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Environmental metabolism of educational services. Case study of nursery schools in the city of Barcelona

ABSTRACT

The environmental analysis of public nursery schools is of great interest since they are crucial in the early education of children and are expected to show high environmental standards. This paper aims to analyse the environmental profile (energy, water and transport flows) of nursery schools. A sample of 12 public nursery schools belonging to the Scholar Agenda 21 (SA21) of the city of Barcelona were selected, for most indicators, to analyse their energy (kWh) and water (m^3) consumptions, as well as the greenhouse gas emissions derived from energy consumption and transport usage. For each centre, energy and water consumptions were obtained from its bills and surveys were conducted to get data regarding the transport associated to the centre. Results show that, in average, a child consumes 966 kWh of energy (electricity and gas) and 12.9 m^3 of potable water every year. Nursery schools with more energy-efficient devices hold lower energy consumptions, a trend which could not be found in the case of water and water-efficient devices. Regarding transport, car usage was the main impacting element, since it accounts for 69% of CO_2eq emissions, though only 19% of the children commute by car.

Keywords: nursery school, services, energy, water, emissions, sustainability

1. INTRODUCTION

1.1 Sustainability and cities

European cities hold around 70% of the energetic (LCSCCI 2011) and 17% of water consumption (Ecologic 2007). These facts make crucial the assessment of its environmental impact in order to minimize them.

The Agenda 21 (A21), which was created in the Rio Earth Summit (1992) (Our Common Future 1987), consists of a comprehensive action plan that can be applied and adapted globally, nationally and locally (United Nations 2013). Since 1992, A21 has been embraced by more than 5,000 cities all over Europe (ESDN 2014). In the framework of the A21, the Scholar Agenda 21 (SA21) has been embraced by several cities around the world aiming to involve educational centres in the environmental improvement of the city. Apart from helping schools to increase their level of sustainability, SA21 wants to include environmental education in the centres and involve children in different environmental issues. Therefore, to carry out an assessment of this service would be useful for making decisions about its resource and energy consumption along with the environmental awareness of the users.

This article has focused on the environmental assessment of nursery schools. The service sector represents 60% -70% of the Gross Domestic Product in developed countries (Carpintero 2003) and accounts for 11.3% of the total energy consumption in the EU-27 (IEA 2008). Therefore, the sustainability of its services is of interest.

1.2 Nursery schools and environment

Previous studies have provide environmental information of service buildings such as hotels (Deng 2003; Priyadarsini et al. 2009; Xin et al. 2012; Wang 2012), office buildings (Edwards et al. 2012; Kong et al. 2012), schools (Santamouris et al. 1994; Pons and Wadel 2011), museums (Farreny et al. 2012), commercial malls (Zhisheng et al. 2012), retail parks (Farreny et al. 2008) and hospitals (Moghimi et al. 2014). In the case of hotels, for instance, an average annual electricity consumption of 361 kWh/m^2 was found in Singapore (Priyadarsini et al. 2009), 143.6-280.1 kWh/m^2 in Taiwan (Wang 2012) and 542 kWh/m^2 in Hong Kong (Deng 2003). Moreover, Xin et al. (2012) showed that the building area was highly correlated with the energy consumption in four- and five-star hotels in Hainan (China), while building age and occupancy rate presented weak correlations with energy consumption.

Educational facilities have a high potential to encourage and change the habits of the children and their families with respect to the environment. Environmental projects and participation programmes linked to the environment increase the students' interest in these issues (Uittoa et al. 2010). Furthermore, environmental education is important at early life stages because children are already able to understand its surroundings and the effects of environmental changes (Palmer and Suggate 2004). In spite of this potential, environmental education in nursery schools is very limited due to the lack of adequate formation of the teachers (Flogairis 2005). In this context, the environmental assessment of nursery schools will provide useful information about its most relevant environmental impacts and how to deal with them.

Regarding previous environmental studies focused on educational centres, McNichol et al. (2011) analysed the ecological footprint in an early childhood centre in Australia (for children from 2½ to 5½ years). The study concludes that the largest contributors to the environmental impacts are food, transport choices and energy use. Another study by Pons and Wadel (2011) conducts an environmental analysis of 200 prefabricated preschool and primary centres in Catalonia. The results show that the phases contributing most to the environmental impacts are the manufacture and use of the building, with similar contributions to the total impact. However, the elements affecting the use phase were not further analysed. In another case, the energy efficiency of a nursery school in Greece was addressed considering the installation of an experimental green roof, which improved the insulation and reduced the conditioning requirements (Santamouris et al. 2007). A specific assessment of a sample of nursery schools – which in Spain host children aged 0-3 years old - would be of interest since they have some specific environmental impacts due to the early age of children. For instance, thermal requirements are stricter than in other educational services, in order to preserve the children's health (Mitchell 2007). As a matter of fact, Oliver-Solà et al. (2013) reported that, in Spain, nursery schools are ranked 8^{th} in a group of 23 different municipal facilities in terms of energy consumption per m^2.

This article focuses on the operational phase of nursery schools. This phase consists of the energy, water and materials flows in the daily life of the centres as well as in the transport related to the service. Some previous studies (Pons and Wadel, 2011; Santamouris et al., 2008) only considered the energy requirements for acclimatization. Thus, there is a lack of data regarding the metabolism of nursery schools.

2. OBJECTIVES

The specific goals of the study consist of the following: to elaborate an environmental profile of a sample of nursery schools belonging to the SA21 in the city of Barcelona through the inputs of energy, water and transport and the outputs of equivalent CO_2 of the use phase; to identify the main variables affecting the results, e.g., building area, opening hours and school age, and to evaluate good environmental practices in the centres. Both the scale of the system (i.e. the nursery school) and the expanded system, which includes the neighbourhood, have been considered when assessing the transport (**Figure 1**).

Thus, this article aims to evaluate the environmental profile of the SA21 nursery schools, which is expected to be better than that of conventional nursery schools, and to identify which centres in the sample have the greatest impact.

3. MATERIALS AND METHODS

This section describes the case studies selection (Section 2.1) and the process and methods used for data collection and treatment (Section 2.2), as well as the assumptions considered in the analysis.

3.1 Sample selection

In the present paper, nursery schools located in the city of Barcelona (Catalonia, Spain) were analysed as a first approach to determining the consumption patterns in Mediterranean regions. To do so, 12 public nursery schools taking care of children aged 0-3 years old were considered (**Table 1**) so as to represent 5% of the centres included in the Barcelona SA21 programme.

In general, centres belonging to the SA21 tend to show greater interest in the environment and, in this case, they were willing to participate in the analysis. However, the required data were only available for 12 centres, which were therefore selected for the study. As a result, the findings of this study may be representative for centres belonging to the SA21 in Barcelona, as their inclusion in the programme might have represented more sustainable behaviour. Therefore, they might illustrate the consumption patterns among those involved in the programme. Moreover, Barcelona is a compact city with a well-developed public transport network, which enables lower car usage.

<Table 1>

3.2 Scope of the analysis

The operational phase of nursery schools was addressed in this paper. **Figure 1** shows the inputs and outputs to the system. Energy, water and transport were the only inputs considered, as data on the material goods (e.g., diapers, toys and office material) were not available. Similarly, waste generation could not be estimated as an output, whilst CO_2 emissions deriving from the energy use and transport were accounted for. However, food consumption and waste generation were addressed in terms of best practices in Section 4.4. Moreover, the use of eco-efficient devices was also taken into account in order to find a relationship between the consumption patterns and their application in nursery schools. All these elements constitute the use phase of the nursery school; when dealing with the maintenance activities, cleaning tasks were accounted for in the water consumption.

<Figure 1>

3.3 Data collection and treatment

3.3.1 Fieldwork activities

To obtain the necessary data, fieldwork was required in order to have an accurate idea of each nursery school. This procedure was needed given that in some cases no record of the energy and water consumption was supplied by the city council – which is responsible for managing these facilities - and further information was required.

Moreover, it was necessary to get acquainted with the habits of the administrators, teachers and families in order to assess their level of environmental awareness. This issue consisted of two different aspects. On the one hand, on-site observations helped to determine environmental actions developed inside the boundaries of the nursery school, including the occurrence and use of different types of devices, such as low-energy lighting, aerated and timed faucets, toilets with dual-flush capacity and drip irrigation, as well as ecological food consumption and the separation of waste fractions. A comparison was made between the degree of energy and water consumption and the implementation of efficient devices for the nursery schools analysed.

On the other hand, surveys were made during the visits to gather information regarding the commuting habits of the families. A set of questions was made when parents picked up their children or it was handed in to be completed at home. Families were asked about the means of transport they used to commute from home to the nursery school and whether they lived in the same neighbourhood where the centre was located or not. As a result, an average distance from homes to the school of 20 km (round trip) was considered.

3.3.2 Data from registers

In the case of energy and water, data could be mostly retrieved from registers for the 2008-2009 period that were supplied by the city council (since the centres do not hold this data). Energy was represented in terms of electricity and gas consumption and it was assumed that the largest consumption came from the built areas, i.e., the interior of the nursery school, including the kitchen, toilets, laundry, office and rooms. The values per unit of area were thus calculated using the built area. In contrast, it was considered that water was also consumed for watering gardens and playgrounds; as a result, the whole area of the nursery school was taken into account when analysing the water-area relationship. It must be pointed out that, in case of having a single educational complex for different school levels, the area considered only covered the nursery school.

The energy and water consumptions could not be found for two of the cases, as the registers were not available. Also for transport, there were no data for two of the cases because the surveys could not be implemented. In those cases, the nursery school was part of an educational complex together with primary and secondary schools and data could not be directly obtained.

3.3.3 Data treatment

After data collection, an environmental analysis was conducted to estimate the carbon footprint. For each type of energy consumption and transport, the equivalent carbon dioxide (CO_2eq) emissions were calculated to determine the impacts of nursery schools on the environment. Different conversion factors were used to translate each flow to CO_2eq emissions. For electricity consumption, the Spanish electricity mix for 2011 was used with an emission factor of 366 g of CO_2eq per kWh of electricity, according to the results obtained applying the CML 2 baseline 2000 method V2.05 (Guinée et al. 2001) and the Ecoinvent 2.2 (Ecoinvent 2009) database. Similarly, 262 g of CO_2eq per kWh of natural gas were considered. In the case of transport, an emission factor was considered for each mean of transport, which was converted after using the appropriate CO_2eq value, depending on the source of energy used in each means of transport (Catalan Office for Climate Change 2012; BEA 2011; Biomass energy data book 2011). The emissions for 2011 were considered in the electricity, gas and transport in order to be able to compare the carbon footprint on the same annual basis.

In addition, statistical analyses included descriptive statistics and correlations, which were developed with the aid of PASW Statistics 17 software, from the Statistical Package for the Social Science (SPSS) – developed by EBM (Armonk, New York, United States).

4. RESULTS AND DISCUSSION

In the following sections, the flows and elements considered (i.e., energy, water and transport) are analysed, with a focus on possible causal relationships between each flow and the features of the nursery school (e.g., area, number of children, building age and opening hours). **Table 2** shows a compilation of the data related to the energy and water consumption for each of the nursery schools included in the sample.

<Table 2>

4.1 Energy and water flows

In this section, analyses were carried out to study water and energy consumption in ten nursery schools using two different reference units: consumption per unit of area (m^2) and consumption per child, as observed in **Figures 2** and **3**. The assumptions made are presented in Section 3.

<Figure 2>

Figure 2 Yearly energy (electricity and natural gas) and water consumption per unit of area. Data for the period 2008-2009

<Figure 3>

First, it can be observed that the energy and water flows show similar trends in both the consumption per child and per unit of area. Whereas in terms of energy consumption all the cases are homogeneously distributed between 50 kWh/m^2 and 200 kWh/m^2, in terms of water consumption 8 out of the 10 values are within the narrow range of 0.4-0.8 m^3 of water/m^2 (**Figures 2 and 3**).Thus, nursery schools present much dispersed results for energy than for water consumption.

There are several variations between behaviours of the centres. The maximum values are 4- to 6-fold greater than the minimum values for both energy and water flows. Considering that they belong to the same geographical area and they carry out the same activities as educative facilities, because they all belong to the SA21, these are important variations. They could be related to different levels of environmentally friendly behaviours in the nursery schools (**Section 4.4**), so differences in the management and the structure of the centres are likely to play an important role.

Drawing comparisons to existing data, the study of Oliver-Solà et al. (2013) evaluated the metabolism from 31 nursery schools not belonging to the SA21, in the same surroundings this article considers (the Province of Barcelona). According to the study, the average annual energy consumption of a nursery school was 123.2 kWh/m^2, which differs little from the value obtained in our study (114.0 kWh/m^2). The slight difference in the mean energy value could be because the centres included in the present study are members of the SA21 programme. In contrast, Pérez-Lombard et al. (2008) reported an average energy intensity in schools in the USA of 262 kWh/m^2. In general, schools in the USA account for 13% of the energy use in the commercial sector, whereas in Spain they are less energy intensive (4%) (Pérez-Lombard et al., 2008); this fact could help to explain the differences between both countries. Results from Pons and Wadel (2011) show that heating a school requires between 20-30 kWh/m^2 (1000-1700 kWh/m^2 in a time span of 50 years), although the energy source (gas/electricity) remains unknown. In our case, nursery schools used gas boilers and the average gas consumption was 72 kWh/m^2 because of the need for stricter climatic conditions in these facilities. Further explanations to these results were searched for in features of the nursery schools. The relationship between energy and water flows and the area, number of children, number of yearly opening hours and building age was analysed by means of regression statistics (**Table 3**). By so doing, it was seen that the area is the main factor influencing the performance of the facilities. In all cases, the area refers to the built area except for the correlations with water consumption (**Section 3.3.2**). First of all, a significant correlation ($p<0.05$) was obtained in the water-area relationship with a Pearson's correlation index (r) of 0.680. This result must be related to the need for watering the garden, given that this area is accounted for in the water requirements.

Other findings show that more children are hosted in bigger centres ($r=0.740$), what is actually an intuitive result. An interesting relationship occurs between the area and the building age. In this case, there is an inverse effect ($r=-0.629$), which means that older nursery schools are smaller. Here, the historical background of each centre and the facilities that accommodate them play an important role. For instance, centre B was founded in the 70s in a small room inside a market and centre K is located in an old rehabilitated house from the early 80s. In contrast, centre J was given a large area in a multi-functional public building of big dimensions 7 years ago. This indirectly affects the water consumption, given that older facilities could have lower water requirements. Regarding the remaining variables, no significant correlations were found. The opening hours, for instance, could hardly explain the variations in energy and water consumption given that most of the nursery schools open during the same period of time (**Table 1**).

<Table 3>

4.2 Transport and CO_2 emissions

Regarding the transport, the percentages of the mean of transport used by children (and their families) to commute from home to school were determined, as well as the transport-derived CO_2 emissions. **Table 4** shows the percentages for the use of each transportation type, CO_2 emissions derived from cars and public transport, and their relative contribution to the emissions of the nursery schools. According to the surveys (Section 3.3.1**)**, a daily average distance of 20 km (round trip) travelled by car or public transport was considered.

More than half of the children (61%) commute by foot or bicycle, and 20% use public transport. This means that most children do not produce any CO_2 emissions derived from motorised transport. Thus, nursery schools have sustainable mobility habits in general terms. In addition, it can be observed that the average percentage of children using cars is less than one-fifth (19%), which is similar to the average percentage using public transport (20%). However, most of the emissions derive from the former, being more than 50% of the GHG emissions in almost all the cases, while the latter produces a smaller part (31%). Commuting by private car is, then, the most important factor to take into account to reduce emissions derived from transport, even though it represents a smaller percentage of children.

However, great differences can be observed in the percentages of each means of transport. Sustainable transport patterns (i.e., a higher percentage in the use of public transport, bicycle and on-foot) can be related to factors shaping neighbourhood where the nursery school is located, such as topography, average economic income, population density or the presence of adequate infrastructure (e.g., train station, bus stop). These relations should be analysed in further studies on the issue.

<Table 4>

Nevertheless, CO_2 not only derives from use of fuel when commuting, but also from the energy use in the facilities. Therefore, the emissions of both systems were compared in each nursery school, as illustrated in **Table 5**.

Globally, transport emissions account on average for approximately 159.7 kg CO2eq per child, representing the 40% on of the total emissions. This result must be taken into account in the management of these educational facilities in order to achieve a reduction in the environmental impacts by actions taking place outside the boundaries of the centre. This goal could be achieved implementing more environmental education programmes, but nevertheless, the location of the centre and the place of origin of the children play an important role, as well.

In addition, one can see that the energy use in the building is an important vector, since it accounts for more than 70% of the emissions in several nursery schools. Indeed, several previous articles on service building have focused on energy consumption, considering it as one of the most relevant contributions to the environmental impacts (Xin et al. 2012, Santamouris et al. 1994, Zhisheng et al. 2012). Therefore, energy saving must be another important objective of the centres by means of different alternatives such as reducing the energy demand or applying efficient devices. The latter were analysed in order to determine its effect in the saving task, together with the application of other environmentally friendly actions (Section 4.4).

<Table 5>

4.3 The environmental profile of a child

To establish the environmental profile of a child, it was determined that on average each requires 966.3 kWh of energy and 12.9 m^3 of water every year to fulfil his or her educational needs, which means, in terms of daily consumption, 5.03 kWh and 67.3 L of water. Data regarding energy consumption, as observed in Section 4.1, could be compared with existing analyses while there is a lack of studies on the metabolism of nursery schools for other flows. Moreover, the centres present an average carbon footprint of 420 kg of CO_2 per child.

Oliver-Solà et al. (2013) also focused on the school system and found that, on average, a student consumed 172.6 kWh annually, which is approximately one-fifth of the calculated value for nursery schools. This highlights the importance of the nursery school system, which was found to be one of the greatest energy consumers in the educative sector.

For water, a comparison could be drawn in relation to the daily consumption of an individual throughout a 24-hour period. An average inhabitant of Barcelona consumes between 130 and 200 L of water every day (CWA 2012). The lower consumption per child (67.3 L/day) could be explained considering age and habits. In general, children under 2 years old are not able to use toilets because they wear diapers, and this fact reduces the number of children consuming water. Furthermore, children do not spend the whole day at nursery school, but around a third of it.

4.4 Application of efficient devices

Efficiency also contributes to the level of consumption by the facilities, and it should be a subject of study. Thus, the infrastructure of the nursery schools was analysed in depth to identify possible relations between the level of the facilities' efficiency and the noted environmental fluxes. **Table 6** shows the degree to which nursery schools adopted measures to save energy and water and manage waste. This degree has been symbolised using crosses: "+" represents the low application of a specific device, "++" medium, and "+++" high. Details of the ranks considered for each measure are found in the legend. The measures considered were as follows: the relative application of several devices for low-energy lighting, time/aerated faucets and toilets with dual-flush capacity; the presence or absence of solar panels and drip irrigation; and the number of fractions being separated. Additionally, the ratio of ecological food in the school was also assessed. According to the nursery school food regulations, applicable to all the centres, at least 5% of foods consumed at school must be ecological.

It was observed that low-energy lighting, solar panels and toilets with dual-flush capacity are measures with lower implantation. Drip irrigation and separated waste fractions have been broadly adopted (+++) by over half of the centres. Timed or aerated faucets and ecological food have different degrees of implementation among nursery schools. Although, as mentioned above, 5% of foods must be ecological at every nursery school, 4 centres did not reach this minimum. In the so-called "green schools" framework, this fact must be taken into account, as it is compulsory but not accomplished by 26% of the centres.

<Table 6>

According to the total punctuation marks in the water and energy measure categories (i.e., adding all the plus signs) and the water and energy consumption per area unit in each nursery school, it could be determined whether applying efficient devices had an impact in the total consumption. In the case of energy, this relation was positive because nursery schools with a higher use of efficient devices (e.g., E, F, H, O) presented a generally lower mean level of energy consumption (88 kWh/m^2) than the others (131.3 kWh/m^2).

This relationship is not so clear for water. An approximation could not be developed because there were some difficulties in the determination of open areas. The garden/playground uses were heterogeneous and varying between vegetable gardens, and some centres had autochthonous plants and a paved playground. Thus, finding a relation held great difficulty, and the use of these types of water-efficient measures could not be directly associated with lower water consumption. It is believed that future investigations should focus on these assumptions, given that it is of great importance to manage and analyse the real efficiency of these well-known devices.

5. CONCLUSIONS

The environmental analysis of the case study nursery schools, considering the inflows of energy, water and transport, shows that this system has an important demand for resources. For instance, around 123 kWh/m^2 of energy are annually consumed in average, which is significantly higher compared to educational facilities in general (87 kWh/m^2) or to sports facilities (90kWh/m^2) (Oliver-Solà et al. 2013). Thus, it is confirmed that these facilities have a high impact on the environment and its reduction is desirable.

Attempts to reduce the energy consumption through the improvement of a centre management should be adapted to its specific conditions, provided that there is considerable variability among the annual consumptions of the nursery schools. The highest value is 4-fold the lowest (from 4.92 to 36.2 kWh), and the centres are distributed homogenously along this range. Previous articles on service buildings also show variability regarding the energy consumption (Farreny et al. 2012; Xin et al. 2012).

Larger nursery schools should be the priority when reducing water consumption in the centres, given that it is highly correlated with the building area (r=0.68). However, the narrow range of values within which the annual water consumptions of the centres is comprised (between 0.4-0.8 m^3 of water /m^2) might indicate that these values are already low and that there is small margin for improvement.

Regarding the transport, the priority for the reduction of its environmental impacts must focus on the reduction of the car usage. This mean of transport represents in average 69% of the transport-derived CO_2eq emissions, in spite of being used only by 19% of children. This vector presents a high potential for environmental savings through the promotion and improvement of sustainable means of transport. However, this might exceed the competence of the nursery school management and require the cooperation of both families (with children attending the centres) and local authorities.

The application of energy-saving devices should be promoted since nurseries with a higher use of these devices show in average lower energy consumption (88 kWh/m^2) than the rest (131.3 kWh/m^2). However, the presence of these devices might be a consequence of a higher environmental awareness and the savings might be at some point a result of a more conscientious management.

Future studies should focus on the development of effective measures to reduce the environmental impacts of nursery schools and services in general. These measures should address with special attention the energy and transport vectors, as they have shown the greater impacts as well as the highest potential for improvement. Also, the measurement methods should be developed in order to check the effect of these measures on the resource consumption of the centres. In the case of energy and water, the centres are unable to know its consumption, given that the expenses are paid by the city council. Thus, reporting these consumptions to the employees might help with the monitoring and the awareness.

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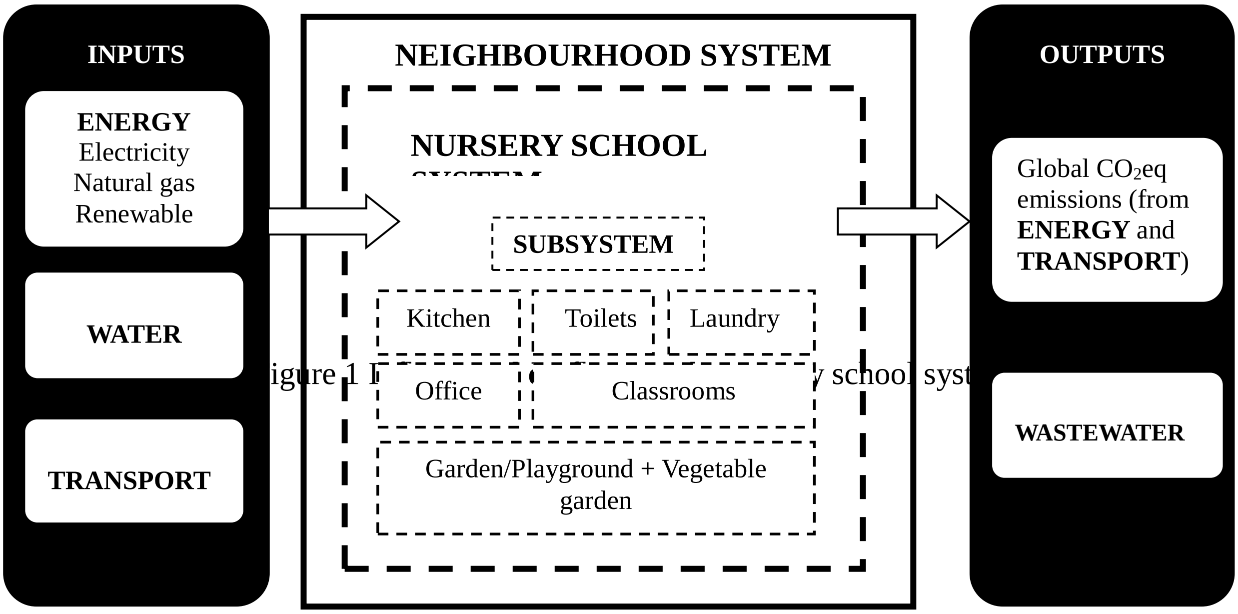
FIGURES AND CAPTIONS



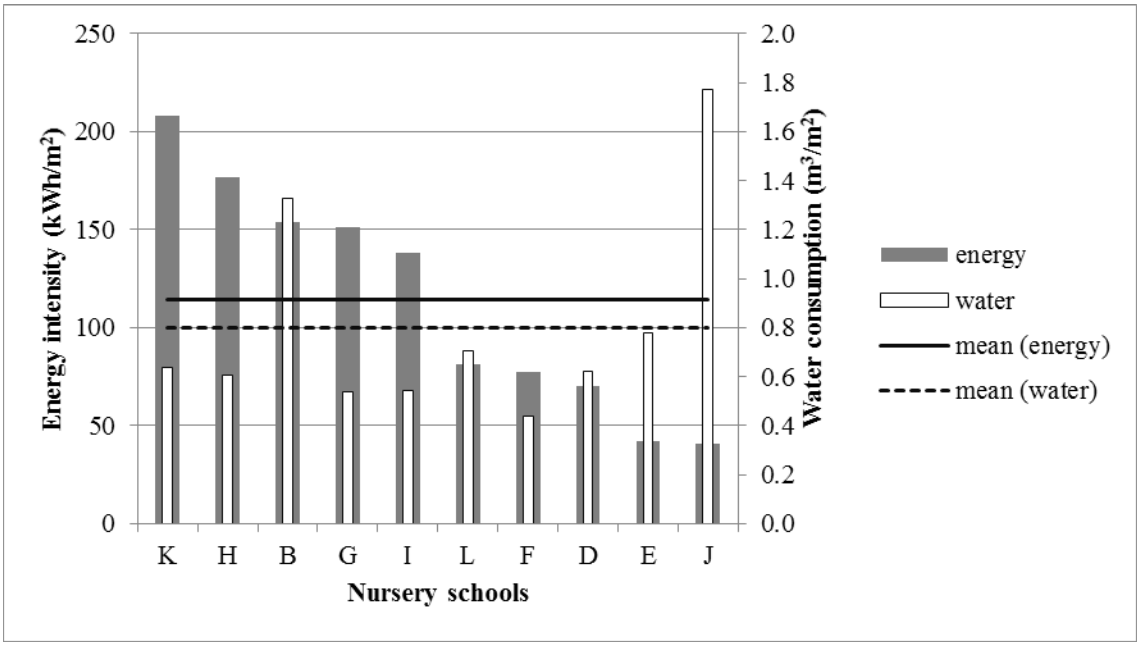


Figure 2 Yearly energy (electricity and natural gas) and water consumption per unit of area. Data for the period 2008-2009

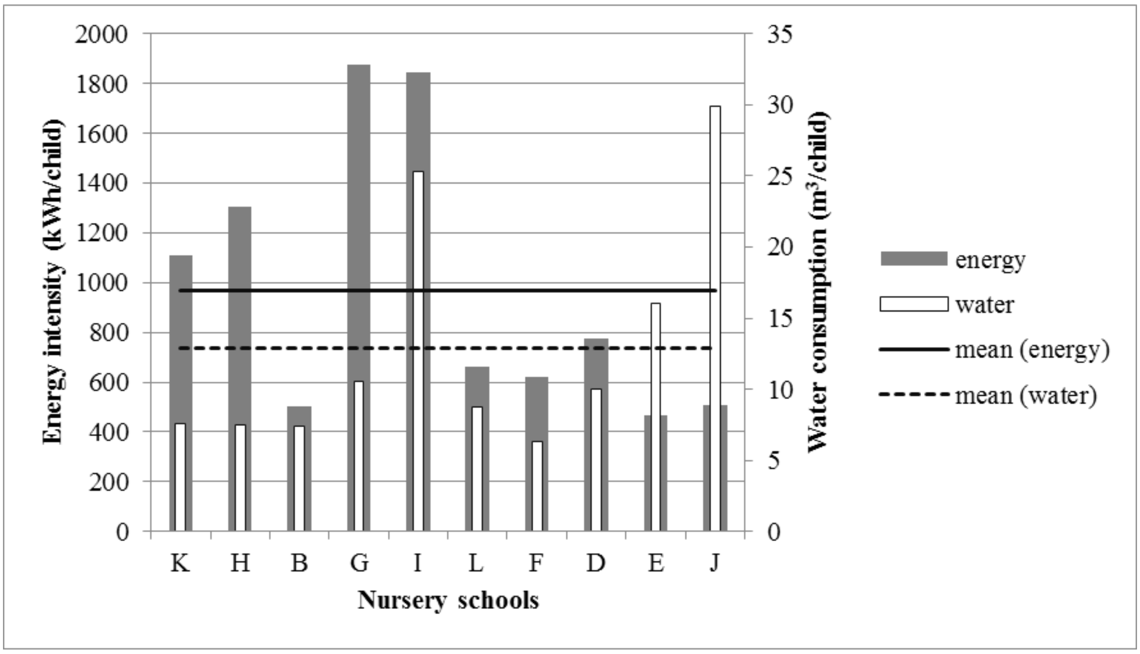


Figure 3 Yearly energy and water consumption per child. Data for the period 2008-2009

Figure 1 Inflows and outflows in the nursery school system

Figure 2 Yearly energy (electricity and natural gas) and water consumption per unit of area. Data for the period 2008-2009

Figure 3 Yearly energy and water consumption per child. Data for the period 2008-2009

Table 1 Main features of the nursery schools (Barcelona, Spain) in 2010-2011

Nursery school ID	**Building area[a] (m^2)**	**Registered children**	**m^2/child**	**Opening hours (yearly hours)**	**Building age[b] (years)**
A	2,142	63	34.0	1,779	4
B	200	36	5.5	1,218	36
C	1,352	63	21.5	1,779	9
D	1,009	63	16.0	1,779	4
E	1,300	63	20.6	2,591	9
F	1,047	73	14.3	1,779	6
G	1,230	63	19.5	1,779	20
H	432	35	12.3	1,779	10
I	2,554	63	40.5	1,779	9
J	1,064	63	16.9	1,779	7
K	750	63	11.9	1,779	29[c]
L	782	63	12.4	1,779	6

[a] Total (building plus playground)

[b] From the foundation year

[c] Since the last relocation

Table 2 Total annual (2009-2010) consumption of gas, electricity and water and total annual emissions derived from transport for transport and energy in the nursery schools

Nursery school ID	Energy consumption (kWh)			Water consumption (m^3)
	Electricity	**Gas**	**Total**	
A	nd	nd	nd	nd
B	4,921	13,104	18,025	265
C	nd	nd	nd	nd
D	31,703	17,092	48,795	628
E	25,479	3,853	29,332	1,013
F	36,267	9,147	45,414	458
G	23,453	94,741	118,194	663
H	12,794	32,831	45,625	262
I	28,170	87,999	116,169	1,593
J	19,660	12,174	31,834	1,886
K	12,523	57,256	69,779	479
L	30,391	11,412	41,803	553
Mean	22,536	33,961	56,497	780
Max.	36,267	94,741	118,194	1,886
Min.	4,921	3,853	18,025	262
Standard deviation	9,940	33,966	34,779	553

nd: no data

Table 3 Correlation analysis for energy/water inflows in relation to the remaining variables (sample size (n) =10)

		Area	**Number of children**	**Opening hours**	**Building age**	**Energy**	**Water**
Area	Pearson's correlation	1	0.740	0.493	-0.629	0.484	0.680
	Sig. (two-tailed)		0.014[a]	0.148	0.051[a]	0.156	0.030[a]
Number of children	Pearson's correlation		1	0.441	-0.469	0.314	0.404
	Sig. (two-tailed)			0.203	0.172	0.383	0.247
Opening hours	Pearson's correlation			1	-0.503	-0.005	0.293
	Sig. (two-tailed)				0.139	0.989	0.411
Building age	Pearson's correlation				1	0.017	-0.394
	Sig. (two-tailed)					0.963	0.259
Energy	Pearson's correlation					1	0.215
	Sig. (two-tailed)						0.551
Water	Pearson's correlation						1
	Sig. (two-tailed)						

[a]A correlation is significant when $p<0.05$ (two-tailed)

Table 4 Percentage of use for each transportation type and percentage of emissions derived from each type

	Mean of transport used (%)				Emissions (tonnes CO_2eq/year)		Relative emissions (%)	
	Car	**Public transport**	**On-foot**	**Bicycle**	**Car**	**Public transport**	**Car**	**Public transport**
A	21	36	43	0	8.62	4.06	68	32
B	9	21	70	0	2.11	1.35	61	39
C	54	33	13	0	22.2	3.72	86	14
D	nd	nd	nd	nd	nd	nd	nd	nd
E	nd	nd	nd	nd	nd	nd	nd	nd
F	45	18	37	0	21.4	2.35	90	10
G	8	26	56	7	3.41	2.92	54	46
H	14	18	64	5	3.19	0.58	85	15
I	15	0	84	1	6.15	0	100	0
J	0	16	84	0	0	1.80	0	100
K	11	11	79	0	4.31	0.56	88	12
L	11	26	57	6	4.51	2.93	61	39
Mean	19	20	59	2	7.58	2.03	69	31
Standard deviation	17	11	23	3	7.82	1.40	29	29

nd: no data

Table 5 CO_2eq emissions derived from energy and transport for each nursery school

Nursery school ID	**Emissions (kg CO_2eq/child)**		
	Energy	**Transport**	**Total emissions**
A	nd	201	nd
B	145	96.1	241
C	nd	410	nd
D	255	nd	nd
E	164	nd	nd
F	214	325	539
G	530	111	641
H	379	120	500
I	406	97.6	504
J	164	28.6	193
K	310	87.9	398
L	224	118	342
Mean	279	159	420
Max.	530	410	641
Min.	145	28.6	193
Standard deviation	134	119	154

nd: no data

Table 6 Punctuations for the application of different efficient devices in each nursery school

		Energy		Water			Food	Waste
		Low-energy lighting	**Use of solar panels**	**Timed/ aerated faucets**	**Toilets with dual-flush capacity**	**Drip irrigation**	**Consumption of ecological food (>5%)**	**Separated waste fractions**
Energy and water existing data	**B**	+	+	++	+	+++	+	++
	D	++	+	+++	+++	+++	++	++
	E	+	+++	+++	+	+	++	+++
	F	+++	+	+	+++	+++	+++	+++
	G	++	+++	++	+	+++	++	+++
	H	+	+	++	+	+++	+++	++
	I	++	+	++	+	+	++	+++
	J	+	+	+++	++	+	+++	+++
	K	+	+	+	+	+	+	+++
	L	+	+++	+	+	+	+	++
Energy and water non-existing data	**A**	+	+++	+	+++	+++	++	+
	C	+	+	+	+	+	++	++
Mean (%)	+	67	73	33	73	40	27	13
	++	20	0	33	7	0	46	40
	+++	13	27	33	20	60	27	47
Legend*	+	0-25%	No	0-25%	0-25%	No	<5%	0-1
	++	25-75%		25-75%	25-75%		5%	2-3
	+++	75-100%	Yes	75-100%	75-100%	Yes	>5%	4

+/++/+++ represent degree of application of the device stated at the top of the column