CARBON FOOTPRINT OF THE LEGALIZATION OF ACTIVITIES AT THE CITY OF SEVILLE

Antonio-Matías Navarro-Torres[1], Ángel Mena-Nieto[2], Gabriel Bravo-Aranda[3], Francisco Hernández-Rodríguez[3]

[1]Ayuntamiento de Sevilla (España)

[2]Universidad de Huelva (España)

[3]Universidad de Sevilla (España)

http://dx.doi.org/10.6036/9885

1.- INTRODUCTION

China, the United States and India accumulate 49.8% of the world's greenhouse emissions (GHG) [1]. However, from a local point of view, it is cities that contribute the most to climate change, especially the large cities of the least developed countries. In fact, according to UN-Habitat, cities are responsible for more than 60% of global GHG emissions [2].

Demand for energy and GHG emissions continues to increase, as it focuses on urban, productive, transport and commercial activities so that by the middle of this century, two-thirds of the planet's population is expected to focus on cities [2], [3]. This concentration and increase of economic activities in cities lead to an increase in the number of legalization procedures that have to be processed in the municipalities to authorize and control the implementation of new economic activities, and this will be the subject of our investigation.

According to the current draft of the National Climate Change Adaptation Plan (NCCP) 2021-2030 [4], all institutions, including city councils, need to adapt their current public policies, plans and strategies to be consistent with the NCCP. In many cases, these regulatory changes force technological changes, which can be opportunities to improve efficiency in the functioning of organizations. Therefore, this article investigates systems to reduce the carbon footprint in the local government of cities.

Seville is the fourth most populous city in Spain (701,455 inhabitants)1 and has signed several commitments to reduce its carbon footprint. Two of the most important is the *Covenant of Mayors for Climate and Energy* [5], by which the city assumes the EU's objectives by 2030, and The Spanish Network of Cities for Climate, whose president is the mayor of Seville himself and which brings together more than 300 town halls and more than 60% of the Spanish population [6].

For achieving climate neutrality by 2050 goals by 2030 raised in the (PNIEC) 2021-20302 The local governments have to implement policies capable of decoupling economic growth (necessary in the current post-COVID-19 situation) of GHG emission growth. The mathematical relationship between the two was discovered in the seminal work of Nobel economics laureate Simon Kuznets and has traditionally been represented in literature by a U inverted called the Kuznets Environmental Curve [7].

In achieving this decoupling, town halls play a key role because they are the administrations closest to the citizen. Its plans and programmes need to promote a set of actions and projects to improve energy efficiency, through actions such as rehabilitation and sustainable construction, integrating renewable energy into homes, offices and public buildings [8]. However, it is also possible to reduce the local carbon footprint through other actions related to the organization of public services and governance, simplifying procedures and saving costs, as we will demonstrate below.

The structure of the article is as follows: the problems associated with the inefficient current legalization system by a responsible declaration are then explained. The third section explains the methodology used to calculate the carbon footprint in the Licensing Service of the City of Seville. In the fourth, the results obtained are presented by comparing the carbon footprint generated in the current situation and the one that would be generated if the KBS proposed in this article were implemented. The last section summarizes the conclusions, benefits and limitations of our proposal.

2.- APPROACH TO THE PROBLEM

The drastic change in the model of administrative intervention that took place in all Spanish municipalities, after the transfer to the Spanish legal order of the *Directive 2006/123/EC*[3], has currently caused most economic activities to cease to be supervised by the

[1]Source: municipal standard as of January 1 2020

[2]Draft National Integrated Energy and Climate Plan. Source:https://www.miteco.gob.es

[3]Source: Official Journal of the European Union L376 of 27 December 2006

administration and to be launched through *responsible statement*[4]. This model eliminated, in most cases, the prior control of activities, and these are only subject to further control by the administration. The increase in legalization procedures by responsible declaration following the Directive and the lack of effectiveness in the processing of such procedures [9] has had a very negative impact on some aspects of processing, in particular on the Carbon Footprint5 of many Spanish town halls.

The model currently followed for the legalization of most activities in the city of Seville is based on confidence in the management and subsequent supervision of its actions. However, in the absence of prior control, nor a system that allows it, there is a high percentage of activities that after its implementation, and after subsequent control by the administration, are not feasible to continue operating, as initially projected [10] (See fig. S1 of supplementary material). It results in numerous activities losing their operating authorization, since the responsible declaration is without effect, because of the deficiencies identified in the subsequent control, and must be legalized again. This redundancy in the legalization procedure generates significant increases in the carbon footprint, mainly due to new displacements, works carried out that are not useful, reforms to correct the deficiencies identified and other actions caused by other environmental impacts (noise pollution, light pollution, contaminated soils) They could be avoided with the knowledge-based system that we raised in this article (See fig. S2 supplementary material).

In response to the problems raised, the results of an investigation whose main objective is to demonstrate that the application of a Knowledge-Based System (KBS) can significantly reduce the carbon footprint currently generated in the Licensing Service of the City of Seville, as a result of the current high failure rate in subsequent control after the implementation of activities by responsible declaration.

3.- MATERIAL AND METHODS

A Knowledge-Based System to remotely support and resolve initial consultations for the implementation of activities by responsible declaration, has been developed. Then, it is used the tools that the Ministry for Ecological Transition[6] has developed to facilitate the calculation of an organization's carbon footprint (scopes 1+2), in line with Royal Decree 163/2014 of 14 March and UNE-EN-ISO 14064-1:2019 to compare GHG emissions generated by the procedure currently in place and those that would be obtained applying an alternative approach, based on knowledge management.

The materials for our research were obtained from the Environmental Protection Service of the City of Seville, where one of the authors is a municipal engineer. Statistical data collected during 2018, through interviews with engineers responsible for this service, show that about 95% of subsequent controls on responsible reporting activities, overseen by engineers from the Technical Licensing Office, are unfavorable. As a consequence, displacements have to be repeated to control the activity, after deficiencies found have been re-addressed. In most cases, the correction of deficiencies requires works or facilities adequacy reforms, which, like displacement, cause GHG emissions that could be avoided if the current legalization procedure were effective. The legalization procedure would be optimal if the activities were legalized with a single subsequent control inspection and did not require additional interventions to address deficiencies.

Once collected information from the breaches and consultations made, our proposal to solve the problems raised, it is the design and development of a knowledge-based system that allows verifying, before its implementation, the feasibility of those activities, thus reducing the high rate of failures and non-compliances in the legalization of activities. It is estimated that this KBS would reduce the default rate by at least 80%, i.e. that, after the initial subsequent control inspection, only 15% of activities would have a second inspection, and 6% a third, since most of the non-compliances detected are due to lack of information or lack of knowledge of the current regulations on activities and their facilities.

Figure 1 summarizes the operation of the proposed Legalization by a responsible declaration system and how the use of the KBS would affect emission reduction for our case and study period, the results of which will be justified later in paragraph 4.

[4]Document signed by the person holding a business or professional activity in which he declares, under his responsibility, that he meets the requirements established in the current regulations, that he has the documentation that proves it and that he undertakes to maintain its compliance during the duration of the activity.

[5]All greenhouse gases from the activity of an organization by direct or indirect effect. (*Royal Decree 163/2014 of March 14*, creating the Carbon Footprint Register, Compensation and Carbon Dioxide Absorption Projects, art.1)

[6]Carbon Footprint Calculator Reach 1+2. Source: https.miteco.gob.es

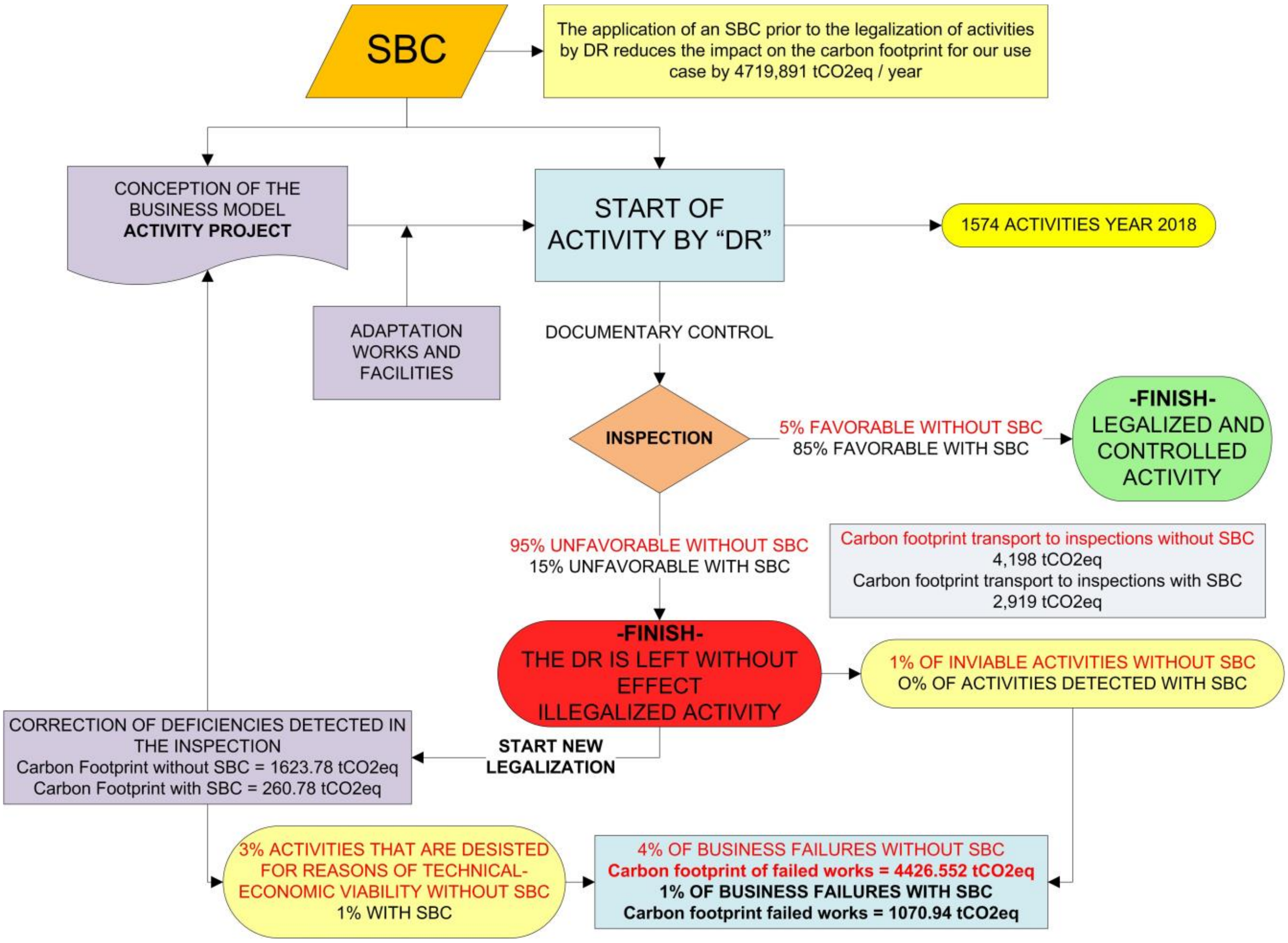

Fig. 1: Flowchart of the carbon footprint reduction procedure in a responsible declaration activity legalization system using a KBS.

The carbon footprint is used as a tool to calculate GHG emissions, associated with organizations, events, activities, or the life cycle of a product. In our case, we will calculate the 1+2+3 scope carbon footprint for the two scenarios raised (with or without KBS). For scope 1+2, we will use the procedures recognized by the Ministry for Ecological Transition for this purpose, quantifying the emissions derived from the activities in the field of a particular event in an organization, related to energy consumption, mobility and waste generation, in line with Royal Decree 163/2014, of 14 March. On the other hand, the following methodology shall be used for the calculation of scope 3 emissions:

1. Determination of machinery and materials used for construction or reform (and their quantities) required as a result of the control of the municipal engineers.
2. Selection of the quantity of each element involved and multiplication by the corresponding emission factor.
3. Sum of the emissions resulting from the above calculations and the result is the carbon footprint of that particular performance in Kg CO_2 equivalent.

The emission factors required to perform the calculations have been extracted from the official and public database of emission factors OpenDAP©, from the HueCO2 tool database® (version v01.01 of your BDFE) and the OERCO2 project[7].

The event we study is the subsequent control of activities carried out by the Environmental Protection Service of the City of Seville, through its Technical Licensing Office. The methodology applied first analyses the sources of scope 1 emissions, i.e. direct emissions from the activities that the organization controls, in our case, the fuel consumption of vehicles used by environmental protection service engineers. Scope 2 sources are indirect emissions generated in electricity production plants, as a result of the organization's own consumption, specifically electricity consumption during the period assessed. Scope 3 sources are emissions from the correction of deficiencies identified after activity control, by the remediation of environmental impacts caused by noise pollution, light, contaminated soils, and by disciplinary inspections following complaints arising from low activity start-ups and loss of their operating authorization.

The data required for the calculations have been the consumption of fuel by transport and the electricity consumption of the organization (litres and type of fuel consumed in the displacements made, electricity consumption and supplying company). For scope 3 of activities requiring remediation of deficiencies following subsequent control, and because it would be likely to quantify the particular emission of each activity covered by the study, an average representative case has been defined with the most common repeating actions resulting from subsequent control of activities.

4.- RESULTS AND DISCUSSION

4.1 CALCULATING THE CARBON FOOTPRINT IN THE CURRENT SITUATION

We start from annual fuel consumption of vehicles assigned to the Technical Licensing Office of 1122 litres of B7 fuel (diesel)[8], an annual number of activities to be monitored implemented by a responsible declaration of 1574[9], the annual electricity consumption of the organization's headquarters building (with an area of 409 m^2) of 64820 kwh[10]. Fluorinated gas leaks (HFC-134a) are also considered[11] refrigeration and air conditioning equipment (annual recharge of 1kg).

In the 2018 financial year, 95% of activities (1469) were accounted for that do not exceed subsequent control, since in the visit of verification to the activities implemented by responsible declaration, non-conformities or non-compliances are detected. Therefore, they require a second inspection visit to verify that the deficiencies initially detected have been corrected. After that second inspection, there are still 30% of these activities that require a third inspection, since they continue to present non-compliance or non-conformity with current regulations. Finally, after a third inspection visit, activities that have not corrected the deficiencies identified in the previous actions may desist in their implementation, so it is only considered in the calculation until the third movement by activity. Therefore, the control shifts performed in 2018 have been:

$$Number\ of\ trips = 1574 + (1574 \times 0{,}95) + (1574 \times 0{,}30) = 3541{,}5\ trips$$

With the above data, we have calculated GHG emissions (scope 1+2), in the current situation without SBS (See Figure S3 supplementary material)

https://oerco2.eu/es/category/general-es/; https://oerco2.eu/es/press-and-events/.

Fuel consumption data during 2018 provided by the Environmental Protection Service of the City of Seville.

Data obtained from the File Management System of the Environmental Protection Service of the City of Seville for the year 2018.

Electricity consumption and surface data consulted in the Municipal Buildings Service of the City of Seville.

Refrigerant leakage and replacement data consulted to the technicians in charge of the maintenance tasks of the Environmental Protection Service equipment.

Institute of Construction Technology of Catalonia

For scope 3 GHG emissions, they should be calculated for the following cases:

Emissions generated in corrective actions resulting from subsequent control of activities.

Emissions of activities that have been implemented but are unworkable because their use is not allowed in that location or because the establishment does not meet the minimum requirements for the development of the activity, not being possible that they are re-established. It happens in 1% of the activities (15 of 1574) that are legalized by a responsible declaration. It is due to lack of

[7] https://oerco2.eu/es/category/general-es/; https://oerco2.eu/es/press-and-events/.

[8] Fuel consumption data during 2018 provided by the Environmental Protection Service of the City of Seville.

[9] Data obtained from the File Management System of the Environmental Protection Service of the City of Seville for the year 2018.

[10] Electricity consumption and surface data consulted in the Municipal Buildings Service of the City of Seville.

[11] Refrigerant leakage and replacement data consulted to the technicians in charge of the maintenance tasks of the Environmental Protection Service equipment.

information and are detected on the first verification visit so that the GHG emissions generated by the adequacy of the entire establishment are quantified, as it is a failed and unworkable implementation.

Emissions of activities that desist from its implementation after a third verification visit motivated mainly by the technical or economic difficulty to correct the detected breaches. It is the case in 3% of activities (47) and is quantified in the same way as the previous case.

Due to a large number of activities typology analyzed in our research, since it is a question of quantifying the percentage reduction in the carbon footprint when implementing an KBS for the processing and commissioning of activities, it has been chosen to calculate the emissions of an average establishment with type characteristics for the implementation of an activity. The implementation of an activity requires a technical project detailing the actions necessary for the adequacy of the establishment. We take as a reference for our calculation, the average constructed area of the analyzed establishments that has turned out to be 300 m2 and the chapters involved: installations, coatings, insulation, carpentry, stained glass and paintings as characteristic parameters.

For GHG emissions calculation, the TOOL OERCO2 was used. It allows the calculation of emissions at all stages of the construction processes, which allows us to quantify the emissions derived from the different chapters involved in the adequacy of the establishment for its implementation in tCO2eq/m2. Most deficiencies are one-off changes in activity facilities and corrections in accessibility conditions for persons with disabilities, so we have also chosen to identify a model non-compliance, which will have an impact on the carbon footprint that is representative of the average number of activities analyzed that have to address deficiencies. For its calculation, the databases of OpenDAP©, HueCO2® (version v01.01) and the bank BEDEC - ITeC .

CARBON FOOTPRINT BY PROJECT CHAPTERS	t CO2eq	t CO2eq/ m2
Installation of air conditioning and ventilation	4,104	0,014
Electrical installations	10,179	0,034
Water installation (supply and evacuation)	10,910	0,036
Installation for domestic hot water production	4,816	0,016
Accessibility	8,413	0,028
Insulation	2,847	0,009
Coatings	12,844	0,043
Carpentry, security and protection	8,928	0,030
Glassware	0,344	0,001
Paints	7,975	0,027
TOTAL CARBON FOOTPRINT	71,396	0,222

General characteristics of the elements considered in the adaptation: PVC sanitation installation, monolayer facade termination, double hollow brick partitions, split-type air conditioning installation, ACS by solar panels, thermal-acoustic insulation through the polystyrene, plaster plastered coatings, removable laminated gypsum ceilings with a hidden framework, sliding lacquered aluminium windows, anodized aluminium shutters, hot-rolled solid steel grilles, aluminium railings, wooden posts and thermo-acoustic glass.

Average constructed area of the establishments under study: 300 m2

Table 1: Data extracted from OERCO2 for carbon footprint calculation in the current situation (scope 3)

From the analysis of the activities inspected, it is verified that the most recurrent or usual breaches are those related to accessibility for people with disabilities, with the correct location of machines of different installations, with the outlets of fumes, gases, etc., and the lack of sound insulation. Therefore, we have focused on calculating the impact on the carbon footprint of budgeted items for the correction of these deficiencies, based on the calculation methods described above and using the databases of the carbon footprint of materials, labor and machinery [11]. See Table S1 supplementary material.

Besides, since not all activities have the same deficiencies, we will calculate an average impact that the carbon footprint has the combination of these deficiencies correction actions detected in the inspection work of the local administration. See Table S2 of supplementary material.

The average estimate has been made for an activity of 300 m2 of constructed area, and which has deficiencies in sound insulation, smoke evacuation, sanitation, safety and ventilation. Of course, the case in the combination of non-compliances is broad, as an activity can present several non-compliances. However, it has been considered a selection of items that allow estimating reasonably representative data on the carbon footprint of the non-compliances detected in the inspection of activities by the administration.

Number of activities that are de deficiencies: 1469

Breaches	MEASUREMENT-UD	% activities
Evacuation fumes	15-m	30%-441
Acoustic insulation	60-m2	30%-441
Security	3-ud	15%-220
Sanitation/discharges	1-ud	5%-73
Ventilation	15-m	20%-294

Table2: Percentage of activities with type defaults associated with the estimated average measurement

Carbon footprint=∑[No.(non-compliances) × No.Ud(Measurement)× HC(kgCO2/Ud)]

Average carbon footprint generated in the adequacy of a raw establishment for the implementation of an activity: 71,396 tCO2Eq.

Average carbon footprint generated in correction of deficiencies and/or non-compliances detected in activities: 1623,780 tCO2eq/1469 activities - 1,105 tCO2Eq.

Carbon footprint from failed activities=(15+47) × (71,396)=4426,552(tCO2eq/year)

Carbon footprint from correction of deficiencies=(1,105×1469)=1623,780(tCO2eq/year)

Carbon footprint (scope 3)=(4426,552+1623,780)=6050,332(tCO2eq/year)

4.2 CALCULATION OF THE CARBON FOOTPRINT WITH AN IMPLANTED KBS.

Figure 2 shows the results of the carbon footprint (scope 1+2), following the implementation of the proposed KBS. By reducing the failure rate to 15% in the second check and to 6% in third, the fuel consumption associated with displacements for subsequent activity control is also reduced by an equal proportion, so the carbon footprint of scope 1 will be significantly reduced.

Average diesel fuel(B7) consumption per trip=1122/3541,5=0,317(liters/trip)

Number of trips=1574+(1574×0,15)+(1574×0,06)=1904,5 trips

Fuel consumption with implanted KBS=(1904,5×0,317)=603,7liters

Fig. 2: Final situation carbon footprint results with KBS (scope 1+2)

As for the scope 3 carbon footprint with KBS:

Average carbon footprint generated in the adequacy of a raw establishment for the implementation of an activity: 71,396tCO2Eq.

Average carbon footprint generated in the correction of deficiencies and/or non-compliances detected in activities: 1,105tCO2Eq.

Carbon footprint from failed activities=(15×71,396)=1070,94(tCO2eq/year)

Carbon footprint from correction of deficiencies=(1,105×236)=260,78(tCO2eq/year)

Carbon footprint (scope 3)=(1070,94+260,78)=1331,72(tCO2eq/year)

Figure 3 compares the results obtained with and without the proposed KBS. We start from the results of the initial and final situation calculated above.

Fig.3: Comparative results and emission reduction after application of the KBS (scope1+2)

Finally, Figure 4 shows the carbon footprint reduction obtained by comparing both systems. The result is that the application of the KBS would result in a 78% reduction in reach emissions1+2+3 generated by the Environmental Protection Service of the city of Seville.

Fig.4: Reduction of Carbon Footprint in percentage with the implementation of the KBS with respect to the initial situation.

5.- CONCLUSIONS

The proposed prototype system developed as a software agent, with a user-friendly interface, allows to consult on the urban and environmental viability of activities in a given location and verify the feasibility of the implementation of activity from anywhere with an internet connection.

Reducing the carbon footprint at the urban level is a significant problem. It has been addressed from an innovative perspective on the approach to its reduction, as our approach proposes an emission reduction system without acting directly on GHG emission sources, but focusing on improving the organizational procedures established for the implementation and legalization of activities by responsible declaration. As stated above, the KBS implementation as a consultative element before the implementation of activities by responsible declaration would reduce the carbon footprint by a total of 4719,891tCO2eq, which means a reduction in the current carbon footprint (scope 1+2+3) of 78%.

If we look at the emissions of scope 1, due to the transport in vehicles necessary to carry out the inspection work by the local administration, we see that they would be able to reduce by 30%, without having to invest in the purchase of less polluting vehicles. Scope 2 emissions are not affected by our method and proposal for improvement as we do not act on the electricity consumption of the building where the Environmental Protection Service is located. It is clear from the analysis of emissions scope 3 that it is in this area the most significant reduction is achieved, both in the amount of tCO2/year as a percentage of the total, as the non-compliance detected in inspections and the impact on the carbon footprint of adaptation works are minimized. Besides, the proposed model helps minimize business failures in the city, sometimes leading to investments to neighbouring cities.

This proposal could be applied to any of Spain's more than 8000 city councils, which would have a considerable impact on reducing their carbon footprint in cities and reducing costs for public coffers, all without having to invest in renewing the fleet of vehicles for others that produce fewer emissions, and facilitating the task of the promoters of economic activities, with the help of knowledge management.

REFERENCES

[1] Ortega-Ruiz, G.; Mena-Nieto, A.; García-Ramos, J.E.2020. Is India on the right pathway to reduce CO2 emissions? Decomposing an enlarged Kaya identity using the LMDI method for the period 1990–2016. Science of the Total Environment, 737. https://doi.org/10.1016/j.scitotenv.2020.139638

[2] Las ciudades, “causa y solución” del cambio climático. https://news.un.org/es/story/2019/09/1462322. (accessed 20-Jul-2020)

[3] United Nations 2015. Demographic Components of Future Population Growth: 2015 Revision. https://www.un.org/en/development/desa/population/theme/trends/dem-comp-change.asp

[4] https://www.miteco.gob.es/es/cambio-climatico/participacion-publica/PNACC.aspx (accessed 14-Jul-2020)

[5] https://www.pactodelosalcaldes.eu/ (accessed 14-Jul-2020)

[6] http://www.redciudadesclima.es/la-red#campos (accessed 20-Jul-2020)

[7] Robalino-Lopez, A., Mena-Nieto, A., García-Ramos, J.E., Golpe-Moya, A. 2015. Studying the relationship between economic growth, CO2 emissions, and the environmental Kuznets curve in Venezuela (1980-2025). Renewable and Sustainable Energy Reviews 41, 602-614. http://dx.doi.org/10.1016/j.rser.2014.08.081

[8] Lopez-Rodriguez, F., Cuadros, F., Ruiz-Celma, A., Segador, C., Mena-Nieto, A., García Sanz-Calcedo, J. 2011. PETER Building. An example of Bioclimatic Building and Integration of renewable energies into the edification. Dyna 86, 212-221. http://dx.doi.org/10.6036/3911

[9] Mena-Nieto A, Navarro-Torres A, Bravo-Aranda G. 2013. Mejoras en la Tramitación de Licencias de Actividades debido a la Directiva de Servicios. Dyna 88(3) 352-360. http://dx.doi.org/10.6036/5264

[10] Mena A., López F., Framiñán, J.M., Flores, F., Gallego J.M. 2010. XPDRL Project: Improving the project documentation quality in the Spanish architectural, engineering and construction sector. Automation in Construction, 19, 270-282.http://dx.doi.org/10.1016/j.autcon.2009.10.001

[11] Martínez Artigas, R. 2016. Método de cálculo de la huella de carbono en edificación basado en el análisis de los elementos básicos descompuestos de unidades de obra del presupuesto de ejecución. Caso práctico. Universidad Católica de Ávila. España.

SUPPLEMENTARY MATERIAL

https://www.revistadyna.com/documentos/pdfs/_adic/9885-1.pdf