



UPVOC

**Frames: Innovative Solution
for Energy Conservation**

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South East Asia (SEA) is a hot and humid region, and together with urbanization, which results in more pollution and heat, natural ventilation is no longer practical. Buildings require air-conditioning so that people within could inhabit them comfortably. Suffice to say, buildings consume a large amount of energy in the effort to lower indoor temperature, resulting in high operation costs. Together with the energy crisis of today, it has become necessary to search for improved methods of energy conservation.

Strengths and weaknesses of both wood and aluminium frames are summarized below;

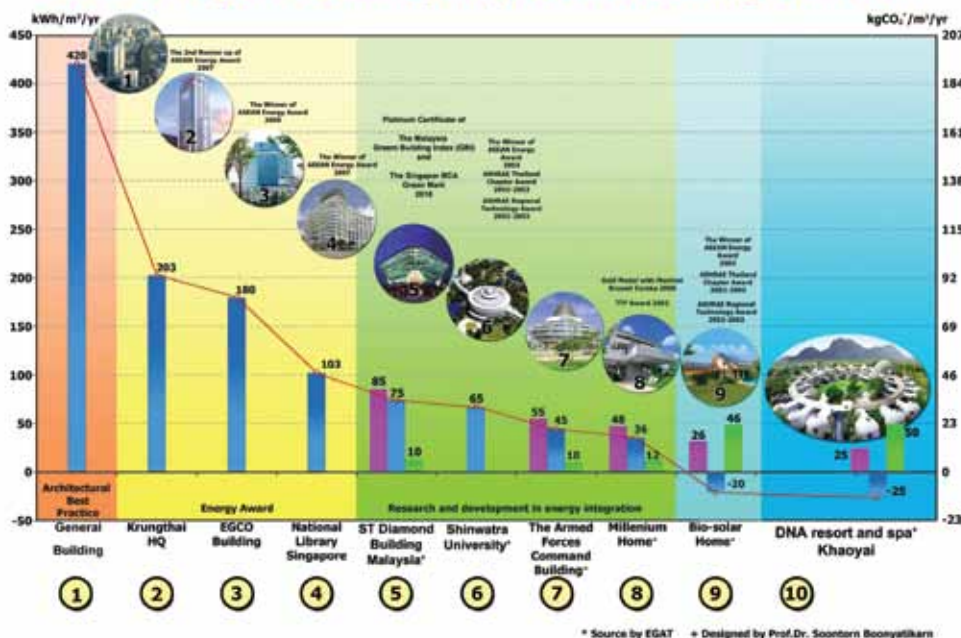
Wood Frames:

Strengths	Weaknesses
<ul style="list-style-type: none"> • Conventional construction and installation • Natural esthetic • Commonly known to designers and owners 	<ul style="list-style-type: none"> • Joints allows moisture and air penetration • Deformation occur when exposed to moisture and heat • Damages from insects • High mass

Aluminum Frames:

Strengths	Weaknesses
<ul style="list-style-type: none"> • Durable • Easily available in market • Light weight • Easy installation • Long life • Does not rust or get insect damage • Modern esthetic 	<ul style="list-style-type: none"> • Heat conductor • Joints allows moisture and air penetration • Scratches form easily

NEW PARADIGM SHIFT IN GLOBAL WARMING SOLUTION
"Where is your building in global warming solution?"



Comparison of energy consumption and CO2 emission in buildings

Saving energy within homes can be easy if one knows the cause. Every day, homes lose a significant amount of energy through window frames. This is because the materials of frames are inappropriate and do not have the qualities that are necessary for energy conservation. Wooden and aluminum frames are two typical frame materials used in SEA today. Wooden frames are part of the traditional architectural design which is very beautiful and gives a natural feeling to the building. The disadvantages of wood are its vulnerability to insects and deformation when exposed to moisture and heat. Aluminum frames are extremely durable and light, but very good heat conductor. Furthermore, both types of frames are not as efficient as they should be since they have leakages that allow heat, moisture and noise to enter into the building.

The Unplasticized Polyvinyl Chloride (uPVC) frame, made from the tough plastic material, is gaining popularity as an alternative solution to conventional frames. The material is extremely versatile and made into numerous products for various purposes – window frames, floorings, wall covers, toys, ducts and tubes, art installations, furniture, etc. Window frames made from uPVC solve many problems that are presented in wood and aluminum frames, such as deformation, leakage of air and noise, and heat conductivity. As a result, uPVC frames are extremely suited for saving energy in homes, Table 1 is a comparison chart of features among wood, aluminum and uPVC frames, rated from 1 being worse to 5 being best. Their compared sizes are:

- 1) Hard wood 100 mm. thick
- 2) Aluminum anodized dark color 1.5 mm. thick
- 3) uPVC white color 2-3 mm. thick



uPVC frames in a home

Table 1 Comparison of features of materials: Wood, Aluminum and uPVC

Features	Wood	Aluminum	uPVC
i Durability	3	5	4
ii Strength	3	5	4
iii Deformation	3	5	4
iv Insect proof	3	5	5
v Installation	3	4	5
vi Repair and Maintenance	3	5	5
vii Cost	3	5	4
viii Heat Transfer	4	3	4
ix Mean Radiant Temperature (MRT) ¹	4	3	4
x Acoustics	1	2	5
xi Leakage	1	2	5
xii Visual	4	4	5
xiii Shape and form	2	2	5
xiv Recyclable	3	1	4
Total Score (out of 70)	40	52	63

Rating	1	2	3	4	5
	Worse	Bad	Neutral	Good	Best

As shown in table 1, the total score of the uPVC frame is rated the highest out of the three. In terms of energy conservation, the uPVC frame is clearly superior. Energy consumption in homes mostly goes towards keeping the house cool through the air-conditioning system. In this case, heat transfer, MRT¹ (or the temperature internal wall surface) and leakage play significant parts in lowering cooling load. Hence, the uPVC frames, which have high scores for heat transfer, MRT and highest for the leakage, are exceptional in saving energy.

The next part will examine more closely on how each feature contributes to the following topics:

- | | |
|-------------------------------|-----------------------------|
| 1. Air Infiltration | 4. Safe, Durable, Beautiful |
| 2. Thermal Property of Frames | 5. Installation |
| 3. Recyclable | 6. Others |

Air infiltration and thermal property are both important in energy conservation, while recyclability, safety, durability, beauty, and easy installation are some qualities that make particular frames more desirable.

1. Air Infiltration (air leakage)

The fenestration of a building plays an important part in determining the amount of energy required for a comfortable lifestyle. For Thailand, the largest concern for a building in terms of energy is leakage, or air infiltration. Air infiltration is the undesirable airflow from outside through cracks and other unintended openings, such as cracks in frames. Preventing air from entering a building through door and window frames can reduce heat and humidity and thus lighten the cooling load. Therefore choosing type and material of frames is an important aspect for a green home.

¹ The mean radiant temperature (MRT) is the temperature of the inside surface of the material within homes. It is heat radiating from the material to the inside space which can make occupants feel hot even when air temperature is low.



uPVC frame cut section (source: Inoutic; Deceuninck (Thailand) Co., Ltd.)

Air leakage can be measured in CFM (cubic feet per minute). For an air-tight frame, such as the uPVC frame, air infiltration may be only 0.1 Air Change (AC), where in regular homes can be very leaky at 0.4–0.5 AC. Air flowing in from outside is hot and humid. The load (Q) can be classified into two categories: sensible load and latent load. Sensible load is the energy required to extract heat from the air, while latent is the energy required to change state of matter, which in this case, is from liquid to gas.

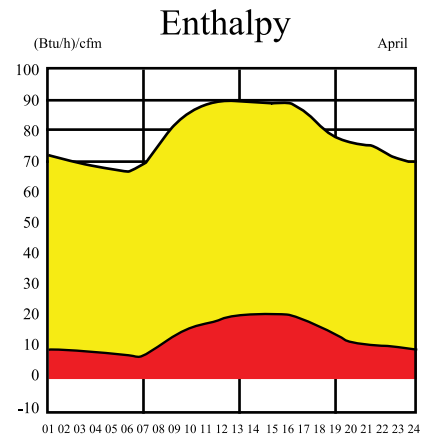


Figure 1 Latent heat (yellow) and sensible heat (red) contained in the air, in April.

Figure 1 shows the sensible load (in red) and latent load (in yellow) for the month of April, the hottest month in Thailand. The over all peak load in this month is 90 (BTU/h)/cfm.

Using the figure above, the cost incurred in a house can be estimated. Take, for example, an average 3-bedroom house with an area of 1000 m³. The following will compare cost calculations between best case frame, like the uPVC with the best leakage score, and worst case frame such as materials like wood and aluminum that received very poor score in this category.

Case 1: Best frame (0.1 CFM),

Total Load = 588.583 CFM* (90 BTU)0.1 =5297.25 BTU/h

Ton(s) of air-condition required = $\frac{5297.25}{12000} = 0.441 \text{ tons}$

Daily cost = 0.441 * 10 * 5THB = 22.07 THB

Monthly cost = 22.07 * 30 days = 662.10 THB

Yearly cost = 662.10 * 12 = 7945.20 THB

Case 2: Worst frame (0.5 CFM)

Total Load =588.583 CFM *(90 BTU)0.5 = 26486.24 BTU/h

Ton(s) of air-condition required = $\frac{26486.24}{12000} = 2.21 \text{ tons}$

Daily cost = 2.21*10* 5THB = 110.50 THB

Monthly cost = 110.50 *30 days = 3315THB

Yearly cost = 3315 *12 = 39780THB

From the calculations above, there is a significant difference in energy costs of the different frames. Frames with little to no air leakage like uPVC frames can make a home 5 times less costly than ones that allow moisture and air penetration like wood and aluminum frames.

For many home owners, air infiltration may not seem a big issue because it is an invisible phenomenon. To understand the seriousness of this topic we must look at our air-conditioning system, which makes up a large part of energy consumption within homes. The system deals with enthalpy, a combination of heat and humidity. Air within home is circulated through the system in order to have heat and humidity extracted from it and one must keep in mind that hot air can hold more moisture. If we were to compare, air at 30 degree Celsius at 50% humidity, and air at 25 degree Celsius at 50% humidity, the amount of moisture in the hot air would be significantly higher than the cold air. Therefore, air leaking from outside where it is hotter, is also more humid. To circulate the hot air from outside in the system would put more burden on the air-conditioner, and would result in higher electricity costs. Leakage or air-infiltration is, therefore, undesirable if one wants to have an energy-efficient home.

2. Thermal property of frames: U-Value

The surface area of frames can account for 5% of total window surface area. The frame of the windows and doors can act as a heat conductor, which means that if the frames have low heat resistance, energy consumption in homes can be exceedingly high. The heat capacity for uPVC is very low and the material does not absorb heat or moisture. The following section will show the heat resistance value and heat transfer rate (u-value) of three types of frames: wood, aluminum and uPVC.

U-Value calculation (Wood section material) (Estimated)

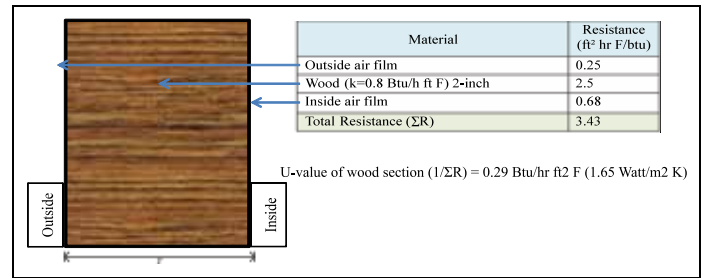


Figure 2 Wood frame: hardwood (section) summer condition

U-value calculation (Aluminum section material) (Estimated)

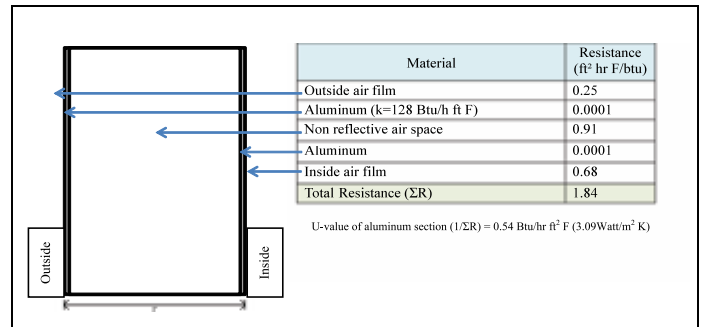


Figure 3 Aluminum frame (section) summer condition

U-value calculation (uPVC section material) (Estimated)

Part 1 between materials (64% of section)

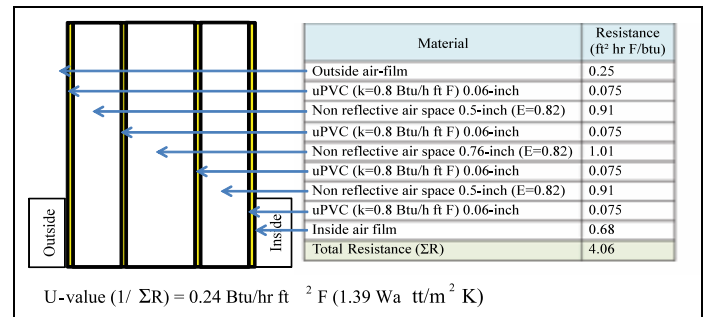


Figure 4 uPVC frame (section) summer condition

Part 2 in material (36% of section) (Estimated)

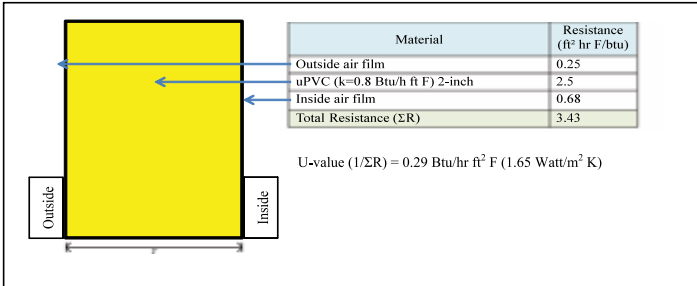


Figure 5 uPVC frame (section) summer conditions

Total U-value of uPVC section = (0.64) (0.24) + (0.36) (0.29)
 = 0.26 Btu/hr ft² F (1.46 Watt/m² K)

As shown in table 2 below the thermal properties of the uPVC frame is best out of the three types, which reflect the high scores it received in the Heat transfer and MRT categories. This is due to the fact that the uPVC frame has several non-reflective air spaces that help thermal insulation, preventing heat from entering through the material from outside. The u-value for wooden frames is similar to the uPVC; it is also good at stopping heat, but due to its mass and the propensity to distort from heat and moisture, makes it a less desirable choice.

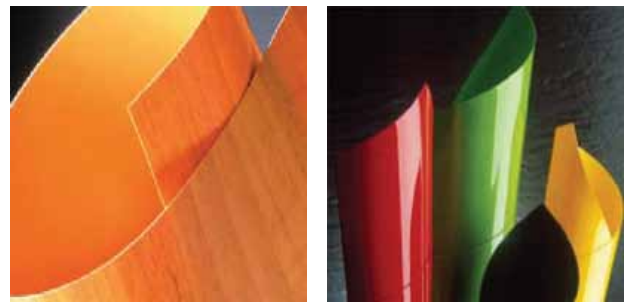
Table 2 Thermal properties of frame materials and different glazing types

Materials	U-value (Estimated) (Btu/hr ft ² F)
Aluminum section 1.5 mm. thickness (figure 3)	0.54
Wood section 50 mm. (2") thickness (figure 2)	0.29
uPVC section 2.5 mm. thickness (figure 4 and figure 5)	0.26

3. Recyclable

In the past uPVC materials have been received negatively by the public. This is due to the harsh chemicals used in production and the difficulty in separating parts to recycle once combined. Parts have to be manually taken apart by people making it a very labor intensive process. As a result, windows, doors and other products made from this material were expensive to recycle and few companies offered the service.

However, over the years, technology in the uPVC recycling business have developed, making the process cheaper and need less labor. It is now much easier to find a recycling service in the market. The technology now enables companies to take uPVC products, break them down into small pieces then separate uPVC from other materials. The uPVC materials are then broken down further and turned into chip granulate, micronized powder or compounded pellets.



Products made from recycled uPVC

Recycled uPVC are used to manufacture products such as coatings for swimming pools, shoe soles, pipes, and plastic coated fabrics. Recycling uPVC is much more useful and much less costly than some other materials. Wood, though recyclable, will only be usable after being reduced into to smaller pieces or in pallets, making its usefulness very limited. While aluminum has to be melted down using an enormous amount of energy, resulting in extremely high recycle costs. This is why uPVC has a higher recyclable score than either wood or aluminum.

Even though uPVC products are found in the land fill of our cities today, the increase in recycling uPVC products is still a positive trend towards a cleaner future.

4. Safe, Durable and Beautiful

The uPVC leads the way when it comes to continuous improvement of security, health and safety measures. In the safety aspect, uPVC frames have advanced locking mechanisms that ensures maximum security, and though they have many tilt and turn options that bring the benefit of fresh air, these does not compromise security.



uPVC frame in a private home (source: Inoutic;Deceuninck (Thailand) Co.,Ltd.)

The durability of uPVC frames is also a feature which supports the green movement of today. The material will not corrode when exposed to air and moisture. Unlike wood, which will deform, be damaged by insect, and break down to produce waste material and release CO₂ into the atmosphere. Though aluminum may be similar in durability, nor does it rust easily, but the material can have scratches over time unlike the uPVC frames. Out of the three materials, uPVC is best in repair and maintenance.



uPVC frames blend well with nature (source: Inoutic;Deceuninck (Thailand) Co.,Ltd.)

The uPVC is a tough material but it can be processed to form a wide range of products and designs that allow it to blend naturally with all styles of structures and locations. The material is so versatile that it can meet all kinds of architectural specifications. In terms of visual, shape and form, uPVC frames are the most adaptable. Wood can look rustic and charming, while aluminum looks modern, but these two materials are hard to shape into different, more customized, form.



uPVC window frames in DNA resort and spa in Khaoyai Nakhonrachasima

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5. Installation

The installation process for door and window frames also plays a part in frame selection. Installing typical frames are extremely time-consuming. Wood frames have to be installed at the same time as the wall that will encase it. Glass panels are then fitted into the frames. Most frequently the frame and glass panels do not match and has to be resized. Its high mass makes maneuvering the frame more difficult. This installation process is not very cost-effective and frames usually get damaged during the process.

Aluminum on the other hand is easy to install. It is light and widely available in the market. It is a conventional frame type in Thailand but rates very low in terms of heat, leakage and MRT, which are crucial in a tropic country.



uPVC frame made it easy for installation (source: Windsor)

For the uPVC frames, installation is easier. Glass panels are already mounted on the frame prior to installation, this make the margin for error very low in terms of matching frame and glass size. However, installing uPVC frames require a certain amount of skill and precision. Main issues that cause unpopularity for uPVC frames are

- 1) The lack of products range in the Thai market,
- 2) Lower grade products from manufacturers who does not reinforce frame to reduce costs,
- 3) Exterior insulation and finishing system (EIFS) wall has to install overlapping unit by 20 mm because of structural weakness.

6. Others

Other features that play a part in the decision process of buyers and designers is how well-known a type of frame is. Wood and aluminum have been around for a very long time. Usually selection of frames is based on old knowledge, while newer better technology will have to become slowly accepted.

Another factor is the acoustical property of frames. The often times, specifically designed rooms, such as meeting room, will required a certain level of quiet. In this case, uPVC has the best score, because its multilayer acts as a sound buffer, while wood and aluminum has just one layer, meaning fewer sound barriers.

To the Future

A good example of Thailand's green architecture, which incorporates uPVC window frame into their designs, is the Bio-solar Home (figure 6). This home has won several awards for its innovative environmental design. The home considers all aspects of energy within a home, and for its frames, uPVC material was chosen.



Figure 6 uPVC frame at the Bio-Solar Home, Rangsit Patumthani

Frames made from uPVC are still not so widely used in Thailand. There are still some doubts being cast on the material because of lack of proper promotion and information. However, this can be easily solved with time. Its energy efficiency, durability, versatility and safety are undeniably superior to other materials to date. With so many advantages, uPVC frames will become extremely popular in the window frame market. No doubt, the future is uPVC.

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