ENVIRONMENTAL REHABILITATION OF PUBLIC BUILDINGS ACCORDING TO THE OBJECTIVES OF THE EUROPEAN DIRECTIVE 20-20-20 . CASE STUDY ON IPARRALDE CIVIC CENTER IN VITORIA-GASTEIZ (SPAIN).

Keywords: Rehabilitation, European Directive 20-20-20, efficient resources; PV roofs ; green roofs

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0: ABSTRACT:

The current report focuses on the analysis of a theoretical case of ecological refurbishment applied to the Iparralde Civic Center in Vitoria Gastéiz. This analysis, which was focused on the accomplishment of the goals of the 20-20-20 Directive, has as its main objective the demonstration of the efficacy of mixed solutions of refurbishment. Whereas, an analysis of a supposed refurbishment on Iparralde Center was performed, using both green roofs and photovoltaic roofs. Within this analysis, the benefits that these refurbishment operations can have towards the environmental objectives of 20-20-20 Directive, were considered. Once this study was done, the conclusion established was that the best solutions facing environmental rehabilitation are the ones including various sorts of retrofitting techniques simultaneously on the same building, which are not on the current local normative , focused on only one solution per building.

1.- STATE OF THE ART STUDY

The issue of energetic efficiency related to construction and retrofitting is today a topic of importance around the whole world. The legal context is aimed at encouraging governments around the world to improve the energetic efficiency of the buildings.

The European Directive 20-20-20 (2008), is a measure related to the European Union, whose objectives are a 20% reduction in the emissions of greenhouse gases and energy consumption, in addition to the coverage of the total energy demand with renewable energies in at least a 20% (1) being buildings responsible of approximately the 40% of energy consumption, and the 36 % of European Union CO_2 emissions. Furthermore the European Commission is committed to launch initiatives for the encouragement and development of sustainable building means (2) (3).

In Spain, during the last years, public authorities have promoted the building retrofitting. However, most of the interventions are mainly aimed at constructive or aesthetic improvement of the building.

New regulations have been established aimed at the improvement of the energetic efficiency. Law 8/2013 of *BOE*. However, it does not propose measures or guidelines facing the reduction of environmental impact (4).

As a result of this law, there are ordinances applied in autonomous regions, provinces and municipalities. Some of them have deficiencies , despite considering carbon dioxin reduction and measures to be taken (5), (6), (7), (8). The council of Vitoria-Gasteiz, offers grants for the retrofitting of residential buildings, considering the 20 -20-20 objectives.

In adittion, the Spanish legislation, concerning the issue of environmental improvements, is designed with a very concrete view, rarely considering multiple solutions.

In South America there are also directives aimed at reducing the energy consumption of buildings. (Programa País Eficiencia Energética). However, the reduction is only a 0.9%. Trevilock M. established the different facts that encourage the usage of construction methods aimed at energy consumption reduction in Chile. (15) As well as the research group composed by O. Escorcia, R. García, M. Trebilcock, F. Celis and U. Bruscato carries out with a research, with the objective of establishing a criteria of sustainable and healthy design for housing developments. (16)

The current paper was focused on the application of different environmental retrofitting techniques, on the public building of the Iparralde Center facing objectives of the 20-20-20 Directive in carbon dioxin reduction. Three retrofitting methods were evaluated:

1-. By transforming the roof and public spaces surrounding the building in green areas .
2-. By the introduction of photovoltaic cells on the roof, in the places where feasible.
3-. By applying a combination of the two proposals mentioned above.

For this study, the following hypothesis was established:

> The combination of green roofs and photovoltaic tiles provides more benefits for buildings of large area, such as public buildings.

2.- METHODOLOGY.

For the current paper, related to Iparralde Center, the studio will be done for the roof, the southwest facade and the public plaza.

The first step in the analysis, was an analysis of sun exposed hours by the usage of solar masks.

The second step in the analysis was to estimate the energy irradiated by the sun. A spread sheet done by the Professor Javier Neila of the Polytechnical University of Madrid (2010) was used, inserting the climate conditions of the city of Vitoria-Gasteiz, and sun exposed hours.

The third step is to estimate what amount of the energy irradiated by the sun can be used to cover the Iparralde Center energy needs. Different statistics about the performance of photovoltaic cells in transforming solar energy were studied, (Intemper technical service, an Spanish commercial enterprise).

The fourth step is the analysis of the carbon dioxin absorption done by plants facing green roof retrofitting. (Figueroa, Getter, Micaela).

The fifth step is to calculate different scenarios of retrofitting. The results of this step were the reduction of carbon dioxin by the usage of green roofs in tons per year, and the generation of clean energy by the application of solar cells in kW/h.

The sixth step is to calculate the energy consumption and carbon dioxin emissions of the Iparralde Civic Center to establish a minimum relevance. CE3X computer program (2013) was used.

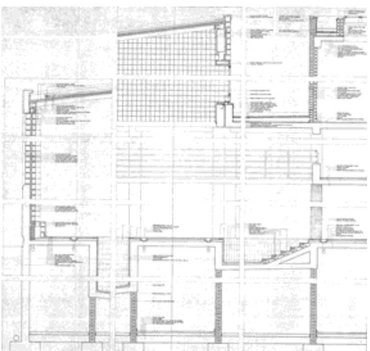
Finally, the results obtained from the analysis of retrofitting scenarios were compared with the energy consumption and the carbon dioxine emissions generated by the Iparralde Civic Center. This was done to establish the conclusions.

3.- CASE STUDY

For this research, the case study was focused on the building of the Iparralde Civic Center placed in the center of the Town of Vitoria Gastéiz in Northern Spain (Figure 1, 2).

Areas and points of study were defined. (Figure 3).

Figure 1: Location of Iparralde Center Source: Bing Maps 2013.



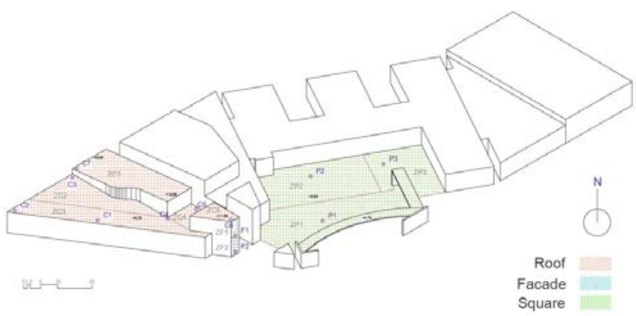


Figure 2: Constructive detail of the Iparralde Center (Project).

Figure 3: Points and analysis areas of Iparralde Center Source: Author´s elaboration 2013

Being of importance too for this analysis, the architectural and bioclimatic features of each area of analysis. (figure 4).

AREA A: SQUARE	Cornice height (m)	Surface (m2)	Refference points	Slope	Azimuth
Roof 1 (ZC1)	12,06 a 8,63	380,88	C7-C8	6º	-135º
Roof 2 (ZC2)	6,76	329,27	C1-C2	0º	0º
Roof 3 (ZC3)	6,76	276,36	C3-C4	0º	0º
Roof 4 (ZC4)	6,76	81,45	C5	0º	0º
Roof 5 (ZC5)	11,56	54,56	C6	0º	0º

AREA B: FACADE	Cornice height (m)	Surface (m2)	Refference points	Slope	Azimuth
Facade 1 (ZF1)	5,9 a 11,56	18,48	F1	90º	45º
Facade 2 (ZF2)	0 a 5,9	18,48	F2	90º	45º

AREA C: SQUARE	Cornice height (m)	Surface (m2)	Refference points	Slope	Azimuth
Square 1 (ZP1)	0	762,84	P1	0º	0º
Square 2 (ZP2)	0	590,62	P2	0º	0º
Square 3 (ZP3)	0	339,7	P3	0º	0º
Canopy 1 (ZM1)	4,79	127,91	P2	0º	0º
Canopy 2 (ZM2)	4,79	65,47	P2	0º	0º

Figure 4: Characteristics of the areas to analyze . Source: Author´s elaboration 2013

Step One: To calculate the sun exposure analysis, thirteen different points were placed on the different areas to analyze, solar stereographical cards of the latitude of Vitoria were used, inserting both draft plan data and cornice heights (Figure 5), establishing the yearly sun exposed hours. (Figure 6).

Point	Yaerly Sun Hors	% related to complete year time
C1	2623,5	0,60
C2	2837,5	0,65
C3	2904,5	0,66
C4	2592,5	0,59
C5	2174,5	0,50
C6	3559,5	0,81
C7	3894,5	0,89
C8	3849,5	0,88
P1	2710,5	0,62
P2	3165,5	0,72
P3	3119	0,71
F1	2264	0,52
F2	1938	0,44

Figure 6: Yearly sun exposed hours . Source: Author´s elaboration 2013.

Step Two: In the spreadsheet done by the professor Javier Neila in 2010 (Polytechnic University of Madrid), exposed hours obtained in the solar mask analysis were inserted, using recuction percentage, the results were the following ones. (Figure 7).

ZC1		YEARLY		Surface	final irradiance W
Yearly W/m2		966357		380,88	368066050,5
ZC2		YEARLY		Surface	final irradiance W
Yearly W/m2		1844258		276,36	509679276,2
ZC4		YEARLY		Surface	final irradiance W
Yearly W/m2		3605240		329,27	1187097533
ZC5		YEARLY		Surface	final irradiance W
Yearly W/m2		6957539		54,56	379603328
ZF1		YEARLY		Surface	final irradiance W
Yearly W/m2		13770735		18,48	254483177,6
ZF2		YEARLY		Surface	final irradiance W
Yearly W/m2		27274789		18,48	504038109,3
ZP1		YEARLY		Surface	final irradiance W
Yearly W/m2		54471438		590,62	32171920650
ZP2		YEARLY		Surface	final irradiance W
Yearly W/m2		54670792		339,7	18571667985
ZP3		YEARLY		Surface	final irradiance W
Yearly W/m2		109021017		762,84	83165592478

Figure 7: Sun irradiation calculus Source: Author´s elaboration 2013 with F.J. Neila, software.

Step three: From data resulting of the spreadsheet, (Figure 7). Next is the calculation of the energy generated by the usage of photovoltaic panels. Intemper technical service estimated approximately 44984.36 kW/h, for an area of 500 square meters considering the climatic conditions of Vitoria (Photovoltaic slab model Filtrón I 40). But because of sun exposure, it was necessary to apply a reduction coefficient. (Figure 8)

Intemper case		500m2	ROOF		1122,52m2	FACADE		36,96m2	CANOPY		198,38m2
% sun	KWh/m2	KWh	% sun ZC1	Kwh/m2	Total Kwh	% sun ZF1	Kwh/m2	Total Kwh	% sun ZM1	Kwh/m2	Total Kwh
100,00%	89,97	**44.984,37**	~61%	63,8778054	**70.052,36**	~32%	31,55	**1.166,33**	~70%	68,03	**12.589,15**

Figure 8: Calculation of solar energy generated using Filtron Tile I40 Source: Author´s elaboration 2013 and Intemper.

Step four: Firstly, the amount of carbon dioxin absorbed per square meter by green elements was established. Data of the results of different research studies about the carbon dioxin absorption done by plants was considered. (K.L. Getter Ea, Carbajal Micaela or Manuel Figueroa Clemente) (10)(11)(12). For each sort of green retrofitting mean were established: 0.00135 (10)(11) tons of carbon dioxin per year for extensive green roofs, or green wall, and 0.04 (13)(14) tons of carbon dioxin absorbed per square meter and year of intensive green roof square meter. The economical cost of these intervention was established according to the Intemper company fares for 2012.

Step five: For the present case study, three scenarios of retrofitting were defined:

Scenario 1: Transformation of both roof and public square in green surfaces.

Scenario 2: Photovoltaic cell application.

Scenario 3: Combination of photovoltaic cells and green surfaces.

The results of these scenarios are defined in the following table. (Figure 9)

Results of retrofitting operations			
Applied retrofitting	Green Roof	Photovoltaic panels	Mixed solution
CO2 Tons assimilated per year	96,108403		95,2096
kW/h generated	0	86753,824	82241,284
Total cost in euros	206304,68	374742,22	521177,71

Figure 9: Combination of different sort of roofs, Source: Author´s elaboration 2013.

Step six: this step focuses on establishing the criteria towards the conclusions. This one will be based on the energy consumption, and the carbon dioxin emissions generated by Iparralde Center. Related to Carbon Dioxin emissions, an estimative analysis was done with CE3X program. Because the characteristics of the facilities of Iparralde Center are not clear, the facilities considered were the following ones:

-Sanitary water and heating using mixed gas furnace of 400 kW, with middle isolation.

-Illumination composed of compact fluorescent light bulbs.
-Refrigeration by the usage of electric air conditioning equipment.

According to the formerly mentioned facilities, there were approximately 56,37Kg/m m^2 of carbon dioxin ton per square meter. Parting from a useful surface of approximately 2258 m^2, the total emissions are about 127283,46 kg of carbon dioxin. (127 Tons). Considering the increase of isolation from the application of green roofs, the emissions of Iparralde Civic Center were of 55,23 kg/ m^2 of carbon dioxin. 124709 kg of co2 (124 Tons).

In relation with the analysis of energy consumption, the program CE3X established an energy consumption of 239,38 kW/h m^2. Considering the surface formerly established, the consumption of Iparralde Center is 540520 kW/h per year. The application of green roofs also supposes a reduction of energy consumption, being possible to achieve a reduction of 32000 kW/h per year.

4: CONCLUSSIONS:

Once comparative data for conclusions (Figure 10) was obtained, a comparison was done considering carbon dioxin reduction by the usage of green roofs, reduction of energy consumption and energy generated by renewable sources. A minimum of relevance was established , considering a 20% in the reduction of energy consumption, the assimilation of the 20% of the emissions generated by the building, and a coverage of the 20% of energy demand. (European directive of 20-20-20).

Furthermore, a combined solution between retrofitting means is the best one, facing the 20-20-20 objectives. However, it is recommendable to consider the economic conditions, because this sort of retrofitting is more expensive.

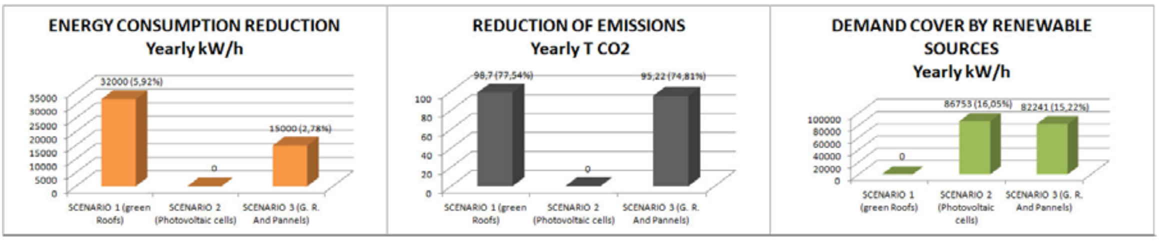


Figure 10: Graphs of comparison between the scenarios according to the 20-20-20 objectives, Source: Author´s elaboration 2013.

To sum up, public buildings must be an example of correct energy management, facing energy reduction challenges, and combined solution can be the best one, because it covers more benefits than the ones focused on one point.

REFFERENCES

(1) European Union (2009). *Communication of the European Comission, of 13th november 2008, appointed "Energetic Effciency: Achieve 20% objectives" [COM(2008) 772 – not published in Official Journal]*. Bruxelles: European Parliament.

(2) European Union (2002). *Energy Performance of Building Directive,2002/91/EC.* Bruxelles: European Parliament.

(3) European Union (2010). *Directive 2010/31/EU Of the European Parliament.* Bruxelles: European Parliament.

(4) Spanish Government (2013). *Law 8/2013 of BOE, related to the retrofitting, regeneration and urban refurbishment*. Madrid: Spanish Government.

(5) Madrid City Council. (1985, last update in 2001).*Ordenanza de Protección del Medio Ambiente urbano del Ayuntamiento de Madrid*. Madrid: Madrid City Council.

(6) Madrid City Council (2003). *Ordenanza Sobre Captación de Energía Solar Para Usos Térmicos*. Madrid: Madrid City Council.

(7) Madrid Regional Government (2011).*Plan de Impulso de las energías renovables de la Comunidad de Madrid*. Madrid: Regional Government

(8) Vitoria Gatéiz City Council (2005). *Normativas medioambientales de Vitoria Gastéiz*. Vitoria: Vitoria Gastéiz City Council.

(9) Vitoria Gatéiz City Council (2012). *Norma reguladora de las ayudas a la rehabilitación de viviendas y edificios residenciales en el Centro Histórico de Vitoria-Gasteiz*. Vitoria: Vitoria Gastéiz City Council.

(10) Neila González F. J. (2004)*. Arquitectura Bioclimática en un Entorno Sostenible*. Francisco Madrid: Munilla Lería.

(11) Getter K.L., Rowe D.B., Robertson G.P., Cregg B.M., Andresen J.A. (2009). Carbon Sequestration Potential Of Extensive Green Roofs. *Environmental Science and Technology,* Oct 2009. 1;43(19):7564-70.

(12) Carbajal Micaela (2011). *"Investigación Sobre La Absorción Del Co2 Por Los Cultivos Más Representativos De La Región De Murcia"*. Madrid: CSIC.

(13) Figueroa Clemente M. E., Suárez Inclán, L. M. (2009). *"Ciudad Y Cambio Climático, 707 Medidas Para Luchar Contra El Cambio Climático Desde La Ciudad".* Sevilla: Universidad de Sevilla, Muñoz Moya Editores.

(14) Figueroa Clemente M. E. , Redondo Gómez S.(2007)"*Los Sumideros Naturales De Co2: Una Estrategia Sostenible Entre El Cambio Climático Y El Protocolo De Kyoto Desde Las Perspectivas Urbana Y Territorial*". Sevilla: Universidad de Sevilla, Muñoz Moya Editores.

(15) Trevilcock M. (2011). Percepción de Barreras a la Incorporación de Criterios de Eficiencia Energética en las Edificaciones. *Revista de la Construcción*, Volume 10, April 2011 p 4-14. http://dx.doi.org/10.4067/S0718-915X2011000100002.

(16) Escorcia O. , García R. ,Trebilcock M. ,Celis F. ,Bruscato U. (2012). Mejoramientos de envolvente para la eficiencia energética de viviendas en el centro-sur de Chile. *Informes de la construcción,* Volume 64, October-December 2012. ISSN: 0020-0883 eISSN: 1988-3234 doi: 10.3989/ic.11.143.