Identification of Energy Appliances for Social Dwelling in Colombia under Net Zero Energy Building Concept

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Abstract— **In this paper, the characteristics and definitions of NZEBs are studied. In particular, the methods for calculating balance for each concept and methodology are analyzed in this work, by taking into account the interaction of the NZEB with the energy grid, the emissions produced per energy consumption and the introduction of the primary energy concept as an indicator of balance. High-energy-efficient appliances are of main interest in this paper due to the importance and level of use in tropical regions. We describe how these appliances will reduce the energy consumption and its impact in the electrical performance.**

Index Terms—**NZEB, NZEB Balance, emission, site, source, on-grid, off-grid, energy efficient appliances, passive applications.**

I. Introduction

IN COLOMBIA, since the Census of 2005 has been recorded a housing deficit close to 3.8 million of households [1].

This represent a social problem that has become a challenge for the national, departmental and local governments; This is the reason why it has been defined two types of housing which aims at solving the deficit housing problem of the most vulnerable population: *vivienda de interes social* (VIS) and *vivienda de interes prioritario* (VIP). [1].

The VIS is a dwelling unit whose value does not exceed 135 SMMLV (current legal monthly minimum wage by his Spanish acronyms), while the VIP must not exceed a value of 70 SMMLV [1]. These buildings are destined to citizens who earn less than 4 SMMLV (about USD 1200) [2].

Given that solving the housing deficit requires a massive construction program, it is considered that the environmental impact of this initiative will be significantly detrimental. The particular reason for this claim is that buildings constructed in a traditionally way are responsible to approximately 40% of the world's energy consumed [3].

Therefore, there is need to find useful and financially viable strategies, to allow the redirecting building design guidelines and make possible to adapt new technologies, in order to make them more environmentally friendly.

One possible alternative is the development of building projects based on the approach Net Zero Energy (NZE).

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Unfortunately, in Colombia there is a lack of this criteria as a successful alternative [4] to design energy efficient homes; which is one of the aspect that makes more difficult the undertaking of projects with a minimum energy consumption of the grid.

For this reason, this document is intended to provide information to fill the identified gap. For this, initially we address the concepts and approaches of NZEB; then we discuss the influence of climatic zones in Colombia on the energy performance of homes. Based on this, considerations are established of a set of energy applications characteristics of NZE housing with potential implementation in tropical environments. Finally, we present a set of conclusions of the this work.

II. Generalities of Net Zero Energy Buildings

Nowadays, some building projects are undertaken to promote the rational use of energy, and these are called "green building" [5], [6], “smart building” [7], “low energy building” [8], [9] or ”sustainable building” [10], etc.

A particular case of this type of buildings are the Net Zero Energy Buildings - NZEB, referring to a building with net zero energy consumption from energy grids.

To accomplish this, first we must reduce energy demand through the use of electrical energy efficient appliances. Then, to establish an on-site system generation to compensate the resulting energy consumption [11–17]. This type of buildings has different approaches, as shown in Table I.

TABLE I
NZEB Concept Approaches

Term	Definition	Reference
NZEB	A building with greatly reduced energy needs that offsets all its energy use from renewable resources.	[18–20]
LC-ZEB	Facilities where the primary energy used and the embodied energy within their constituent materials is equal to or less than the renewable energy produced inside the building during the life of the building.	[21–23]
NZEB-Grid	Facility connected to the grid that find a balance between energy sold and purchased power.	[24]
PEB	Facility that generates more renewable energy than it consumes from the grid.	[16], [25], [26]

From the revised literature [23], [27–30] we present, in Fig. 1, definitions associated to a NZEB networked. In the definitions of a system it is important to take into account aspects such as the generation on-site or off-site, and if it covers a single building or group of buildings.

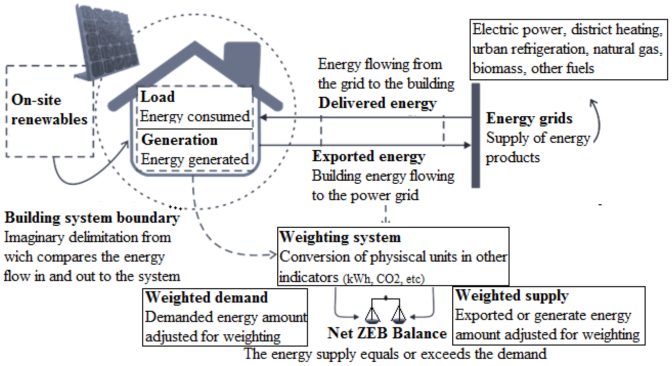


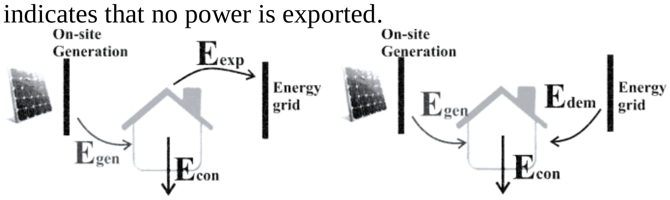
Fig. 1. Schematic of a site generation system connected to the network.

A. *Methodologies for calculating the balance*

The balance is the comparative study of the factors that play a role in the energy process of a system. The main objective of any NZEB is to produce a balance, and this is made looking for the correct way to improve energy processes. The period chosen for the balance calculations of a building is called energy balance period. [31].

It is important to understand that the energy that enters or leaves the system must be characterized, considering that not always the energy consumed (E_{con}) coincides with demanded energy from the network (E_{dem}), and similarly, the energy generated (E_{gen}) not always coincide with the energy exported (E_{ex}). This is when you can use the energy produced by the on-site generation for self-consumption, producing less demanded energy than consumed and less exported energy than generated.

The Fig. 2(a) illustrates the case where the power consumed is lower than the generated energy, so there's no grid power demand ($E_{dem} = 0$). The Fig. 2(b) shows the case when the consumed energy is greater than the generated energy on site, so the missing energy is demanded to the network. This indicates that no power is exported.



(a) E_{gen} is higher than E_{con} (b) E_{con} is higher than E_{gen}

Fig. 2. Schematic of energy flow.

The energy balance of a dwelling is produced by offsetting the energy from on-site generation. Based on the type of balance and indicator, the Table II describes the most common concepts, as presented in [12], [15], [23], [32].

TABLE II
BALANCE TYPE AS DEFINED BY NZEB

Definition	Type of Balance	Indicator
Site ZEB	Balance between energy generated on-site with the energy consumed in the facility	Electric power
Source ZEB	Balance between the primary energy consumed in the facility with power generated on-site.	Primary Energy
Cost ZEB	Balance between the cost generated by energy consumption and the economic profits generated by energy exports.	Cost of energy
Emission ZEB	Balance between the amount of emissions produced by the power consumption and the amount of emissions that is not produced by the energy from on-site generation.	Carbon Emissions

We now explain in detail each indicator.

1) *Electric Power*

The analysis is based on making the amount of electric power demand of the building network (E_{dem}) equals the exported (E_{ex}) [33], from the balance shown in Equation (1), provides the condition shown in Equation (2)

$$E_{con} = E_{gen} + E_{dem} - E_{ex} \tag{1}$$

$$E_{con} = E_{gen} \tag{2}$$

An assessment of this type is easily verified through on-site measurements. The downside of this method is that a unit of electricity energy has the same value no matter what type of generation process that has suffered the energy.

2) *Primary Energy*

This indicator seeks to equal the amount of energy that the building primary demand network ($E_{prim,dem}$) with the primary energy exports ($E_{prim,ex}$), seeking a net consumption of primary energy $E_{prim,neta}$ equal to zero.

With primary energy, it becomes possible to consider the different types of energy (eg, thermal and electrical) in the calculations, since this approach integrates the losses of the energy chain [34], [35]. The net primary energy is calculated from Equation (3) [35].

$$E_{prim,neta} = E_{prim,dem} - E_{prim,ex} \tag{3}$$

Where,

$$E_{prim,dem} = \sum \left(E_{dem,i} \cdot f_{dem,i} \right) \tag{4}$$

$$E_{prim,ex} = \sum \left(E_{ex,i} \cdot f_{ex,i} \right) \tag{5}$$

Where $E_{dem,i}$ is the energy delivered by the power grid i, $E_{ex,i}$ is energy exported to the power grid i, $f_{dem,i}$ is the primary energy factor for electricity supplied by the grid i and $f_{ex,i}$ is the primary energy factor for energy exported to the power grid i.

The electrical energy generated and consumed could not be calculated as shown in Equation (1) and Equation (2) because the primary energy associated not only electricity, but also other energy sources such as natural gas or wood.

The conversion factors are linked to the type of energy and power that is supplied. In Table III can be observed type values taken from [35], [36].

TABLE III
PRIMARY ENERGY FACTORS [35], [36].

Energy Carrier		Primary factors	K - CO_2 [kg/MWh]
Fuel	Fuel Oil, Liquefied Petroleum Gas .	1,1	330
	Natural Gas	1,1	277
	Anthracite, Coal	1,1	394
	Lignite	1,2	433
	Wood	1,2	4
Electric Power	Electricity hydropower plant	1,5	7
	Electricity from nuclear power	2,8	16
	Electrical energy mix	3,31	1340
	Electricity from coal power plant	4,05	617
Renewable Energy	Electricity and solar thermal	1	0

3) *CO_2 Emissions*

With this indicator is intended that the system exports as much free energy emissions as to offset the amount of emissions produced by the amount of energy required. The mass of CO_2 is calculated from the energy demand (E_{dem}) and exported energy (E_{ex}) for each grid, as shown in Equation (6).

$$M_{CO_2} = \sum\left(E_{dem,i} \cdot K_{dem,i}\right) - \sum\left(E_{ex,i} \cdot K_{ex,i}\right) \quad (6)$$

Where $K_{dem,i}$ is the emission coefficient CO_2 to the energy delivered by the grid i, and $K_{ex,i}$ is the emission coefficient CO_2 or energy exported to the energy grid i. $K_{dem,i}$ and $K_{ex,i}$ will always be of equal value if there is only one energy supply system regardless of the on-site generation. The coefficients for calculation of emissions CO_2 are presented in Table III.

4) *Energy cost*

With this indicator is intended that the system, at the end of each period, the net cost C_n is equal to zero [33], and calculated as described in Equation (7).

$$C_n = \sum\left(E_{dem,i} \cdot C_{dem,i}\right) - \sum\left(E_{ex,i} \cdot C_{ex,i}\right) \quad (7)$$

Where $C_{dem,i}$ is the energy cost delivered by the grid i and $C_{ex,i}$ is the cost for energy exported to the electricity grid i.

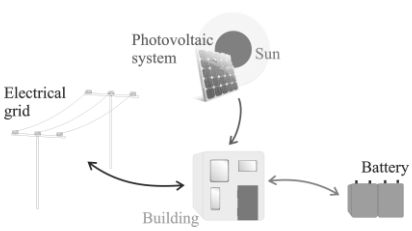
The costs of both, export and demand energy, are determined by the entity that governs the energy price in each country. If they are equal the balance would be the case of the power indicator.

B. *Base Configurations*

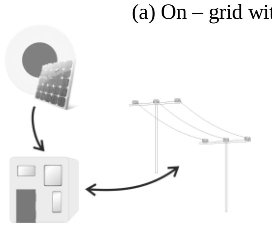
The NZEB are classified into on-grid and off-grid according to the interconnection or not the grid [29]. For the case of off-grid NZEB energy consumption must be supplied by the generation site, which describes its permanent condition balance.

According to [12], [16], [34], [37–40], it could be possible to consider the connection to the supply grid as an energy storage system because of the bidirectional flow of energy, so it would not be require the addition of batteries.

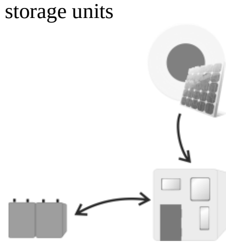
Figure 3 shows three basic configurations of building's operation constructed under the NZE concept.



(a) On – grid with energy storage units



(b) On – grid without batteries



(c) Off – grid

Fig. 3. Configurations of a Net Zero Energy dwelling.

The advantages and disadvantages of each form of connection are shown in Table IV.

TABLE IV
CONNECTION PLUSES AND MINUSES

Configu-ration	Advantages	Disadvantages
(a)	Guarantees reliability	It requires a higher initial investment
(b)	Cheaper	There is no backup system in the case where the supply network fails
(c)	Works in interconnected and non-interconnected areas (Autonomous)	Requires a high storage capacity and high initial investment

III. TECHNICAL ASPECTS THAT HAVE INFLUENCE IN THE ENERGY PERFORMANCE OF A DWELLING SOCIAL, CONSIDERING THE THERMAL LEVELS IN COLOMBIA

The residential electricity demand in Colombia depends of sociocultural, socioeconomic, political, climatic (thermal levels variety) [41] and geographic [42] factors, among others. Those factors characterize the electricity demand in a home, so that influence in the design of energy efficient systems in place.

A. *Energy performance of residential sector in Colombia*

The analysis of the energy performance of a house located in Colombia allows the identification of factors to consider for a residential energy design, such as socioeconomic strata.

1) *Social dwelling location according to the socioeconomic strata*

Currently, in Colombia the residential property is classified in six socioeconomic strata: low-low (1), low (2), medium-low (3), medium (4), medium-high (5) and high (6) [43].

The VIS and VIP are buildings design to guarantee the right to the dwelling for low income families, which are localized primarily in the strata 1, 2 and 3 and have a subsidy in the collection of public services [44]. It is worthy to mention that these strata have the major percentage of country´s inhabitants (87%) as can be determined in the Fig. 4.

However, must be taken into account that the VIS are intended for people who have a monthly income less than 4 SMMLV and aren't allocated according to socioeconomic strata [2], although the correlation is remarkable.

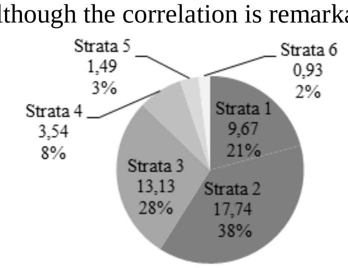


Fig. 4. Number of inhabitants (millions) by strata. 2012 projection [45].

Therefore, in Table V shows the average monthly income per home in dollars and pesos according to each specific strata and many SMMLV equivalent monthly income per home. This projection was made with the income values found in [46] for the 2008 and with the consumer price index found in [47] for the 2012.

TABLE V
AVERAGE MONTHLY INCOME PER HOME -2012 [46–49] .

Social strata	Dollars [USD$]	Pesos [COP$]	Equivalent salaries
1	639,76	1 150 455	2,03
2	909,76	1 635 994	2,89
3	1 415,43	2 545 329	4,49
4	3 062,57	5 507 307	9,72
5	3 241,08	5 828 313	10,28
6	5 681,73	10 217 228	18,03

In that way, we can observe that the candidate homes to the VIS are located primarily in the 1 and 2 strata.

2) Behavior of the electricity demand according to the possible strata where the VIS are located

Once identified the strata where could be locate possibly the VIS, we describe the behavior of the energy demand following the residential sector per strata in the country.

The Fig. 5 shows the annual electricity consumption per strata and the percentage of the total consumption (23 748.04 GWh/year). This shows that the total demand of about 85% is consumed in the strata low-low, low and medium-low.

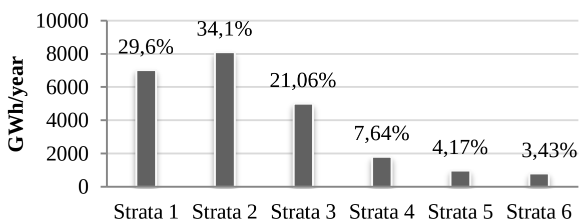


Fig. 5. Yearly consumption electricity of all residential users per strata. 2012 [50], [51].

On the other hand, the Fig. 6 shows the average monthly consumption per user to the each stratum, and the major a minor consumption are in two and six strata, respectively.

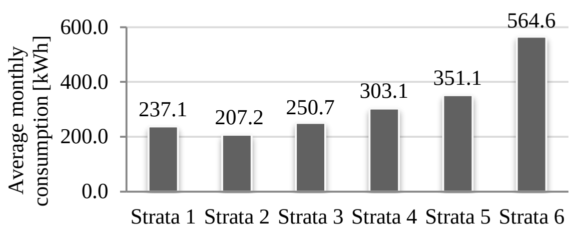


Fig. 6. Average monthly electricity consumption per user, 2012.

3) Thermal levels influence in the potential energetic appliances that are customizable in Colombia

Colombia are located in the tropical area, therefore it have a significant solar radiation throughout the year; moreover, has a high relief characteristic of the Andes range, for this reason the altitude is a meaningful climatic factor and gives rise to thermal levels [52].

The Fig. 7 shows the thermal levels associated to the temperature range and the elevation above sea level; also relates some Colombian cities according to the altitude and temperature values.

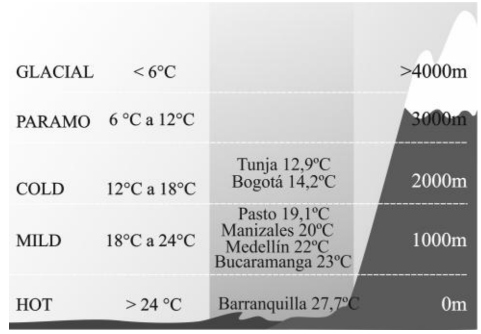


Fig. 7. Thermal levels in Colombia [52].

4) Thermal levels classification per cities to the identification of the potential energetic appliances in the VIS

In Colombia, the climatic diversity found in the same state makes it difficult to classify the climates [52], being easier do it by municipality.

Thus, to represent the several scenarios of climatological and energy behavior, we selected five cities according to three aspects:

--Main cities of the country where are localized the operation areas that are managed by the meteorological inspection, measurement and vigilance system of the IDEAM.

--From the cities found in [52], five have the highest number of families with electricity availability according to the DANE [47]: Bogotá, Medellin, Cali, Barranquilla and Bucaramanga.

--Last, it is relevant the representation of the thermal levels to the chosen cities.

The Fig. 8 shows the average temperature for each one of the selected cities, where the cities can be classified in a specific thermal level considering the information given in the Fig. 7. Barranquilla and Cali represent the hot climate, Medellin and Bucaramanga the mild climate and Bogotá the cold climate.

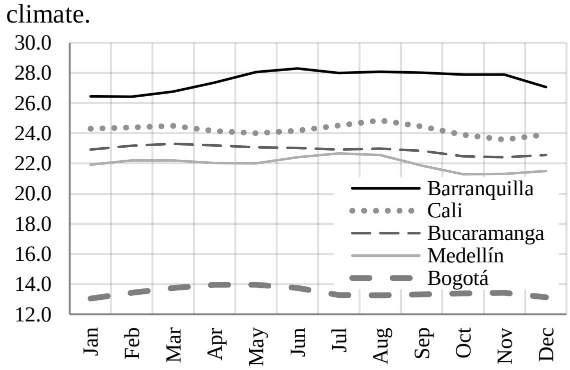


Fig. 8. Average temperatures from five Colombian cities [52].

Once the chosen cities are classified in a different thermal level, it is possible to identify the energy appliances that have a relevant usability in the house.

The Fig. 9 shows the percentage of the housing for Bogota, the Atlántico region (Guajira, Cesar, Magdalena, Atlántico, Bolívar, Sucre y Córdoba) and the Antioquia department that in 2012 bought some kind of electrical appliance or household gas; this places represent the cold climate, mild climate and hot climate, respectively.

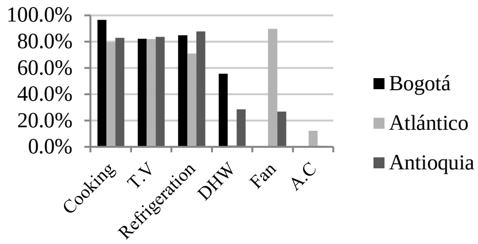


Fig. 9. Colombian housing that have energy appliances. 2012 [53].

It is relevant the need to adequate the house environment, in hot and mild climates like the Atlántico region and the Antioquia department, making use of the fans and air conditioning; also, it is important the domestic hot water use in cold and mild climates like Bogota and the Antioquia department, respectively..

In the identification of the potential implementation energy appliances for the different thermal levels in NZE homes, the methodology used is given in [40], [54–59] Such a methodology starts with the reduction of the energy demand through the passive building design, next the energy efficiency of the appliances rise and makes rational use of the energy, last the micro generation systems are identified from renewable energies adaptable to the house.

A. Recommendations for the low energy consume from the use of the passive appliances and energy efficient systems

The recommendations are given taking into the account the passive and active energy appliances that could be adaptable in a social dwelling, highlighting those that have a frequently use according to the thermal level presents in place, as it is shown in Fig. 9.

1) Construction materials

The construction materials have to renewables and their production emit to the atmosphere low amounts of CO_2. Table VI describes the materials that are considered more adequate for the social dwelling construction in terms of thermal inertia and his adaptability in the different climates [60].

TABLE VI
CONSTRUCTION MATERIALS MOST USUALLY IN SOCIAL DWELLING [60].

Weather	Cold	Mild	Hot
Walls			
Regional	Rammed earth and adobe	Guadua mat with clay and adobe	Guadua mat with clay and adobe
Modern	Units of masonry and plastering	Units of masonry and plastering	Units of masonry and plastering
Roofs			
Regional	Structure in wood and clay tile	Wood and tile zinc	Wood
Modern	Fiber cement roof tile and clay tile	Fiber cement roof tile and clay tile	Fiber cement roof tile, clay tile and tile zinc
Floors			
Regional	Wood	Wood	Tile
Modern	Carpet, wood and vinyl	Carpet, wood, vinyl and ceramic floors	Cement tile and ceramic tablet
Windows			
Regional	Wooden vertical tilt	Wooden swing middle vertical opening	Wood with large aperture vertical tilt
Modern	Aluminum, glass and angle	Aluminum, glass and angle	Openwork, wood, foil and burlap

The regional materials have a manufacturing process that has been transmitted from generation to the next and the modern materials are industrialized. When the materials have a high thermal inertia, maintain a stable temperature, the time that they take to let the heat pass to the building inside is long and they are recommended for cold and mild climates acquiring the heat in the morning and is conducted into the dwelling in the night; if material has a low thermal inertia the time is short and is recommended in hot climate because is required avoid the heat gain [60]. Also, the house have a thermal insulation in walls, floors, windows and roofs (green roofs) and can use eaves, blinds, cantilevers and shadows to avoid the solar gain in hot climates.

2) Strategic orientation and location

For mild and hot climates, it is recommended that the facade orientation is in NORTH-SOUTH direction and located such a way that is protected from the sun and exposed to the cold winds. In the cold climate the façade must be in NORTHEAST-SOUTHEAST or EAST-WEST direction and located such a way that is exposed to the sun and protected from the cold winds [60].

3) Natural ventilation and lighting

As passive technique are typically installed significant window areas to facilitate the airflow through the housing and is designed so that there is natural cross ventilation.

For natural lighting the passive techniques that can be used are the solar tubes [39], skylights [61], low-growing trees that allow the incidence of light in the house, and large areas of windows.

4) Energy efficient systems on a VIS

The housing design must reduce energy consumption by replacing the conventional systems using high-efficiency systems. The Table VII compares the two systems that may be used in a dwelling.

TABLE VII
COMPARISON BETWEEN CONVENTIONAL AND EFFICIENT SYSTEMS FOUND IN A DWELLING.

System	Characteristics	
	Conventional	Efficient
Lighting	Incandescent bulbs convert 5% of the energy used into light.	The LED bulb generates energy savings up to 90% and compact fluorescent to 80%.
Refri-geration	Low efficiency of conventional refrigerators, freezers side	Efficient refrigerators can consume 20% less energy than required by some standards.
Space heating and DHW	Central heating system, low efficiency, fireplaces. Gas water heater, electric shower.	Radiant floor can generate energy savings of 52% while heat pumps 30% to 40% over conventional. Solar water heater.
Ventilation	Mechanical Ventilation and low efficiency air conditioners.	Heat extractors, reversible heat pump, room coolers.
Cooking	Horn gaseous fuel based 65% efficiency, liquid fuel 50% -55%	Furnaces that consume electricity present a yield of 65% - 70%.

B. Energy generation in situ

To implement an energy generation system must consider the energy supply, project scale and sector of the economy to which it is directed. The Table VIII highlights the power generation according to the generation and obtaining resources site.

TABLA VIII
DESCRIPTION OF THE ON-SITE AND OFF-SITE ENERGY SUPPLY SYSTEMS

Option	Energy Supply	Description	Example
1	On-site	Power generation in the building footprint from site resources.	Photovoltaic panels and solar collectors installed on the building roof or façade.
2	On-site	Power generation near to the building footprint: open and parking areas, the resources are on-site.	Small wind turbines
3	Off-site	Power generation in the building and resources proceeds from off-site generation.	Biomass, ethanol, biofuel, waste treated at the site.
4	Off-site	Off-site power generation and partly financed by the homeowner.	The owner invests in wind farms, solar and wind turbines remote.
5	Off-site	Off-site power generation and the owner is sold through a supply contract.	Power grid trade certified renewable energy.

In the Table IX, according to the installed capacity the generation systems are classified depending to the scale, residential or industrial application and the way to energy supply. It is important to observe that the photovoltaic a wind generation systems can be adapted to the residential level according to the installed capacity, however it depends on the wind speed and the solar radiation in generation place.

TABLA IX
RENEWABLE POWER GENERATION SYSTEMS CLASSIFICATION ACCORDING TO THE GENERATION CAPACITY

Renewable Energy		On-site	Off-site
Wind			
Small scale	<2.5kW	×	-
Medium scale	2.5kW-20MW	×	×
Large scale	>20MW	-	×
PV			
Residential system	<10kW	×	-
Industrial buildings	10kW-100kW	×	-
Small industrial plants	100kW-1MW	×	×
Large plants	>1MW	-	×

Generally, Colombia shows a monthly average global solar radiation uniformly throughout the year approximately from 4,0 kWh/m^2 to 4,5 kWh/m^2, being the largest spatial distribution. However, some areas are outstanding like the Table X shows.

TABLA X
AVERAGE MONTHLY GLOBAL SOLAR RADIATION UNIFORM FOR DIFFERENT COUNTRY ZONES [62].

Departments or Regions	Insolation [kWh/m^2]
Arauca, Casanare, Meta, Boyacá, Vichada and the Caribbean Coast including San Andrés y Providencia Islands	5,0 – 6,0
Orinoquía, Santander and North Santander, Cundinamarca, Tolima, Huila, Cauca and Valle del Cauca	4,5 – 5,5
Chocó, Nariño y Putumayo	3,0 – 4,0

Typically, solar energy has three technology trends, photovoltaic, thermal and passive [63], these being easily implemented in residential areas as seen in Fig. 10.

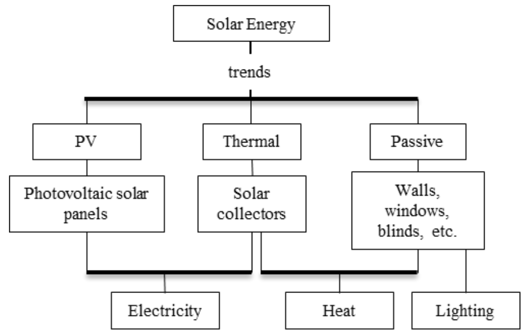


Fig. 10. Solar energy trends, technologies and uses.

1) Photovoltaic energy

This application is based in the photovoltaic panels placed strategically to capture solar radiation. The most used systems are shown in the Fig. 11.

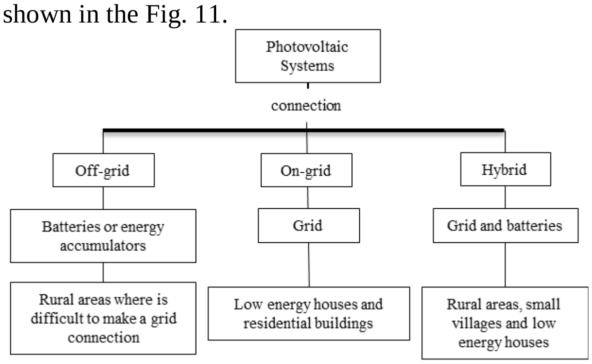


Fig. 11. Photovoltaic systems according to the connection type.

2) Solar thermal energy

Solar thermal energy is mainly used in homes as a source of heat for space conditioning through the use of radiant floors and the usability of domestic and swimming pools hot water [64], additionally has other uses according to the temperature required as seen in Fig. 12.

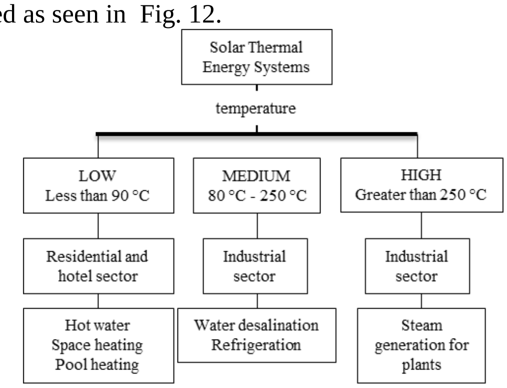


Fig. 12. Temperature ranges, applications and uses of the solar thermal energy.

3) Winds energy

Colombian winds mainly located in the peninsula of La Guajira, are among the best in South America for wind power generation, reaching speeds around 10 m/s.

In [65], we can see that the annual wind power density to 20 meters high has values 216 W/m^2 and 343 W/m^2 for areas in the department of La Guajira, Atlantic and between the Quindío and Tolima departments.

Also, some extent of the department of La Guajira can be achieved wind density values between 343 W/m^2 and 729 W/m^2, is important to highlight that to major altitudes and to different times of the year the energy densities can increase considerably; however, the wind resource is sectored in Colombia and not all regions enjoy wind speeds suitable for generation.

IV. Conclusions

The concept of NZE homes indicates cover the basic needs of energy consumption that occur in residential buildings, using highly efficient energy applications; homes around the world have been able to reduce its energy consumption in a way that the comfort of their was no degradation residents thanks to new technologies developed to cover the basic needs in these homes.

A building can achieve NZE energy balance being off-grid, but this type of housing requires a large autonomous investment due to the cost of energy storage systems, therefore internationally buildings on-grid type are preferred and autonomous housing design is performed for non-interconnected areas or difficult access to supply networks.

In on-grid NZE buildings the bi-directionality in the energy grids has a great weight requirement when we want to produce balance compensation, because energy injection into the grid is required.

In buildings NZE designed under the methodology cost-ZEB will be always necessary to ensure the payment by the energy exported to the network; this is because only in this way it could produce a balance. The NZE concept applied in social dwellings could generate a very positive impact in the society and the environment. This can be seen through the analysis made about the behavior of the country energy demand according to the socioeconomic strata; there was possible to infer that the applicant homes to acquire a social dwelling could be localized in the one and two strata primarily and the major residential energy demand is from the same strata, generating a reduction in the energy consumption in the residential sector and in the low strata.

The thermal levels influence the consumption of the energy appliances that are used in the home, having a substantial impact since they cause an increase or decrease energy demand. Thus, it can be known for each place what kind of appliances have a major energy demand when the thermal levels vary and how could be replaced by other more efficient, considering those with more frequent use and can meet a basic needs of a social dwelling.

In the residential sector the utilization of solar resource in the energy generation through the use of photovoltaic panels and solar collectors has great utility, taking into account that Colombia enjoys this resource in abundant quantities, encouraging the energy generation on-site and fulfilling one of the main features of a NZE home, the energy generation using renewable sources for energy demand compensation.

In the NZE home design is important to establish the NZEB concept you wish to operate and the type of balance to be achieved giving way to correct sizing of efficient energy systems and alternative energy source that best suits to the place, also is very important to design a home that is financially feasible and especially oriented to the social dwellings.

V. References

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