NZB.RGChan.
5.1 San Marino_ADP

Architectural Design Program for Residential

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R.G.CHAN & ASSOCIATES
ARCHITECTS ENGINEERS ENVIRONMENTAL PLANNERS
888 City Camp Road Baguio City, 2600 Philippines

Table of Contents

ABOUT THE SERIES

This pdf file-binding is part of the NZB.RGChan.Series on foundational researches undertaken by R.G.CHAN & Associates for in-house office use, towards systematic steps for Net Zero Building Design of projects.

THE PROJECT BRIEF

The NBZ1_San Marino Project is a Proposed Two (2) – Storey Residential house located at San Marino Subdivision, Bonuan, Dagupan City, Pangasinan having a total lot area of 400.00 m^2.

General Classification of Use:	**Group A** – Residential (Dwellings)
	Division A - 1 (Residential building / structure for exclusive use of single family occupants)
Principal Use:	Single - Detached Units
Zoning Classifications:	**Residential R - 1** – a low-density zone characterized mainly by single-family, single-detached dwellings with the usual community ancillary uses on a neighborhood scale, such as executive subdivisions and relatively exclusive residential communities which are not subdivisions.
Key Zones:	Public, Private, and Service
Individual Spaces:	Carport / Garage Porch Foyer Living Area Dining Area Kitchen Pantry Powder Room Guest's Room with T & B Maid's Room with T & B Laundry Area/Room Stair, Storage Master Bedroom (w/ Walk-in Closet, T & B, Balcony) Two (2) Bedrooms with 1 common T & Bb One (1) Bedroom with T & B Family Area Balcony

GOALS AND OBJECTIVES

Economic Goals

The main objective is to come up with a design solution towards net-zero building. Because of the different factors, design challenges, and sensitivity of the site that should be considered in order to efficiently meet the needs of the building and its occupants, there must be the application of energy-efficient strategies and design principles, and take advantage of the free naturally occurring assets available, such as passive solar orientation, natural ventilation, daylighting, thermal mass, and night time cooling.

Organizational Goals

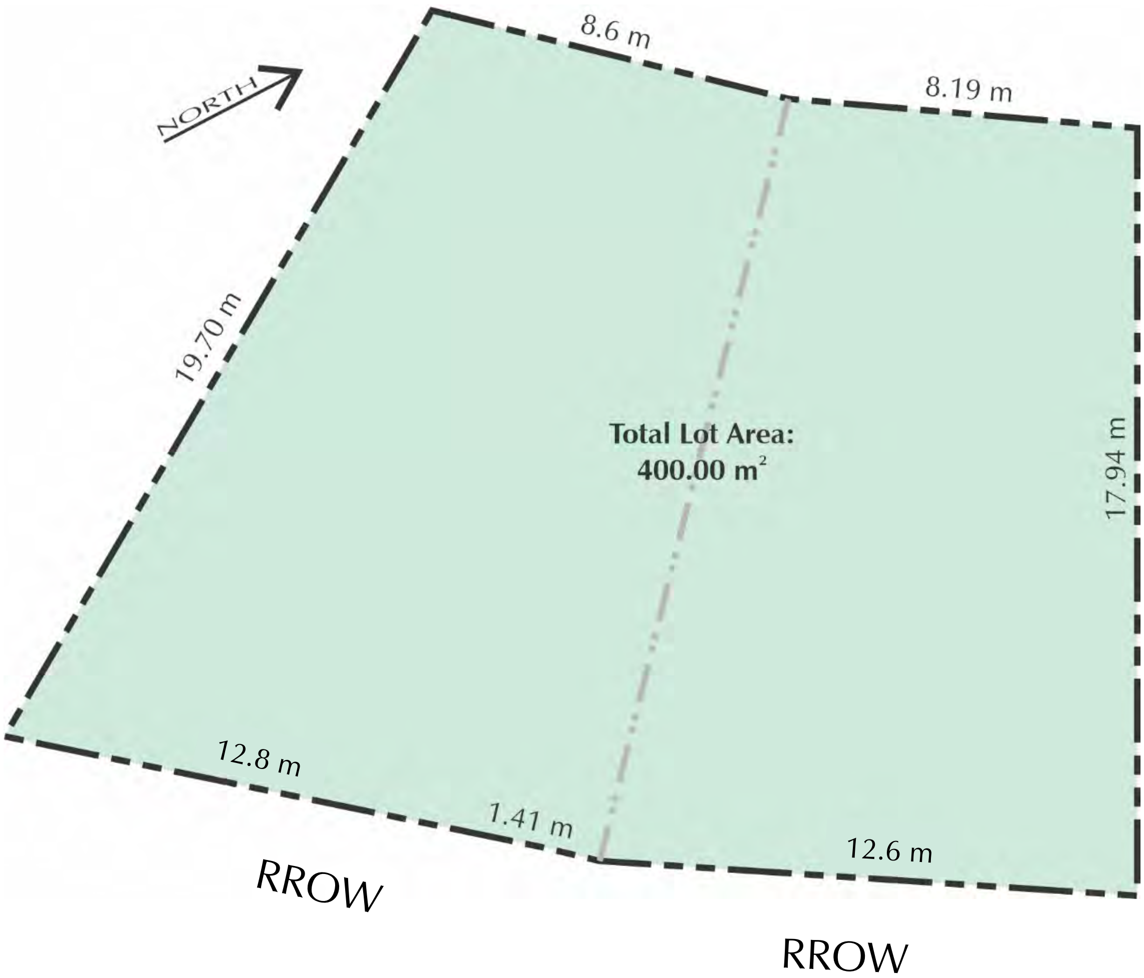
In terms of the organization of spaces, the owner wants the design to be an open plan to maximize the **use of air-conditioning system**, which will then be incorporated as additional element in cooling the building.

Function Goals

The major function of the building is residential, R-1 type of dwelling that will be occupied by six (6) to eight (8) people. There will be public, private, and service zones that will have impact in the occupant interactions.

RELEVANT INFORMATION

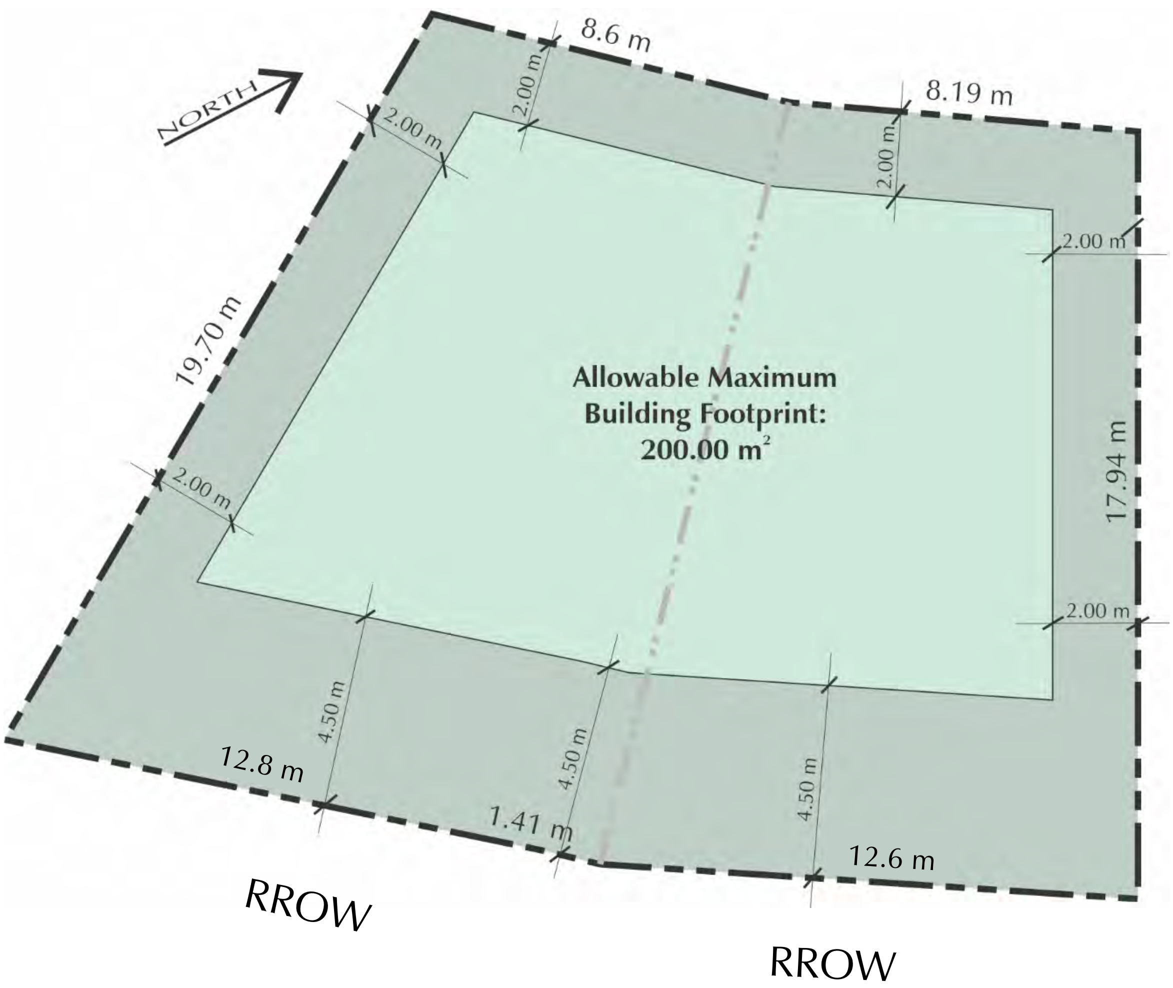
Development Control



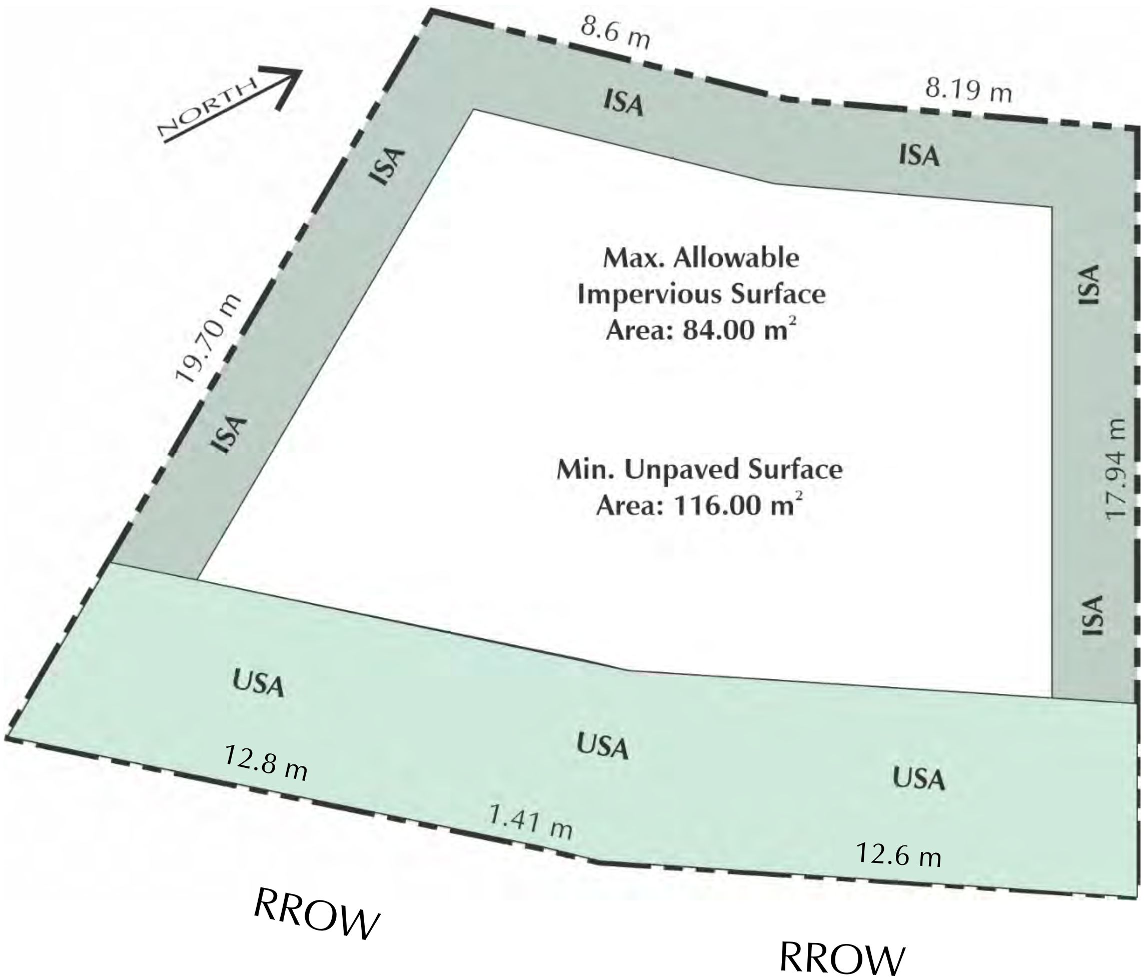
Total Lot Area (TLA) = **400.00 m²**

Table 1.0 A portion of Table VIII.2. Minimum Setbacks for Residential Buildings / Structures under Rule VIII of the National Building Code of the Philippines.

YARD	R – 1 (meters)
Front	4.50
Side	2.00
Rear	2.00



Allowable Maximum Building Footprint **(AMBF)** = **200.00 m²**



Max. Allowable Impervious Surface Area **(ISA)** = **84.00 m²** (21% of TLA)

Min. Unpaved Surface Area **(USA)** = **116.00 m²** (29% of TLA)

Maximum Allowable Percentage of Site Occupancy **(PSO)** = AMBF / TLA

= 200 m² / 400 m²

= **50 %** (of TLA)

Maximum Allowable Construction Area **(MACA)** = PSO + ISA

= 50 % + 21 %

= **71 %** (of TLA)

Open Space within Lot **(OSL)** = USA + ISA

= 116 m² + 84 m²

= **200.00 m²** (50 % of TLA)

Minimum Requirements for Group A Dwellings

The following statements are some of the necessary requirements for Group A Dwellings as seen in Section 708 of the National Building Code of the Philippines (from which will be referred to as NBCP from this point in this report):

(a) For dwelling location and lot occupancy, the dwelling shall occupy not more than 80% of an inside lot and shall have a setback of at least 2 m from the property line.
(b) For light and ventilation, the dwelling shall be constructed and arranged to provide adequate light and ventilation as provided under Section 805 of the NBCP.
(c) For sanitation, the dwelling shall be provided with at least one sanitary toilet and adequate washing and draining facilities.
(d) For entrance and exit, there shall be at least one entrance and another one for exit.

Location of Property (General Requirements)

It is stated in Section 704.a of the NBCP that eaves over required windows shall not be less than 750 mm from the side and rear property lines. Projections beyond the exterior wall shall not exceed beyond a point 1/3 the distance from an assumed vertical plane located where the fire-resistive protection of openings is first required to the location on property whichever is the least restrictive (Section 704.b).

Footprint Based on Firewall Provisions

According to Section 704.4.c.iii of the NBCP on Footprint Based on Firewall Provisions, "Absolutely no firewalls are allowed for a low density residential (R-1) uses or occupancies". However, an abutment of up to 3.2 m from the established grade level may be permitted but solely for the purpose of supporting a carport roof. The abutment must also be constructed of perforated or decorative concrete blocks above 1.50 m measured vertically from the established grade level. The length of the abutment shall not be longer than 7.00 m or 50% of the side property line in total length, whichever is shorter.

An abutment is defined as a form of a semi-permanent or permanent structure constructed along a property line, usually of masonry or reinforced concrete or other fire-related material.

Size and Dimensions of Rooms

Section 806 of the NBCP states that the minimum sizes of rooms and their least horizontal dimensions shall be as follows:

1. Rooms for Human Habitations – 6.00 m^2 with a least dimension of 2.00 m;
2. Kitchens – 3.00 m^2 with a least dimension of 1.50 m;
3. Bath and toilet – 1.20 m^2 with a least dimension of 0.90 m.

Also, habitable rooms shall have a minimum of 14.00 m^3 of air space per person (Section 807 of the NBCP).

Building Height Limit

As per Section 707 under Rule VII of the National Building Code of the Philippines, the building height limit for Residential 1 (R-1) structure is three (3) storeys above established grade or 10 meters above highest grade.

Table 2.0 A portion of Table VII.2. Building Height Limit (BHL) by Type of Use or Occupancy under Rule VII of the National Building Code of the Philippines.

Character of Use or Occupancy	Type of Building / Structure	Building Height Limit (BHL)	
		Number of allowable storeys / floors above established grade	Meters above highest grade
1. Residential	Residential 1 (R-1)	3	10.00

Ceiling Heights

Based on Section 805 of Rule VIII of the National Building Code of the Philippines, habitable rooms provided with artificial ventilation shall have ceiling heights not less than 2.40 m measured from the floor to the ceiling; provided that for buildings of more than one (1) storey, the minimum ceiling height of the first storey shall be 2.70 m and that the second storey 2.40 m and that the succeeding stories shall have an unobstructed typical headroom clearance of not less than 2.10 m above the finished floor. Above-stated rooms with natural ventilation shall have ceiling heights of not less than 2.70 m.

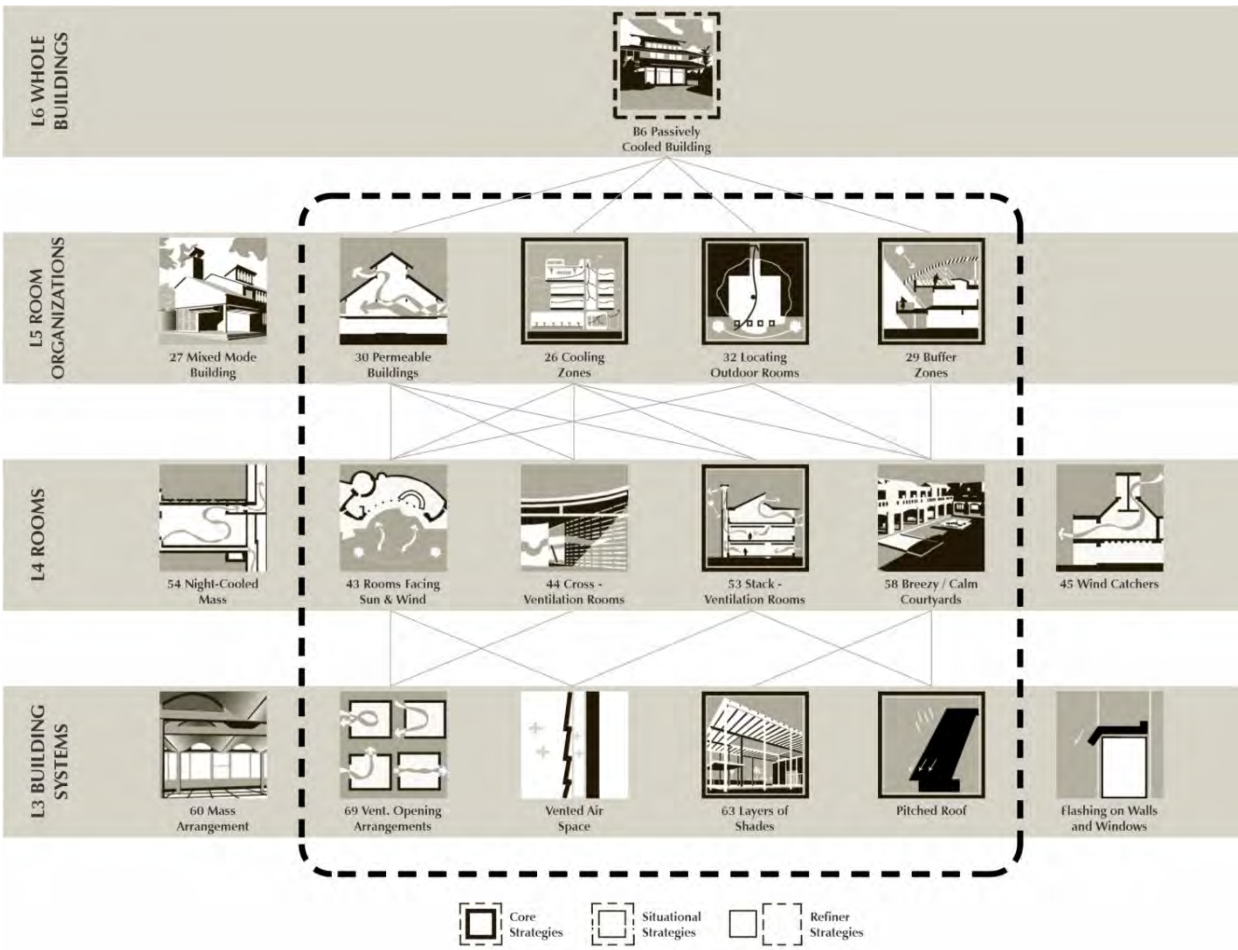
Window Openings

As per Section 808 of Rule VIII of the National Building Code of the Philippines, rooms intended for any use, not provided with artificial ventilation system, shall be provided with a window or windows with a total free area of openings equal to at least 10% of the floor area of the room, provided that such opening shall be not less than1.00 m^2. However, the toilet and bath rooms, laundry rooms, and similar rooms shall be provided with window or windows with an area not less than 1/20 of the floor area of such rooms, provided that such opening shall not be less than 240 m^2. Such window or windows shall open directly to a court, yard, public street or alley, or open watercourse. Also, section 808 stated that eaves, canopies, awnings over required windows shall not be less than 750 mm from the side and rear property lines.

When openings (door and windows) in exterior walls are required to be protected due to distance from property line (minimum setback), the sum of areas of such openings in any storey shall not exceed 50% of the total area of the wall in that storey, based on Section 704.b of the NBCP.

DESIGN STRATEGIES

Design strategy for NZB1 will utilize B6 bundle for hot-humid bundle with an addition of *Pitched Roof* and *Flashing on walls and windows*. This will affect massing, spatial organization, and orientation. Note that according to Koppen climate, Dagupan is a hot-arid climate. However the tropical hot-arid climate in the Philippines still have high relative humidity, especially for this project which is characterized by high average outdoor temperature and is surrounded with bodies of water.



Bundle Core strategies

To achieve a **net-zero building** in the tropical hot-humid climate of Dagupan city, this architectural program make use of **SWL** Core, situational and refiner strategies by importing data from the **Weather Tool** and existing **site conditions**.

Cooling Zones

Rooms can be grouped into cooling zones based on similar cooling requirements, facilitating the use of the same cooling strategies at the same time (SWL). In general, houses have low typical internal heat gains due to its low number of users and limited number of equipment **(14 Watt per square meter)**. Internal heat gain is caused by mechanical, electrical and lighting equipment; thus, we can group the spaces of NBZ1 according to how much equipment the room has and how frequent a space is used to dedicate proper cooling strategies.

Table 3.0 Zoning by cooling requirements.

Internal gain	**NZB_1 Rooms (Ground floor and Second floor)**
High	Kitchen
Mid	Living, Dining, Bedrooms
Low	T&B, WIC, Pantry

Locating Outdoor Rooms

In relation to **sun and wind** can extend the seasons of outdoor comfort. Since hot-humid climates depend greatly on ventilation to cool the spaces, outdoor spaces can be a buffer zone that invites natural ventilation to cools the house.

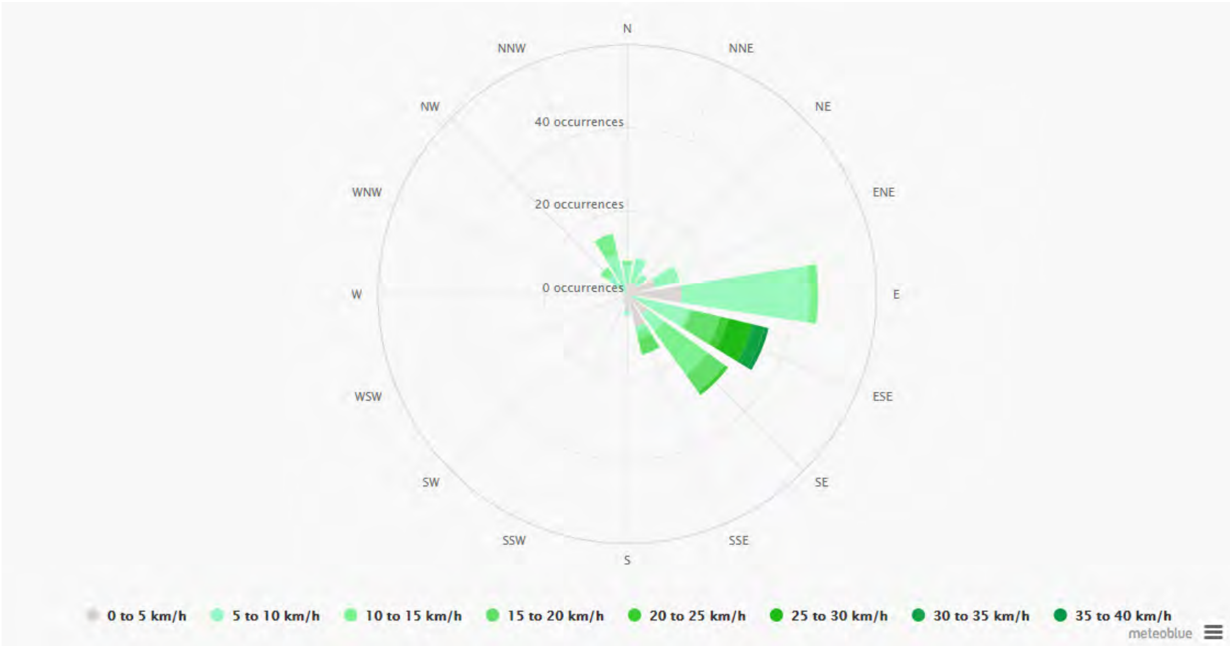


Figure 1.0 Wind rose by Meteoblue

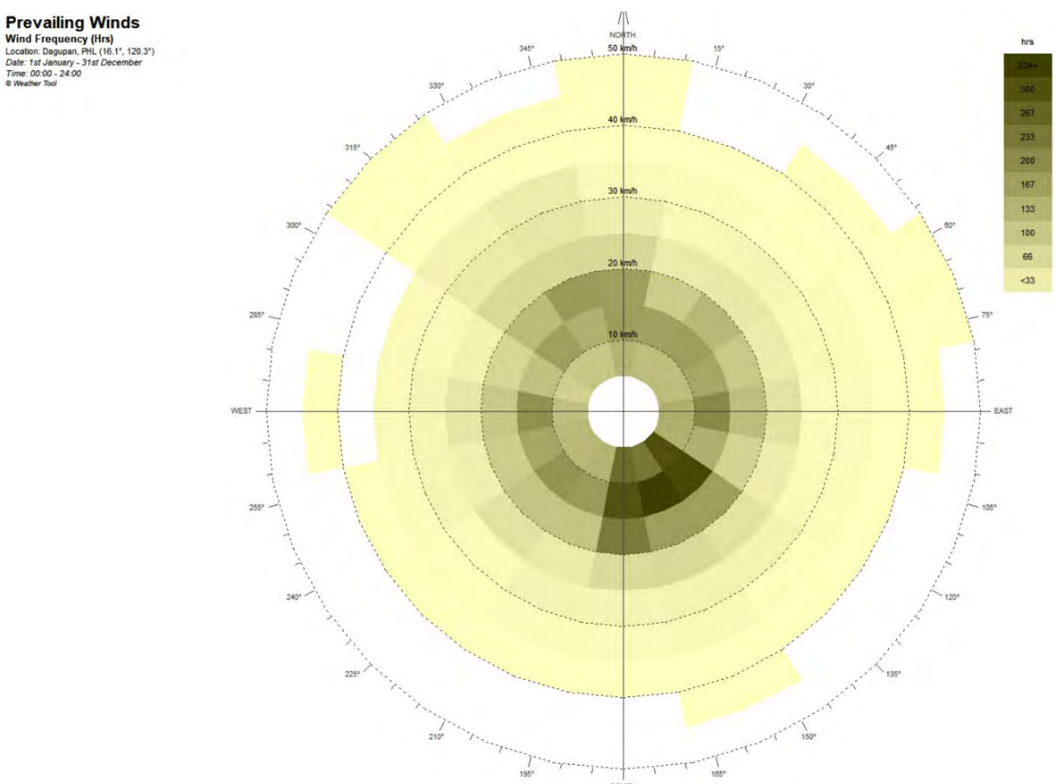
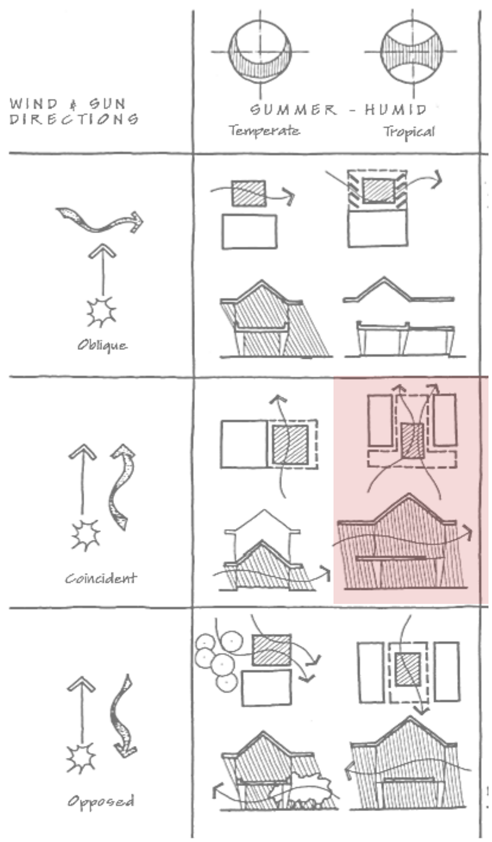


Figure 2.0 Wind rose by Weather tool

According to weather tool, supplemented by Meteoblue, the prevailing winds blows from Southeast making the wind coincident to the south sun in the tropics. **Therefore, outdoor space(s) must be located at the middle of the house (shaded rectangle) facing Southeast.** Outdoor spaces can also function as BREEZY COURTYARD.

Table 4.0 Locating outdoor rooms (SWL).



Buffer Zones

Rooms that can tolerate temperature swings can be located between protected rooms and undesired heat or cold and can temper fresh ventilation air before it enters the occupied space

Utility spaces (carport/garage, comfort rooms, laundry, and porches) can be use as buffer zones to protect the living spaces from the direct solar radiation and heat gain. Locations with direct heat gain includes east-west wall and roof.

Stack-vent rooms

Air flow through stack-ventilation rooms in increased by open sections and unrestricted pathways between the low inlets and high outlets. Unlike cross ventilation, stack ventilation works even without prevailing winds.

Stack towers are best located on the overheated part of the house to increase the temperature difference with the incoming air (known as the solar chimney effect).

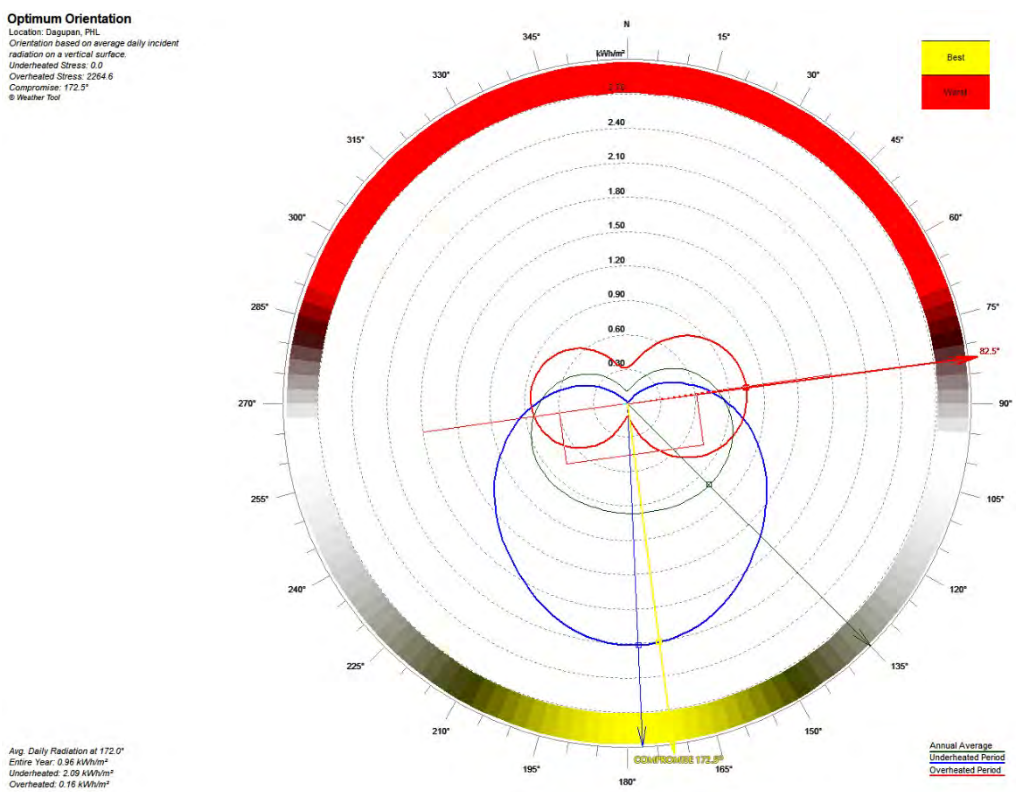


Figure 3.0 Optimum orientation by Weather tool

Locating stack-vent tower

Base from the weather tool, the overheated area would be at the northeastern side. The location is also strategic since the inlets will be at the prevailing winds at the southeast. In relation to lot shape, **the stack tower will be at the north side of the house with an outlet facing northeast.**

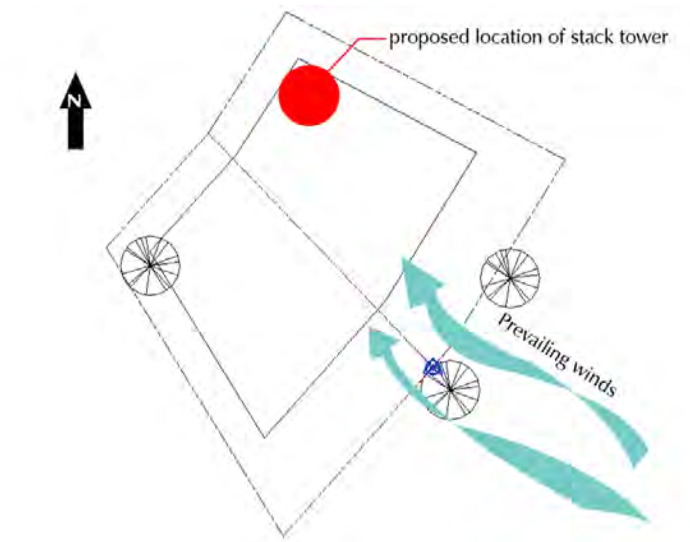
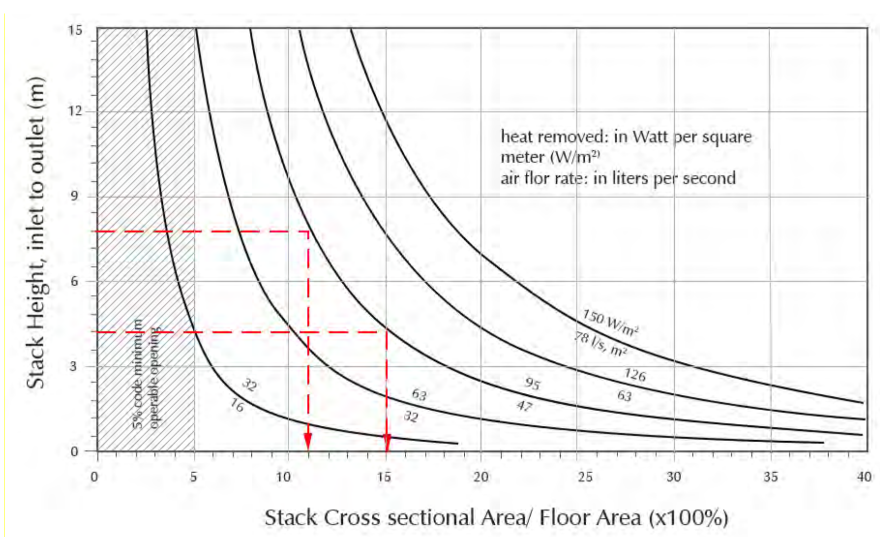


Figure 4.0 Proposed location of stack-vent tower in relation to the prevailing winds and lot shape

Sizing of stack vent (inlet and outlet)

The height of the tower will be a variable. Since the NZB_1 project is a two-storey house, the rough total height would probably at 6.4 meters. The tower can be 7.8 meters as in the table below. The curve lines represent the airflow rate that the stack vent can produce.

Table 5.0 Sizing stack-ventilation (SWL).



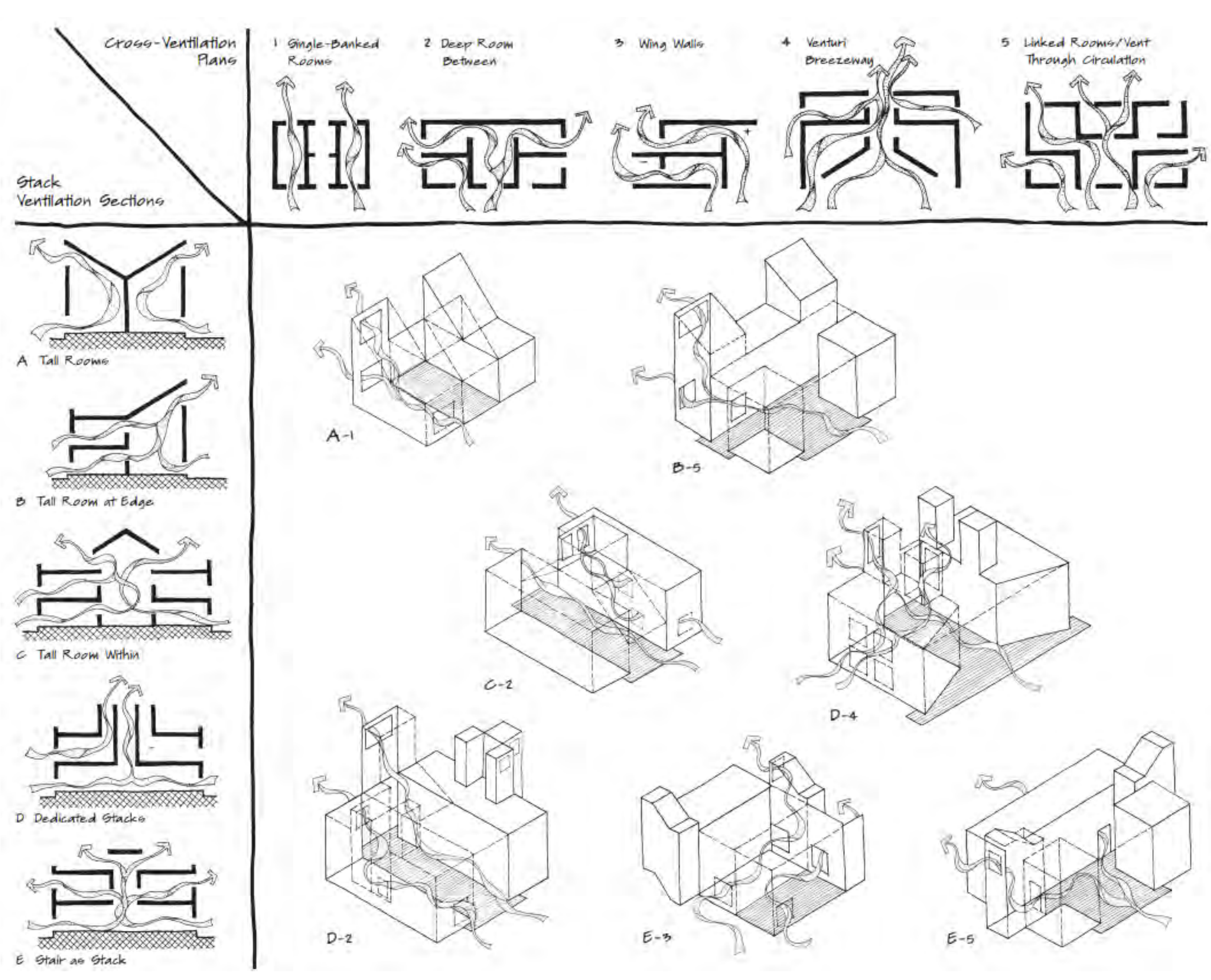
For example, if we choose to have a 47 liters/second, airflow rate; the stack cross sectional area should be 11% of the 200 m^2 conceptual floor area of NBZ1.

200 m^2 x 11% = 22 m^2 total area of inlet and outlet

For second floor, where the stack vent will be shorter (4.8 m) with 47 liters per second airflow rate, the stack cross sectional area should be 18% of the second floor area.

Stack ventilation is maximized when combined with CROSS VENTILATION. The combination will result to PERMEABLE BUILDING. The combined effect of stack and cross ventilation is due to the sum of the pressure driving both air flows. Thus, windows and openings must be placed strategically.

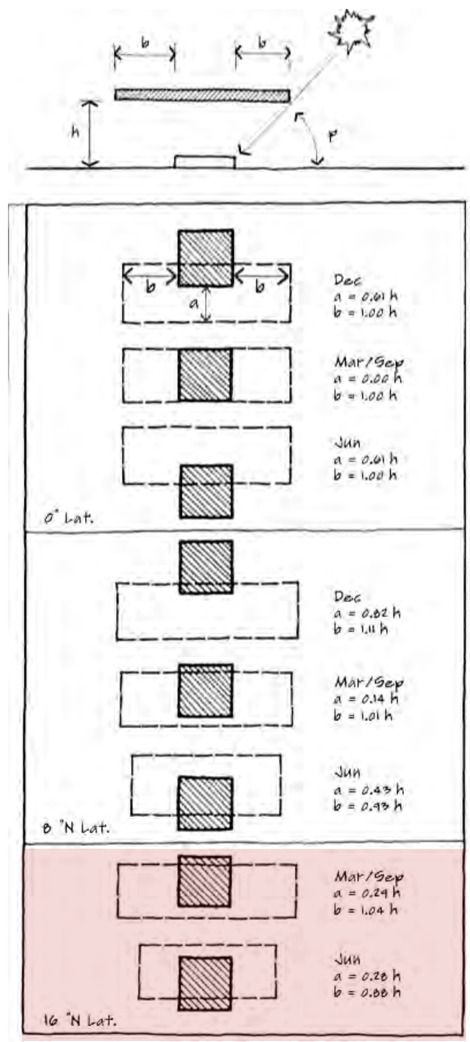
Table 6.0 Room organization strategies that facilitate both cross and stack-ventilation (SWL).



Layer of shades

Overhead protects the courtyard and building from the high sun, while a layer of vertical shades can protect from low sun.

Table 7.0 Locating outdoor rooms based on Microclimate (SWL).



NZB1 Latitude is 16° N. **Therefore, with a typical floor height of 3.2 meters, the shade should have at least 0.89 meters of shade due north and 0.92 meters due south. Shades due east and west is recommended to have vertical shading devices or have minimal openings that produce direct heat gain to the interiors-** ***Rooms facing the Sun and Wind***

CONSTRUCTION AND MATERIALS

In choosing materials and construction, moisture control is particularly important since Dagupan have consistent high relative humidity throughout the year due to its proximity to bodies of water (Lingayen Gulf, Rivers, fish farms) and high temperature. To control humidity and temperature, materials will be categorized whether an insulation or thermal mass. Heavy-weight materials are thermal mass that store heat, however thermal mass are commonly porous and relatively poor in repelling moisture. On the other hand, lightweight materials insulate repelling both heat and moisture however; it cannot be a load being element. **MASS ARRANGEMENT** can be optimized for passive cooling and thermal mass can be located in rooms where heat gain is effectively collected.

Core (frame and floor)

In addition to its cooling properties, we can the house is encouraged to use common reinforced concrete for columns and beams as well as for the floor. **Ceilings in hot-humid climate are good location of THERMAL MASS because during the cooling season warm air rises and accumulates near the ceiling. Placing high openings on the walls will also make the ceiling thermal mass a NIGHT COOLED MASS; thus heat exchange will be maximized (SWL).**

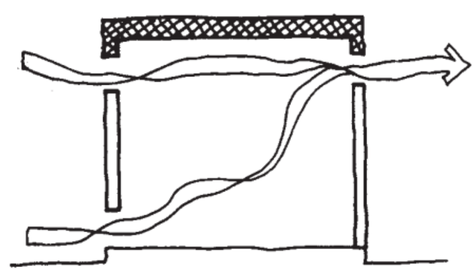


Figure 5.0 Ceiling as Thermal and Night Cooled Mass (SWL).

Envelope (walls, openings, and roof)

The prevailing strategy for designing net zero buildings, which is based on cold climate regions, is to ensure airtight, highly insulated buildings with controlled airflow coupled with efficient heat recovery (S. Hoque and N. Iqbal, 2015). Cooling a building on a Hot-humid climate on the other hand, invites outside air to flow in to the house while protecting the indoor from direct sunlight. While the project goal is to make a Net Zero building in a hot-humid climate, the owner wants this house to be fully air-conditioned. **MIXED MODE BUILDING** strategy can be used to address these conditions. The air-conditioning can "change-over" between passive and active cooling on a seasonal or daily basis. For example air conditioning units will automatically shut down anytime a sensor indicates that a window has been opened or an thermostat is installed.

Wall

Insulation levels for skin-load-dominated, passively cooled buildings are based on maintains a temperature difference between inside and out the reduces solar gain. If cooling strategies like CROSS-VENTILATION ROOMS and STACK-VENTILATION ROOMS are used, the inside temperature is slightly higher than the outside, so insulation isn't needed to reduce the heat flow due to temperature difference. It is needed only to reduce the flow due to SOLAR HEAT GAINS. If walls and roofs are protected from solar gain by full shading [EXTERNAL SHADING] and/ or radiant barriers [DOUBLE SKIN MATERIALS], insulation levels can be significantly reduced (SWL).

To seal the house during active cooling, Structural insulated Panels (SIP) will be used for the walls. As compared to conventional CHB wall, SIP is excellent for insulation because of the polystyrene core and fiber cement skin. With proper installation, the house can be sealed from heat and humidty transfer, thus reducing the cooling loads for the air-conditioning system.

Figure 6.0 Structural Insulated panel (photo retrieved from innovaecobuildingsystem.com).

Table 8.0 Wall material Resistance values

Material	Thickness in (mm)	R-value
Masonry & Concrete		
Concrete Masonry Unit (CMU)	4″ (100 mm)	0.80
Concrete Masonry Unit (CMU)	8″ (200 mm)	1.11
Structural Insulated Panel (SIP		
Fiber Cement Board	(4.5 mm)	0.11
Fiber Cement Board	(6.0 mm)	0.14
Polystyrene (EPS)		3.6 / inch

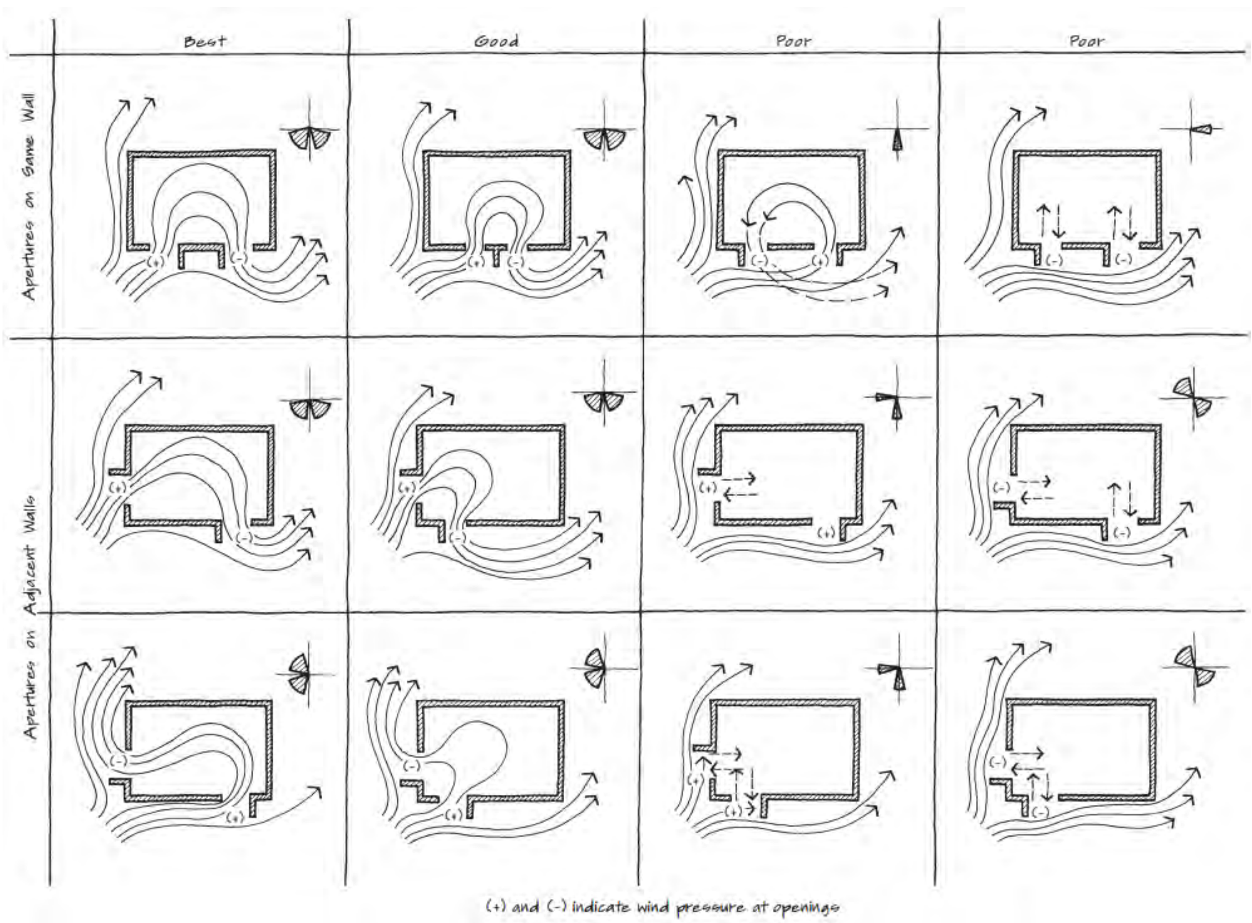
Source(s): www.archtoolbox.com, primafibrecement.com, & SWL

The thickness of commercially available SIPs in the Philippines ranges from 4 ½ to 6 ½ inches. According to https://www.mordorintelligence.com/, the whole wall R-value of a 4-inch structural insulated wall panel is 14. From the table above the R-value of a 4 inch thick Structural Insulated panel will be 14.4 for the Polystyrene core plus 0.22 from the two fiber cement boards facing. Thus, the exact Resistance value of the SIP is **14.62.**

Window

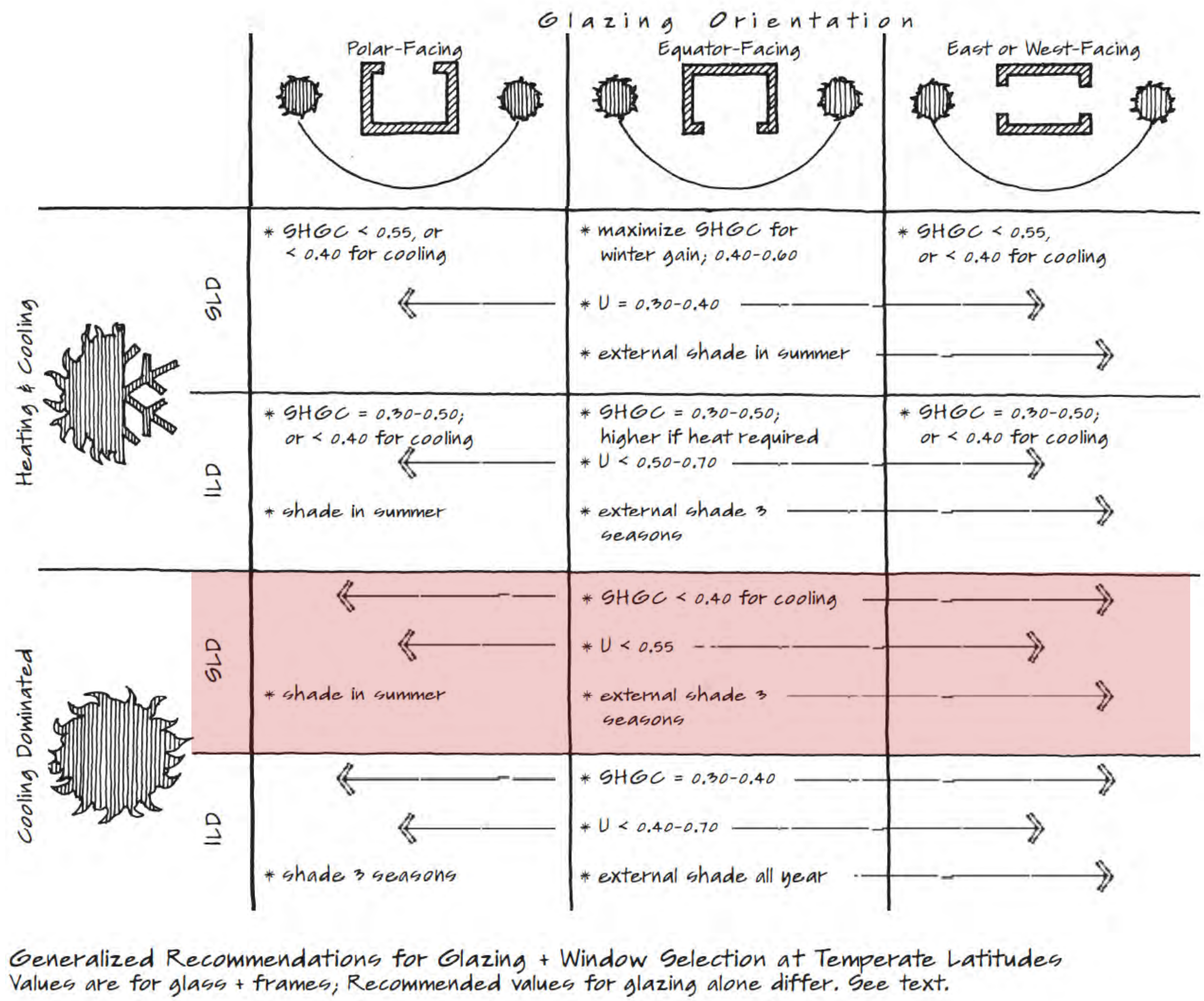
Since the house can switch to passive cooling, the window must utilize **CROSS VENTILATION** strategy which is dependent on wind pressure. To set windows in relation to wind pressure, wing wall strategy can be a guide. Design the depth of wing wall protrusions to be at least 0.5-1 times the width of the windows (SWL).

Table 9.0 Wing wall Design Strategies



Another important issue to consider is the type of glazing to use for the windows. Since some parts of the house will be air-conditioned, the emissivity of the window or its ability to repel heat will play a huge in role in keeping the cooling load as low as possible. Conduction transfers through the window are controlled by the window's U-Factor, which indicated the rate of heat flow through a material. Lower U-factors (or higher R-values) indicate better insulation. **Glass has a much lower resistance to heat than most other building materials** (SWL).

Table 10.0 Glazing recommendation in relation to orientation (SWL)



The house will be at SLD or skin-load-dominated and will be in need of cooling. **Thus the U value of the house should be less than 0.55 and should have a low Solar Heat Gain Coefficient (SHGC).**

Roof

Roofs in tropical climate are considered the most important component of a house for thermal and moisture control. **PITCHED ROOF** are recommended to wash the rain effectively along with deep overhangs to keep water off the walls and windows. Additional option is to have an insulated roof to minimize heat transfer from the roof to the interiors and thermal mass ceiling to absorb internal gain

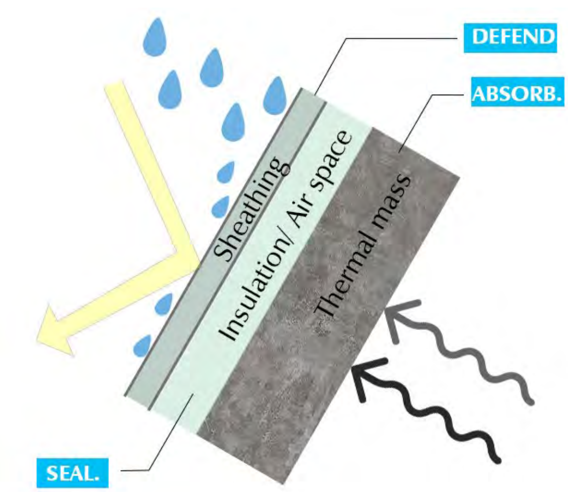


Figure 7.0 Proposed roof system for hot-humid climate.

MECHANICAL AND ELECTRICAL EQUIPMENT

The general rule of net-zero building in terms of electrical and lighting equipment/appliances is that it must be top of the line energy efficient products. Although the goal of net-zero building is to eliminate mechanical cooling, client specification calls for air conditionings system. MIX MODE BUILDING strategy can be used to address this issue. A mixed mode building can be organized to make use of passive, active and hybrid space conditioning systems in different parts of the building and at different time of the day and year.

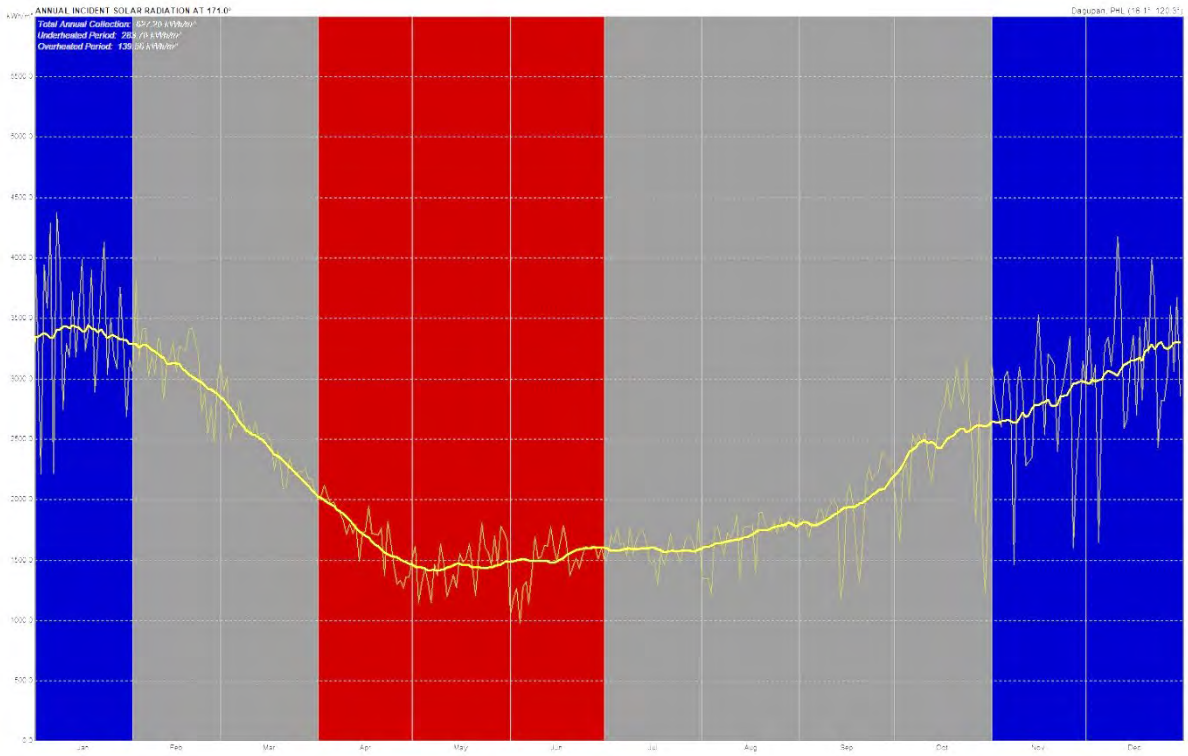


Figure 8.0 Overheated periods by Weather tool.

Overheated period of the year is from April to June. During these months, users can used air conditioning equipment on living and working spaces (as client specifies). High electric load during summer can be recovered using photovoltaic solar panels.

PHOTOVOLTAIC WALLS & ROOFS should be oriented to collect sun and large enough to meet the building's electric load. [power] Photovoltaic cells (PVs) convert sunlight to direct current (DC) electricity. Like any solar collection surface, photovoltaics collect more sun when oriented properly. A true south-facing (true north in Southern Hemisphere) orientation maximizes yield. Solar collection surfaces should be oriented within 30° of south (N in SH).- SWL

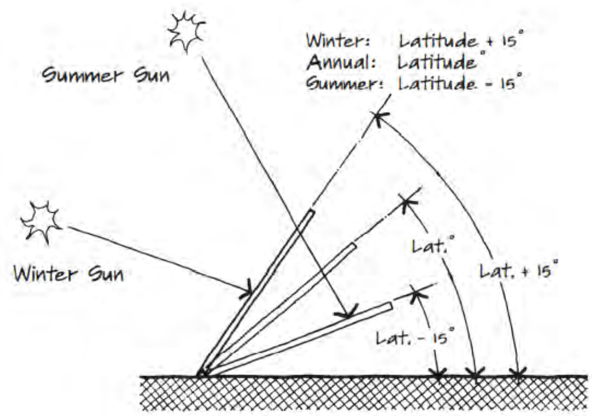


Figure 9.0 Recommended PV tilts (SWL).

The site is at 16.1 Latitude; therefore photovoltaic solar panels can be as low as 2 degree (minimum angle for surface draining) up to 16.1 degree facing south. The size of PV panels depends on the electric load that the house may have.

Table 11.0 Electric load of very conserving appliances for Residential buildings (SWL).

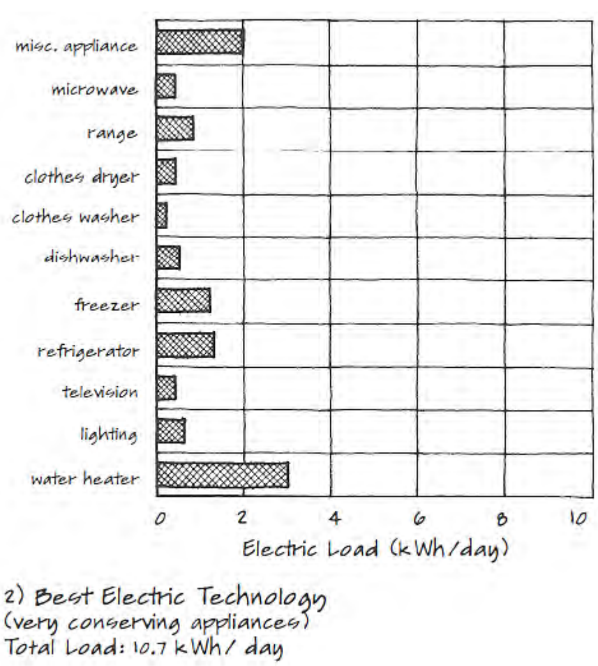
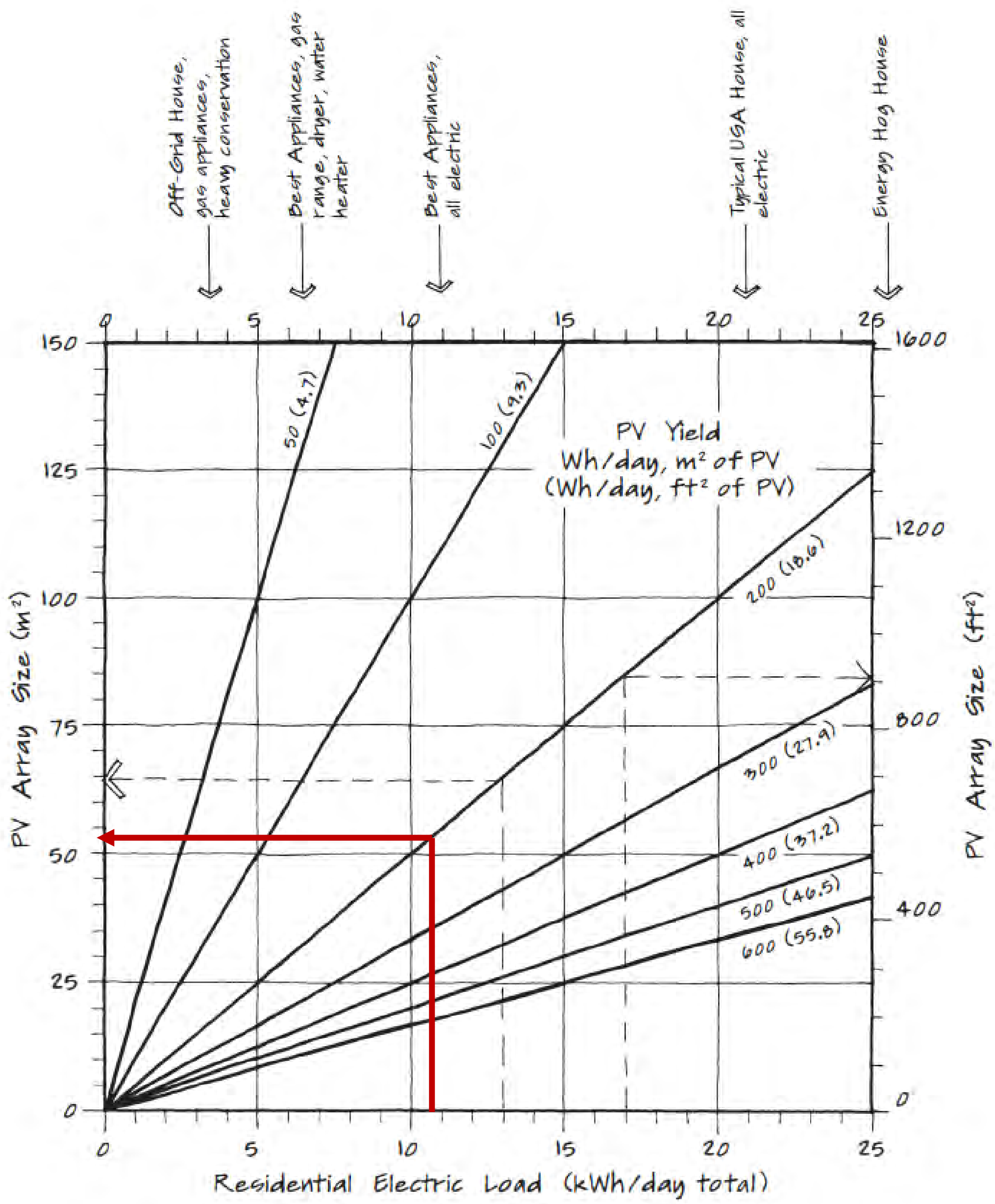


Table 12.0 Sizing Photovoltaic panels, 12% efficiency cells (SWL).



Considering the appliances' specification for NZB_1, the electric load will be at 10.7 kWh/day. From the graph *Sizing Residential PV,* the total size of the solar panels should be 53 m^2 to cover 100% of building's electric load. The size can be reduced since electric loads will be at maximum only during summer. It is also advisable to use applicable storage batteries for excess electricity during non-cooling periods.

REFERENCES

Hoque, S. & Iqbal, N. (2015) Buildings. *Building to Net Zero in the Developing World,* 57. 10.3390

DeKay, M., & Brown G.Z., (2014) *Sun, Wind and Light* (3rd ed.). New Jersey: John Wiley & Sons Inc.