9. Environmental and economic indicator in administrative buildings during their service life

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Resumen It has been defined a theoretical indicator of the economic and environmental cost which a public building based on use and surface might incur. It has been followed the methodology for developing the Ecological Footprint, the UNE-EN 15221 and the General Accounting Plan of the Administration of the Government of Andalusia and its Administrative Agencies and Special Regime. Firstly, it has defined the per capita spending on building maintenance so that we will have a reference of the economic figure within the life of the building. Subsequently, it has been taken an administrative building adjusting the main items (consumption energy, maintenance and cleaning), it was associated with various significant sections of the UNE-EN 15221 Facility Management and Support Services and the General Public Accounting Plan administrative headquarters. Similarly, the coding of the items studied according to the Andalusian Construction Costs Database (ACCD). Finally, representativeness and consistency of the environmental economic indicator of the expenditure budget in our case study and real expenses incurred during the year 2015 are concluded.

Keywords Energy rehabilitation, Energy efficiency, Facility management, Direct costs, Ecological indicators.

1 Introduction

The environmental and economic assessment through indicators becomes essential during the lifetime in administrative buildings. Technical management at this stage causes a considerable impact during the life cycle of the building which must be measurable and quantifiable.

Developing an indicator for the efficiency in the use and maintenance management of administrative buildings is essential for administrations, since it

generates a turnover of close to 55,000 million per year according to IFMA Spain (International Facility Management Association) in its June 2016 report.

Having isolated the expenditure of Chapter 2 for current goods and services of public administrations, at state level, it is achieved that in 2015 are generated 7.869 M € (12%) and autonomic 28,472 M € (50%) being the other local entities, according to the Public Expenditure Report IFMA. This leads to a spending figure of close to 1,182 € /capita in FM during 2015.

While traditionally the professional management through Administrator / Property Manager was considered, given the economic relevance that is generated during the life of the building, it has been defined the Facility Manager (FM, hereinafter) who might meet technical, economic, environmental and administrative aspects of the building. Although in the private sector, the FM has been shown the efficiency for the proper functioning of the installations and building, in the public sector it is not yet.

The FM is defined in the series of seven UNE-EN 15221 (2007). In this paper, Chapter 2 of current expenditure on goods and services has been disaggregated for an administrative building and it has been compared with the UNE-EN 15221 in the categories of energy consumption, maintenance and cleaning. Thus, it is intended to demonstrate the consistency through an economic and environmental indicator the possible correlation between economic and environmental data which are FM's duties in a building.

The adaptation of the Ecological Footprint (hereafter EF) indicator to the stage of use and maintenance of buildings allows, through conversion factors, transforming hectares of productive land needed to produce a given resource (productivity factor) or absorb waste in global hectares (equivalence factor).

In this paper, an environmental economic indicator is proposed, showing the value of the real expenditure on the theoretical one, approved in the budget of a public building, following the FM structure. To develop the first stage of this indicator, we study the energy consumption, maintenance and cleaning, given that they do not raise any doubt regarding what FM is considered in buildings.

2 Case study

The budget of any administrative headquarters in the County of Andalusia has to fulfil the General Accounting Plan approved by the Order of March 30, 2015 (Andalusia Government, 2015). For this work, some limited sections of the UNE-EN 15221 (2007) concerning maintenance, cleaning and energy consumption of the Government Delegation in Seville has been chosen. However, it has been taken as a reference Chapters 1 (staff), 2 (current expenditure on goods and services) and 6 (investment) budget of the 2015 budget (Table 1), as economic costs are generated in all of them within the three chapters above (maintenance, cleaning and energy consumption).

For the definition of use and maintenance´s economic and environmental indicators of public buildings, it has been taken the last financial year, the

headings of energy consumption, maintenance and cleaning of our building case study.

Subsequently, we have taken the actual costs of energy consumption, maintenance and cleaning and associated with the structure of the UNE-EN 15221 and the public budget: staff, current and investment expenditures (Table 1). The actual expenditure has been divided into economic and environmental costs by following the structure of the Ecological Footprint (built-up area, CO_2-absorption land, forest land, cropland, grazing land and fishing grounds).

Thus, the raised indicator might show how representative the theoretical assumptions are in budgets with real expenditures which arise during the maintenance of a building.

To facilitate the procedure, the economic cost elements, which are going to be verified, have been firstly detailed in the following table.

Table 1 Cost elements association following the UNE-EN 15221 and General Accounting Plan of the Andalusia Government

Economic cost element	Annual amount **(€)**	UNE 15221	Accounting Plan of the Andalusia Government
Facility Manager	31,700.00	1140. Real estate manager	Chapter 1: Staff
Maintenance agreement	56,264.00	1160. Operations and maintenance	Chapter 2: current expenditure on goods and services
Maintenance materials	9,757.00	1160. Operations and maintenance	
Electricity consumption	39,201.00	1171. Energy	
Gas consumption	5,480.00	1171. Energy	
Water consumption	1,218.00	1172. Water	
Garbage generation	-	1173. Garbage	
Cleaning agreement (materials included)	123,511.00	1310.Cleaning	
Machinery	-	1160. Operations and maintenance	Chapter 6: Investmen
TOTAL (€)	**267,131.00**		

Coding according to the Andalusian Construction Costs Database (ACCD) (Barón Cano et al. 2016) would require to follow the proposal of Martínez-Rocamora et al. (2016) and raise Basic Costs (energy supplies), Functional Costs (cleaning tasks) and Complex Costs (preventive and corrective maintenance tasks) within Chapter 20: Use and Building Maintenance.

Given the facility management expenses within the building in our case study, we will define the surface and content data in expenditure-related chapters (Table 2). The building follows these characteristics: structure distributed load-bearing walls in the basement (files), ground floor (offices and garden) and first floors to

fourth (offices). The building has been dedicated to administrative use with various reforms.

It should be noted that during this last period (since 2010), some renovations of facilities are being carried out to reduce energy consumption. Each time a new luminaire is replaced, the new one causes half consumption. The gas installation was derecognized during 2015, so that the air conditioning became electric.

The air conditioning lifetime became exhausted due to its obsolescence and high emissions of greenhouse gases. Because of budget-related issues, reinforcement individual air conditioners were installed, not enabling a comprehensive study of the air conditioning in the building.

Table 2 General and economic data in our study case building

General data		Economic data	
Total office	3,388 (m^2)	Chapter 1: Staff	9,917,758 (€)
Total surface	4,375 (m^2)	Percenteage Chapter 1/m^2 office	2,267 (€/m^2)
Ground Surface	1,642 (m^2)	Chap. 2: Current expenditures	2,793,418 (€)
N workers	160 (people)	Percenteage Chapter 2/m^2 office	639 (€/m^2)
Nº visitors/year	8,914 (people)	Chapter 6: Investment	180,000 (€)
Nº floors	GF + B + 4	Percenteage Chapter 6/m^2 office	41 (€/m^2)

The EF indicator is a tool that enables the study of the environmental impact of a building during its lifetime. Its study by sources of impact, becomes proper enough to associate to the work under study. In our case, since we have defined the tasks of energy consumption, maintenance and cleaning, we can easily bring them back for sources of economic impact values that we generate through their performance, the ecological footprint of maintaining our building (Table 3).

To obtain the EF (depending on the type of productive area: carbon, crops, pastures, forests, urban land and fishing), each source of impact requires to be Split into energy consumption, labour, equipment and machinery. Afterwards, susceptible annual items to be included in this study are defined in the following table.

Table 3 Ecological footprint association by land type, impact source, UNE-EN 15221 and General Accounting Plan of the Andalusia Government

Ecological footprints by land type	Impact sources	UNE 15221	Accounting Plan of the Andalusia Government
Built-up surface	Built-up surface	-	-
CO_2-absorption land	Electricity	1171. Energy	Chapter 2: current expenditure on goods and services
	Water	1172. Water	
	Materials	1160. Operation and maintenance	
	Machinery	1160. Operation and maintenance	

	Manpower	1160. Operation and maintenance	
		1310. Cleaning	
		1140. Facility Manager	Chapter 1: Staff
Forest land	Materials	1160. Operation and maintenance	Chapter 2: current expenditure on goods and services
Cropland	Manpower	1140. Facility Manager	Chapter 1: Staff
		1160. Operation and maintenance	Chapter 2: current expenditure on goods and services
		1310. Cleaning	
Grazing land	Manpower	1140. Facility Manager	Capítulo 1: Staff
		1160. Operation and maintenance	Chapter 2: current expenditure on goods and services
		1310. Cleaning	
Fishing grounds	Manpower	1140. Facility Manager	Capítulo 1: Staff
		1160. Operation and maintenance	Chapter 2: current expenditure on goods and services
		1310. Cleaning	

To develop an Economic / Environmental Expenditure on Use and Maintenance Indicator for any building according to the UNE-EN 15221 (2007), we must consider that the result ought to be one if all sections of the standard were included. Costs or EF included on the table we will able to obtain the consistency of energy consumption, maintenance and cleaning.

In the EF´s research for the maintenance phase of our building we follow the economic chapter under study (personal, current or investment expenditure), we have associated the structure of the UNE-EN 15221 (management ownership, maintenance, operation and routine cleaning). Each section defined is associated by its impact on the final result of the ecological footprints.

To achieve the consistency of our real values over the theoretical ones, we have taken the sum of each concept within each chapter and its relevance is calculated out of the total sum. This impact is added to the other chapters and the

full impact of the actual expenditure on the budget is obtained theoretically. Should the total real spending be justified with the theoretical one, this impact would result a unit value.

At the moment different buildings should be studied in the maintenance area and for the same use, we could obtain an average value representative of the spending on FM in a public budget.

For each economic chapter of the budget we would have the following relevant indicator which could be calculated for economic amounts (€) or environmental ones (gha/yr):

$R_i = (\sum_1^n (G1 + G2 + \cdots + Gn) \ / \ Ci)$; $0 < R_i < 1$ (1)

R_i: Economic relevance to the total defined chapter ($0 < R < 1$).

G_i: Expenditure (€ o hag/year) following the UNE-EN 15221.

C_i: Total expenditure in each budget chapter (€ or gha/yr).

Subsequently, every chapters´ sum is referenced to the surface of the building which give us the economic indicator of spending on facility management by built surface:

$I_{EG/FM} = (\sum(G1 + G2 + \cdots + Gn))/St$ (2)

$I_{EG/FM}$: Economic indicator for Facility Management expenditure

G_i: Expenditure analysed (€ or gha/yr) following the UNE-EN 15221.

S_t: Building total surface.

Obtained results calculated on an annual basis for our building (table 4) are shown by following the systematic approach shown in the work of Martínez-Rocamora et al. (2016), where the methodology for obtaining ecological footprints according to their impact is laid out.

Table 4 Economic and Ecological Footprint (EF) calculation of the building use

Impact source	Consumtion	Unit	Cost (€)	Carbon (gha/yr)	Built-up (gha/yr)	Total (gha/yr)	EF (%)
Electricity	249,741	kWh	39,201	15.650	-	15.650	18.09
Water	311	m³	593	0.0160	-	0.009	0.02
Gas	107,195	kWh	5,480	70.430	-	70.43	81.42
Built-up area	0.164	nha	-	-	0.41	0.410	0.47
Total			**45,274**	**86.096**	**0.41**	**86.499**	**100.00**

The consumption of electricity in the building (power, lighting and air conditioning), water (discounting which is used for cleaning), gas (heating) and plot area (Table 5) have been studied. These consumptions are converted into euros (by billing the building) and gha/year (Martínez Rocamora et al. 2016).

We can see that there is no economic and environmental correlation in energy consumption, since electricity represents 39,201 €, which is 85.41% of the total

cost. On the other hand, ecological footprint owing to the gas consumption is 70.43 gha/year, accounting for 81.42% of the total ecological footprint of supplies (Table 5).

Since the cleaning agreement in our case study includes the material, the material consumption has been estimated at 0.69 € / hour following the work of Rocamora Martínez et al. ‹6› in cleaning jobs (Table 6). Water for cleaning is obtained from the daily volume used for cleaning (1.69 m^3/day for 250 days). Similarly, data have been taken from the cleaner's working hours (6 h/day and 6 laborers) and supervisor (4 h/week) that apply to our building under study.

Once the number of hours which represents the cleaning of our defined building (Table 6), they have become sources of impact on gha/year according to data from similar buildings (Martínez-Rocamora et al 2016).

Table 5 Economic and Ecological Footprint (EF) calculation of the cleaning up

Code	Description	Concept	Total	Unit	Cost	Cropland	Grazing land	Fishing grounds	Forest land	Carbon Footprint	Total
					(€) (1)	(gha/year)					
	MATERIALS	Total			5,962						0.522
		Manufacture									0.481
		Transport									0.011
		RSU									0.030
GW00100	Drinking water	Manufacture	423	m³	820					0.012	0.012
		Transport								0.000	0.000
		RSU								0.000	0.000
JL00100	Cleaning trolley	Manufacture	8,640	h					0.319	0.150	0.469
		Transport								0.011	0.011
	MANPOWER	Total			117,171						1.167
		Food									1.125
		RSU									0.042
TP00500	Cleaning labourer	Food	8,640	h		0.607	0.162	0.259		0.070	1.098
		RSU								0.041	0.041
	Indirect Costs Supervisor	Food	208	h		0.015	0.004	0.006		0.002	0.027
		RSU			1					0.001	0.001
	Total				**123,953**	**0.622**	**0.166**	**0.265**	**0.319**	**0.317**	**1.689**

(1) Manpower and materials are included in the cleaning agreement. The agreement bill shown in the Manpower row

Table 6 Economic and Ecological Footprint (EF) calculation of the building maintenance

Code	Description	Concept	Total	Unit	Cost	Cropland	Grazing land	Fishing grounds	Forest land	Carbon footprint	Total
					(€)(1)	(gha/yr)					
	MATERIALS	Total			9,757						4.398
		Manufacturing							0.437	2.877	3.314
		Transport								0.244	0.244
		Mat. MSW								0.840	0.840
	MANPOWER	Total			87,964						1.171
		Food									1.036
		MSW									0.135
TO01500	Facility Manager	Food	1,950	h	31,700	0.178	0.040	0.104		0.033	0.355
		MSW								0.046	0.046
TO02100	Special Laborer	Food	3,640	h	56,264	0.333	0.074	0.195		0.060	0.662
		MSW								0.087	0.087
	Indirect costs Supervisor	Food	104	h		0.010	0.002	0.006		0.001	0.019
		MSW								0.002	0.002
	MACHINERY(2)	Machinery	5,990	h	0.000	0.000	0.000	0.000		0.000	0.000
	Total				**97,721**	**0.521**	**0.116**	**0.305**	**0.437**	**4.190**	**5.569**

(1) Manpower and toolbox are included in the maintenance agreement. The agreement bill is included in the Special laborer row.

(2) The energy consumption by machinery is included in the electricity consumption, both in economic and environmental terms.

Materials consumed in the maintenance (9,757 €) are structured as follows: paint (262 € - 2.68%), masonry (2,230 € - 22.86%) and electricity (7,265 € - 74.46%). It is not possible to ensure which tasks are only maintenance or reinstatement, which estimated the consumption in the field of environmental impact of similar buildings affected by the meter (Martínez-Rocamora 2016) (Table 7).

Supervisor and workers´ costs were obtained from existing maintenance (7 h/day and 2 officers h/week for supervisor). It has been included 100% of the FM, which is a property technician and works by following tasks contained in the UNE-EN 15221 (2007). The ecological footprint for machinery has not been estimated, as its amount is reflected in electricity consumption and its use is sporadic and belongs to other administrative offices.

The aim of this paper is define the percentage of Chapters 1 (staff), 2 (current goods and services) and 6 (investments) of any budget from an administration, which is representative of the spending on facility management (Table 7). Since we have assigned a part (energy consumption, cleaning and maintenance) of reflecting the UNE-EN 15221, we can only obtain that part and see which amount of the chapters represent the public budget.

Table 7 Environmental and economic costs apportion to the public budget

UNE-EN 15221	Budget chapter	Economic budget (€)	FM cost in case study (€)	% €	Total environmental cost (gha/yr) (1)	Environmental cost in study case (gha/yr)	% gha/yr
1140	1. Staff	9,917,758	31,700	0.32	500.41	0.401	18.86
1160, 1170, 1310	2. Current good and services	2,793,418	234,806	8.41		93.356	
1160	6. Investments	180,000	0	0.00		0.000	
Total		**12,891,176**	**266,506**	**8.73**	**500.41**	**93.757**	**18.73**

(1) Total EF in Spain in 2005, following the average anual growth rate from 1985.

If the cost of these three chapters studied related to facility management reaches almost 10% of total economic output, it reaches nearly 20% of environmental cost. This disparity may be related to the use of energy (in particular gas), which represents a huge burden on the ecological footprint.

3 Conclusions

The economic and environmental implications which would be caused by the use and maintenance studied over the lifetime of the building for example for 10 years (the tenth of the life of a standard building) would generate 2,665,060 € and 5,004.10 gha, which is a period of time in which we usually carry out significant reforms in administrative headquarters for adapting them to new space

requirements. These figures are relevant enough and it becomes necessary to continue the study of this part of the buildings lifetime.

From the data obtained, it appears that public budget chapters studied mean almost 9% in the economic area and around 19% in the environmental field. It would be interesting to parameterize the data of this building, adding these same percentages of other buildings and see whether it holds that spending on facility management is similar to our building. On the other hand, as a future task should be studied, all tasks, not only energy consumption, maintenance and cleaning which UNE-EN 15221 considers FM and link them to the budget of the public administration to verify what percentage of the chapters of staff, current expenditures and investment are affected by facility management.

Final figures are similar to the results from Martinez-Rocamora (2016), although in the differences which can be noticed between residential and administrative use the organization of cleaning work is affected. However, the proposal related to maintenance section is quite similar.

The results associated with Chapter 2, current expenditures in our building case studied, covering almost 90% of the economic cost (234,806 €) and 99% of the environmental one (94.032 gha/year), which can be considered consistent since the FM works on use and maintenance of the building. Financially, Chapters 1 (staff) and 6 (investment), are considered negligible since most FM work is performed as a support service (Chapter 2, current goods and services) to the main activity.

It would be interesting to associate the General Accounting Plan (Andalusia Government 2015) to the coding of UNE-EN 15221 (2007) so that it could be associated the economic cost of a public budget with the spending on facility management. However, the approach to the European System of Accounts (European Commission 2013) does not seem relevant, since this work is just one part of the UNE-EN 15221. The study should be addressed once the General Accounting Plan is associated to the various items contained in it.

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