (Head/m^2)	VENT (l/s/m^2)	Total Energy Consumption (kWhr/Year)
1	1	1,200.00	1,000.00	1,100.00	46.79	9.16	0.00	0.00	0.00	0.10	0.25	0.00
2	2	200.00	250.00	400.00	59.09	9.16	0.00	0.00	0.00	0.10	0.25	0.00

Energy by Building Zone

	Zone Name	Zone Floor	Zone Area (m^2)	Wall Area (m^2)	Roof Area (m^2)	OTTV (W/m^2)	RTTV (W/m^2)	COP	LPD (W/m^2	EPD (W/m^2	OCCU (Head/m ^2)	VENT (l/s/m^2)	Heat Gain Through Exterior	Heat Gain Through Roof (W)	Interior Heat Gain (W)	Energy Consumption of A/C System (kWhr/Year)	Energy Consumption of Lighting System (kWhr/Year)	Energy Consumption of Equipment (kWhr/Year)	Total Energy Consumption (kWhr/Year)
1	OFFICE	1	100.00	80.00	0.00	59.34	0.00	0.00	0.00	0.00	0.10	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	OFFICE2	2	100.00	80.00	200.00	59.34	9.16	0.00	0.00	0.00	0.10	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	STORAGE	1	100.00	180.00	0.00	54.47	0.00	0.00	0.00	0.00	0.10	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	STORAGE2	2	100.00	180.00	200.00	54.47	9.16	0.00	0.00	0.00	0.10	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	WAREHOUSE	1	1,000.00	1,000.00	1,100.00	46.80	9.16	0.00	0.00	0.00	0.10	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The results of the research have been evaluated the energy consumption with analysis heat through the building frame by using OTTV and RTTV evaluation program with BEC V1.0.6 Building Energy Code program (Department of Alternative Energy Development and Efficiency Ministry of Energy). The assessment results showed "Building energy code compliance "PASS" as shown in Table 1.

5. Conclusion

Based on the feasibility study conducted on the adoption of the energy-saving building design concept and the use of high performance energy-saving materials, it is evident that many factors need to be appropriately applied to the design of a modern building supply store. For instance, the building layout should be optimized to utilize natural light and wind, and different building framing systems should be selected to address the limitations of sunlight.

Additionally, planting heat-resistant trees and enhancing the outdoor environment through horizontal and vertical gardening can reduce the heat load entering the building. Shading devices should also be installed in the openings and translucent walls to reduce direct sunlight entering the building. The interior layout should be separated, and green spaces should be created between buildings to make it easier to control the air conditioning, logistics, and lighting systems. By applying the energy-saving concept through a natural approach (Passive Design), the design of modern building supply stores can significantly reduce building management costs in the long term. Therefore, the prototype model designed by the researcher can help operators of local building material businesses to compete favorably in the sector. Although the natural energy-saving concept (Passive Design) has not been widely applied in the construction materials business sector, it is evident that designers can apply this concept appropriately with the right intention.

6. Acknowledgement

This research study was successfully completed. With great kindness of our research participant. I would like to express my sincere gratitude to them.

7. References

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