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DOMESTIC ELECTRICITY GENERATION AND ENVIRONMENTAL PROTECTION: A METHOD FOR INTEGRATING RENEWABLE ENERGY IN URBAN AREA

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ABSTRACT

This paper aims to present a method for applying renewable energies in urban areas.
Since the use of renewable energies contributes to the sustainable development of the states. This pushes us to find solutions to integrate them easily in urban areas. During our work, we tried to answer this problematic by elaborating a specification based on several parameters, which combine (efficiency, low nuisance, and aesthetics ...).
We tested the effectiveness of the use of wind turbine, type darrieus-(Pramac) and the adjustable sunshade in blade of glass bearing multi-junction cells based on III-V materials. After the application of the approach developed on the chosen case of study, the results show large decrease in the rejection of co2.

Keywords:
Integration - Urban areas - Energy - Domestic production-Environment

1. INTRODUCTION

This paper aims to present a method for applying renewable energies in urban areas.

Despite the fact that the renewable energies play important raw and contributes to the sustainable development of the states [1]. A very few researches have been conducted in this domain. We cite the work of Karim et al [2], Lee et al [3], and Al Busaidi et al [4] .This is why it is necessary to find solutions to integrate them easily in urban areas. During our work, we tried to answer the problematic of the integration of the wind and solar energy by elaborating a specification based on several parameters, which combines efficiency, low nuisance and aesthetic.

To integrate renewable energies in urban areas one must meet a set of criteria [5] that requires:

- Have a deposit Satisfactory in the built-up areas (Urban).
- Find solutions compatible with the built environment.
- To be accepted by the citizens and have a low nuisance.
- Have the design of an urban furniture.

2. FRAMEWORK

Our method has been perceived from different angles :

i. First, we tried to explain what is an energy system producing wind and solar electricity an urban area, on what it depends, and the preliminary questions to ask before the execution.

ii. Second, we try to show the relation between the deliverability and the protection of the environment.

iii. Third, we have explained the principle of sizing which is divided into three parts. The first part provides the steps to follow ,we start with the assessment of the energy requirement through a table to be completed, then the estimate of the available resource solar or wind potential, finally the choice of the device the wind generator or panel and fixed or removable technology.

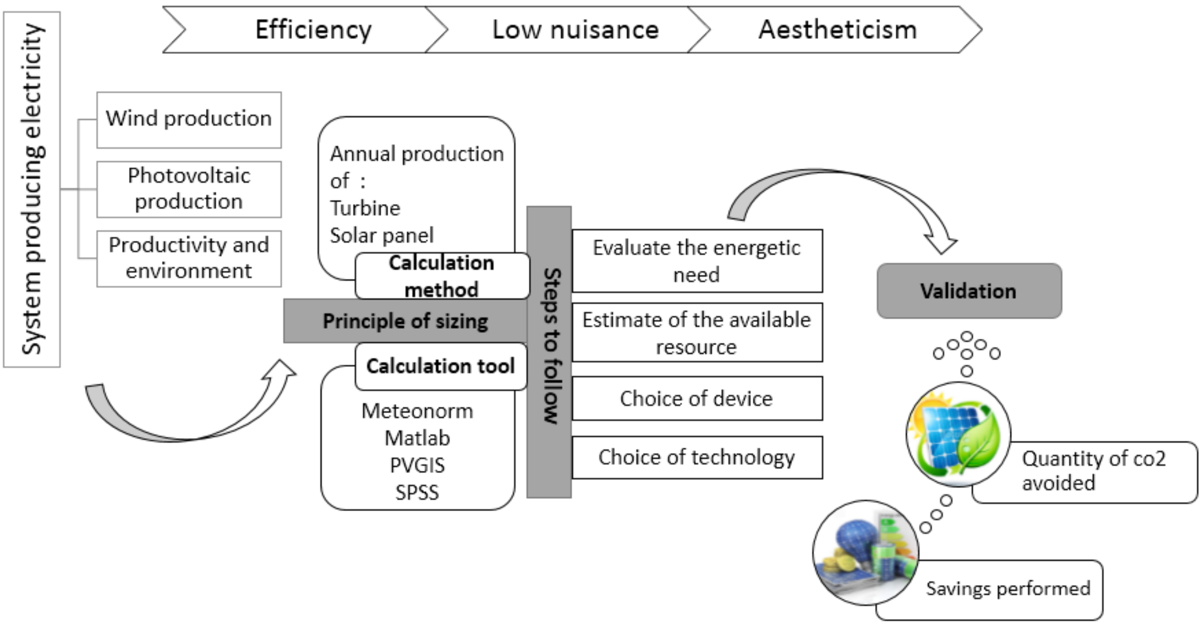


Fig. 1. Method developed and steps to follow

iv. The last step is the calculation method, once we assessed our need for electrical energy, estimated the available resource, selected technology, yield and available area, we are able to calculate the required production to fill our needs with the help of one of a sizing software using the approved equations.
The diagram above briefly explains the method developed.

2.1.Energy systems producing electricity

2.1.1. Energy systems producing wind electricity

The use of renewable energy as a source is an option that contributes significantly to the supply of our buildings. Indeed, urban wind electricity could be very beneficial if we opt for adequate strategies to enjoy the max. It is a solution that makes it possible to cleanly produce electricity [6]. Its performance is characterized by the wind speed. The yield is difficult to evaluate a priori because it depends on variable parameters whose the wind speed profile, the installation site, roughness element height, building and canopy [7].

Wind technology has been particularly well developed. The project to install a wind turbine to meet electrical needs thus offers an image of the dynamism and development and the integration of a citizen project [8]. The wind power sector has also provided many local jobs .

Prerequisite questions to ask:

- Am I in a windy area?
- Sufficient wind in ours site?
- Are there any encouraging signs?
- Energy and environmental benefits.
- My direct environment is it adapted?
- The sustainable aspect of social development in relation to activity (proximity location)

2.1.2. Energy system producing photovoltaic electricity

The solar deposit is the amount of energy available per square meter per day (kWh / m^2.day) with that we begin to dimension our system.

Installing photovoltaic solar panels on our buildings allows producing electricity for the urban residential buildings, respecting the environment and generating important gain

[9-10-11]. Photovoltaic power generation depends on three factors:

- Geographical location.
- The orientation and inclination of the solar panels
- Possible shading.

2.2. Productivity and environment

The operation of a one MW wind turbine allows avoiding a rejection of 2000 tons of CO_2 per year [12].
Every megawatt hour produced by a photovoltaic installation avoids the emission of 456 kg of CO_2 [13].

2.3.Principle of dimensioning

The steps to be followed to design a system producing electricity, either wind or photovoltaic, must be firstly sized. For this purpose, we will follow the steps below:

2.3.1. Evaluate the energy requirement

It comes to estimating the electrical energy needs according to the equipment used for domestic needs (individual residences, collective residences) or industrial (plants). To estimate the energy needs to be filled by the wind or photovoltaic system, either fill this table or take the values of the invoices.

Appliance	**Furnace**	**Lamp**	**TV …**
CC/AC			
Number N			
Nominal power P			
Frequency of use F			
Consumption N*P*F			

TABLE 1.CALCUL OF ENERGY DOMESTIC NEEDS

2.3.2. Estimated resource availability

Evaluate the deposit wind/solar is an indispensable step.

For wind energy, the strength, frequency and regularity of the winds are essential factors.
Estimating wind energy in a given location requires knowledge of the distribution of wind speed. This is determined either by a speed and direction measurement campaign of the wind or by using a statistical distribution law.
Studies shown that the Weibull distribution is the most representative of the behaviour of wind speed. Furthermore, it provides ease of handling.
Indeed, empirical and semi-empirical models have been developed to determine the behaviour of this distribution depending on the height and location (e.g. the height of the propeller of a wind turbine at a nearby site).

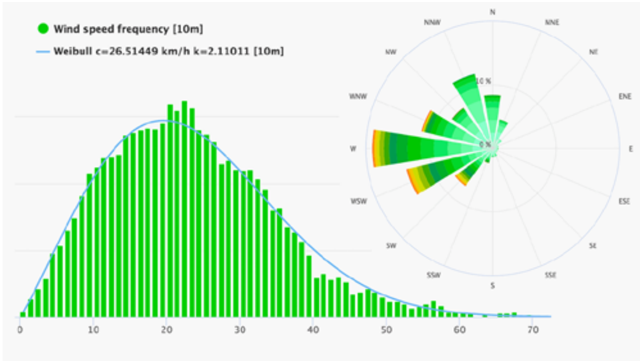


Fig. 2. Tool for estimating wind potential.

However, it is possible to use existing data and extrapolation methods. By coupling these data with the power curve of the selected wind turbine, the producible is estimated; that is, the potential production of the wind turbine over one year.
For the deposit solar, the design of a photovoltaic system requires knowledge of the available solar resources depending on the site where the installation will be located.
These data are normally provided monthly by software and represent a statistical source to assess the availability of the solar resource throughout the year.

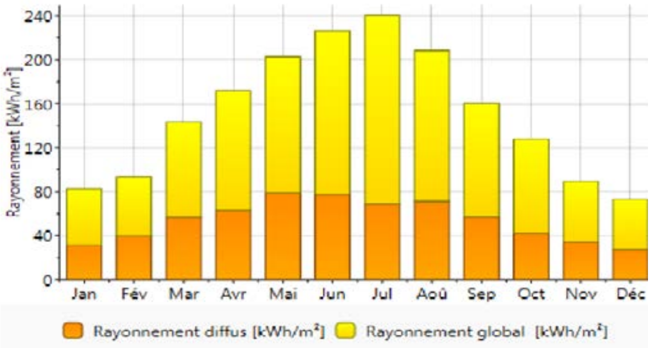


Fig. 3. Global horizontal radiation average (KWh / m²) per month .S Meteonorm 7.

2.3.3. Choice of device (panel or wind turbine)

We often criticize solar panels and wind turbines for denaturing buildings, in particular, not to be compatible with architecture and the environment built especially in urban areas.

Recently, solutions that combine the use of wind and solar energy with aesthetics have been developed [14]. Some examples are cited in the table below:

Table 2. SOME EXAMPLES ON WIND / SOLAR DEVICES.

Wind	**Solar**
	
Pramac wind turbine	Solar sphere Rawlemon
	
Aerovironment	Solar tile

2.3.4. Choice of technology

An interesting option is to install the panels on structures capable of following the sun in its celestial course.

A "follower of the sun" as the sun evolves in orientation and inclination, in the course of the day and the seasons. They are mobile supports that function like sunflowers.

This option effectively keeps the sun at right angles to the surface of the panels; this is in order to optimize performance at all hours of the day. The electricity production can be increased compared to fixed panels of about 30%.

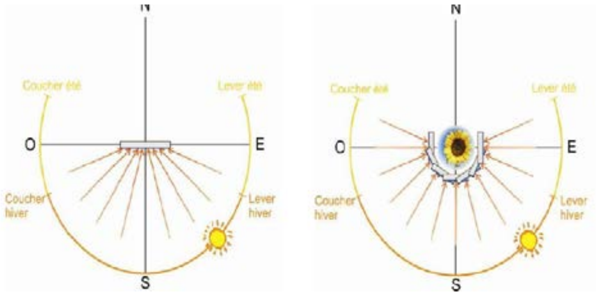
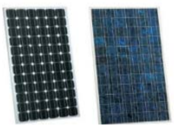


Fig. 4. A schematic, which shows the two technologies. Fixed and removable

For photovoltaic cells according to their technological developments, there are three types:

Table 3. DIFFERENT TYPES OF PHOTOVOLTAIC CELLS.

Crystalline cells	**Thin-layer cells**	**Third generation cells**
Yield 12-18 %	Yield 7-10 %	Yield 30 % multi-junction
		

2.4.Méthode de calcul

2.4.1. Equations

Once we know our need for electric power, a good evaluation of the available resource, and have chosen technology, efficiency and available space, we are able to calculate the required production to fill our needs with the help of one of the software of the dimensioning of electrical energy[15-17],using the following equations :

The energy supplied by the wind is a kinetic energy; it is a function of the mass and the velocity of the volume of air. It is equal to:

$$Ec = ½ (mv^2) \quad (1)$$

The instantaneous energy density or available power in an airflow passing through a unit surface section perpendicular to its direction is given by the formula:

$$Pd = ½ (\rho v3) \quad (2)$$

Considering that the density of the air is constant, the average available wind energy density is given by:

$$\overline{Pd} = ½ \overline{(\rho v3)} \quad (3)$$

The calculation of the average wind power available requires knowledge of the law of distribution of the wind speed.

$$\overline{V^3} = \int_0^\infty v^3 f(v)dv \quad (4)$$

Where f (V) is the distribution law of the wind speed. It represents the probability for that the wind blows at the speed V. The Weibull distribution function is given by the following formula:

$$P(v) = \frac{k}{v}\left(\frac{v}{c}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (5)$$

Or:

P(V) is the probability for that the wind blows at the speed V.

K is called the form factor, dimensionless, it characterizes the dissymmetry of the frequency distribution.

C is the scaling factor, (m / s).

The extrapolation of the wind speed as well as the parameters of the Weibull distribution can be done using the following power model:

$$\frac{\overline{V_2}}{\overline{V_1}} = \left(\frac{Z_2}{Z_1}\right)^{\alpha p} \quad (6)$$

αp Depending on the speed of the measurement height.

$$\alpha\, p = a + b \ln V_1 \quad (7)$$

$$a = \frac{0.037}{1 - 0.088 \ln\left(\frac{Z_1}{10}\right)} \quad (8)$$

$$b = \frac{-0.088}{1 - 0.088 \ln\left(\frac{Z_1}{10}\right)} \quad (9)$$

a and b were obtained by Justus and Mikhail (Justus and Mikhail, 1976) from a smoothing by the least square method of speeds observed at several heights at the level of 4 meteorological towers.

The variation of the scale parameter as a function of the height is also given by (Justus and Mikhail):

$$\frac{C_2}{C_1} = \left(\frac{Z_2}{Z_1}\right)^{\alpha pl} \quad (10)$$

$$\alpha\, pl = a + b \ln C_1 \quad (11)$$

The variation of the shape parameter as a function of the height is given by (Justus and Mikhail):

$$\frac{K_2}{K_1} = \frac{1 - 0.088 \ln\left(\frac{Z_1}{10}\right)}{1 - 0.088 \ln\left(\frac{Z_2}{10}\right)} \quad (12)$$

C1 and k1 represent respectively the scale and shape parameters at the height Z1.

C2 and k2 represent respectively the scale and shape parameters at the height Z2.

Estimation of the annual production of wind turbine depends to the two functions; power P (u) of the selected wind turbine and Weibull distribution f (u) of the measured site.

$$E_{Brute}\,(kwh) = 8760 \times \int_0^\infty p(u) \times f(u)\, du \quad (13)$$

Photovoltaic solar production (E) depends on three components [18-19]:

$$E = Hi \times pc \times \eta_{system} \quad (14)$$

Hi Annual sunshine of the sensor, which depends on the geographical location , the orientation and inclination of the sensor.
Pc (kWc) Peak power of the photovoltaic field which characterizes the power of a system in optimal standard irradiation conditions of 1000 W / m², a temperature of 25 °.
η_{system} Yield of the system, also called performance ratio to know what we're really going to produce over one year .
It is necessary to take into account the losses on which this coefficient depends.

2.4.2. Dimensioning tool

For the design of the wind system, we will use the METEONORM software [20] for wind speed data, the Matlab language for the statistical analysis of the wind as well as for the vertical extrapolation of the wind data.
Using the PVGIS [21] application, we will calculate the photovoltaic electricity production, based on the available solar field and the efficiency of the chosen technology.

2.5.Validation

After the calculation of our needs one has to check whether the choice is well made or not.
Depending on the area available and the needs, the system efficiency is used to obtain sufficient production.
Once the size of the facility is estimated, we can calculate the cost according to the market price and evaluate the amount of co2 avoided.

3. RESULTS AND DISCUSSIONS

3.1.The production of wind power

The choice of a wind turbine depends on the type of application (autonomous or connected to the network), of the place of Implantation (urban or clear site) and finally of the electrical needs.

In our case, the choice was made for Darrieus type wind turbines which have the advantage of good urban integration.

TABLE 4. A TECHNICAL SHEET OF THE AEROGENERATOR CHOOSE PRAMAC 1KW

Power speed 10 m / s	410 w
Power speed 14 m / s	1000w
Mini start speed	3m/s
Max speed stop	18m/s
Diameter * height	1.45m*1.45m
Area	2.10m²
Alternator return weight included	65
Braking system	Passive
Max rotation speed	415 trm
Alternator	
Number of phases	3
Number of poles	32
Nominal power	1KW@vitesse 14 m/s
Nominal voltage	240 Vac @ 14m/s

With a rated power of 1KW at 14m/s speed and a starting speed of 3m /s.

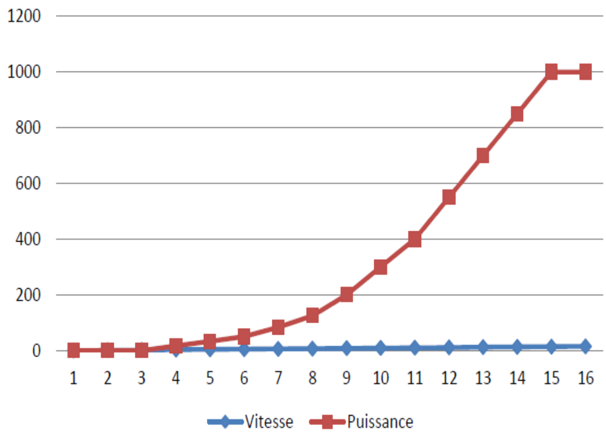


Fig. 6. Pramac 1KW wind power curve

The electrical needs filled by the wind system are just the power supply of the common parts (lighting and elevator).In our case, the METEONORM 7 database was used in the absence of the availability of wind speed measurement. This data was used to study the sample of the available hourly speed at 10 m from the ground.
The next step was to estimate the wind potential available from the statistical study of wind speed (mean speed, distribution frequency and Weibull distribution law).
The wind velocities were then extrapolated to the height of the wind turbine helix including the height of the building, using the power

model given by the equation presented in the calculation method of the wind power system.

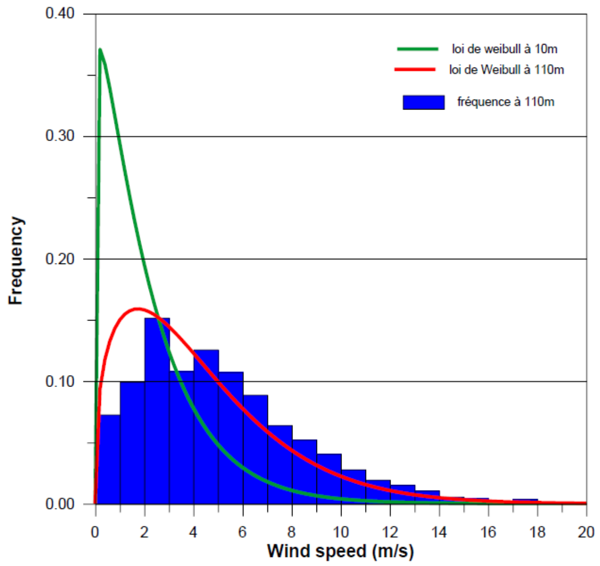
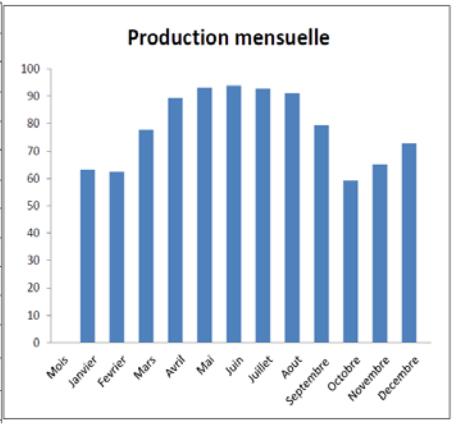


Fig. 7. Frequency and law of Weibull distribution.

Finally, the last step allows calculating the power produced by coupling the obtained wind speeds to the power curve of the chosen wind turbine.

TABLE 5. MONTHLY PRODUCTION OF WIND ELECTRICITY

Mois	Production
Janvier	63.17
Février	62.36
Mars	77.72
Avril	89.42
Mai	93.08
Juin	93.78
Juillet	92.74
Aout	91.08
Septembre	79.34
Octobre	59.23
Novembre	65.05
Décembre	72.69
Totale	939.66



By comparing to electrical energy needs, we calculate the number of wind turbines necessary according to the possibility.

In our case, we used four wind turbines on the corners of the building, to supply the lighting and part of the elevator. The rest of the need will be filled by solar photovoltaic energy thanks to the modules installed in each apartment

3.2. Production of Photovoltaic Electricity

One opts for removable technology for two reasons, to prevent the intense rays of the sun from penetrating our interior in summer especially if we have large openings, thus reducing the load of the air conditioner and allowing these rays to penetrate our interior in winter.

Cells of 3 generations, which allows a smaller surface and a higher efficiency than the fixed technology and the other two cell types.

Energy requirements filled by the PV system in our study was limited to household appliances (refrigerator, washing machine, television, computer, lighting ...).

Fig. 8. PV Breeze adjustable

We took in our case: A family of four people will require about a daily consumption 4 kWh. The power of solar panels that can be installed according to the area available and the efficiency of selected cells is (9 * 0.33) = 3 kWc.

Table 6. RESULTS OF ESTIMATION WITH A SYSTEM FOLLOWING SOLAR ON TWO AXES.

Month	Ed	Em
Januar y	11.30	349
Februa ry	13.50	378
March	17.40	539
April	18.60	559
May	20.40	633
June	23.80	714
Juliet	24.10	748
August	22.40	695
Septem ber	18.50	555
Octobe	16.50	513

r		
November	11.90	356
December	10.90	339

Total electricity production (Em): 6380 kWh.
Total irradiation received by the defined modules (Hm): 2760 kWh / m2.
Ed Average daily electricity production by the defined system (kWh).
Em Average monthly electricity production by the defined system (kWh).
Hm Average sum of the total irradiation per square meter received by the modules of the defined system (kWh / m2).

4. CONCLUSIONS

The integration of renewable energies in urban areas is an alternative that will solve many problems such as depletion of resources, environmental degradation, and energy efficiency.
Wind energy is not an option; it cannot provide all the production alone. However, when wind energy is coupled with the solar energy, it offers us the opportunity to produce electricity through wind turbines when there is wind, solar panels when the sun is shining; this is an effective solution.
The results found in the research are estimating. There must be a margin of error which is linked to the imperfections of the database to which we can also add those due to software, also the losses that may appear on our installation (shadows, under or on dimensioning etc…).
This alternative to a significant weight in sustainable development projects.
After the application of the approach developed on the chosen case of study, the results show large decrease in the rejection of co2, approximately180 tons per year.
In this work, we tested the effectiveness of the use of wind turbine, type darrieus (Pramac) and the adjustable sunshade in blade of glass bearing multi-junction cells based on III-V materials.

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