Energy, water and economic savings by changing habits of users in twelve schools in Spain

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Abstract

Energy saving and the development of renewable energies already form part of the daily discourse in our society. Climate change and the environmental problems arising from it affect all of us on the planet. In view of the recent energy supply crisis in Europe and in line with the EU's Sustainable Development Goals, it is necessary to accelerate the ecological transition. This means, among many other things, encouraging energy efficiency and energy savings. This research is based on the EURONET 50/50 max project, which applied a methodology with no upfront capital outlay, but based on changing user habits to save energy in educational buildings. It was carried out in twelve educational centres of the Spínola Foundation throughout Spain. Significant reductions in energy and water consumption were achieved. The maximum reduction obtained in water consumption was 29%, 24% in electricity consumption and 33% in heating consumption. The average reduction in consumption obtained was 13% compared to 11% achieved in the 50/50 max project. It was concluded that, on the journey to optimising our energy consumption, working on patterns of usage is fundamental, raising awareness and involving users in order to give rise to permanent processes over time, gradually reversing climate change.

Key words: energy empowerment, user habits, energy efficiency, energy consumption in educational buildings, participation of the educational community

Introduction

Relevance of the issue

The increasing climatic and environmental problems require human consumption habits to be reconsidered. The European Union's energy strategy aims to promote energy efficiency, energy saving, and the development of renewable and innovative energies (Comisión Europea, 2016). At COP21, held in Paris, in December 2015, the Paris Agreement was reached. This was the first universal and binding pact on climate change. It also gave rise to the Paris Protocol, applicable from 2020, which establishes urgent and collective action measures for decarbonisation, i.e. a reduction in greenhouse gas emissions (Comisión Europea, 2016) (Comisión Europea, 2015). Proposals such as the "European Green Pact" aim to "make Europe the first climate-neutral continent by 2050" (Comisión Europea, 2016). This action plan includes: ensuring zero net greenhouse gas emissions by 2050, rethinking the energy market by decoupling economic growth from resource use (efficient use), restoring biodiversity, and reducing pollution (Comisión Europea, 2019). Another of the EU's objectives is to guarantee energy supplies to member countries and ensure security in the process. Russia's recent military aggression against The Ukraine has severely affected the EU energy market by increasing the, already very high, electricity and gas prices (Comisión Europea, 2022). Ninety percent of the gas consumed in the EU is imported from abroad, with forty percent coming from Russia. Of petroleum and coal imports, 27 percent and 46 percent respectively come from Russia. Given the current situation, the EU points out that "the need for a rapid transition to clean energy has never been stronger and clearer", and proposes to accelerate the ecological transition. The way forward is to eliminate dependence on imported fossil fuels, reduce greenhouse gas emissions, regulate energy prices, and incentivise energy efficiency and energy savings in order to reduce energy bills and curb climate change (Comisión Europea, 2022).

Literature Review

Energy consumption and the use of natural resources are becoming increasingly important in public spheres as well as in research and academia. The natural and human environments are exposed to growing risks triggered to a large degree by the emission of greenhouse gases in the energy consumption sector (Zhang et al., 2018). These include more frequent and severe extreme temperature events, floods, and cyclones (Easterling et al., 2000). In Europe, the construction sector contributes up to 36% of the total CO_2 emissions released into the atmosphere and consumes 40% of the total energy (Macarulla et al., 2015). Technological innovations by themselves will not be able to achieve low energy consumption targets for buildings: human behaviour must be considered. The potential for energy savings through changes in the occupants' patterns is estimated at a maximum of 25% in residential buildings and 30% in public or commercial buildings (Zhang et al., 2018). There is a need to involve users and raise awareness in them of inefficient consumption's environmental footprint. It has been proven that the most effective methods for raising awareness are: Feedbacks (Chatzigeorgiou & Andreou, 2021), gamification (Morganti et al., 2017), labelling (Neves & Oliveira, 2021), target setting (Sardianos et al., 2020), and community initiatives (Rolim, 2021); with consumption reductions of more than 20% (Iweka, 2019). Digital marketing has also been shown to be more effective than informational approaches, increasing the motivation of individuals through ubiquitous persuasive technologies (Mota et al., 2020). Above all, acting upon habits is a desirable tool for obtaining sustainable behaviour due to its automatic and resilient nature (Bas Verplanken, 2021). A reduction in energy demand by up to 20% can be achieved through citizens´ engagement (Energy Environmental Agency, 2013). In order to change the current consumption pattern, it is necessary to focus on environmental education, both for adults and for children and teenagers in educational centres (Ntona et al., 2015). A study carried out in 50 Greek schools recorded savings on the electricity bill between 5% and 15% by monitoring energy consumption, educational work and participation of the educational community, modifying the behaviour of users (Koumoutsos et al., 2015). Recent studies have shown that there is a two-way influence between parents and children on energy saving. This implies that students, the implementers of future energy policies, are a major stakeholder group in this issue (Wang et al., 2022) (Mylonas et al., 2019). To promote active involvement and awareness, an optimal strategy is to implement learning activities based on experimentation and measurement. The setup of a living lab in which students can go deeply into energy issues and support transformative institutional change (Soko, Setiawan & Widodo, 2019). In working environments, the tendency to save energy and a sustainable consciousness is closely linked to the socio-economic characteristics of each household (Al-Shemmeri, 2017), which is why the employees' willingness to change is not always enough. There has to be a motivational and promotional programme coming from the leadership highlighting the willingness to change from the top and a bottom-up collaborative process (Nisiforou et al., 2012). Energy-efficiency policies in buildings need to be improved by taking into account human behaviour, habits, and local identity.

Euronet 50/50 max

Euronet 50/50 max was a European energy saving project for schools and public buildings, led by the *Diputación de Barcelona* (DIBA) and funded by the European Union through the Intelligent Energy Europe (IEE) programme (*Diputació de Barcelona*, 2016) (Calvo-Gallardo et al., 2022). This programme supported the use and dissemination of clean energy and innovation in energy efficiency (Carvalho, 2012). It was first developed in 50 schools in several European countries between 2009 and 2012. A second part of the project took place between 2013 and 2016, this time in 500 schools in primary and secondary education, and 48 municipal facilities in the participating European countries. In addition, the project included 48 non-educational public buildings such as municipal buildings, sports facilities, museums, libraries, and others (1st Newsletter on the EURONET 50/50 MAX project, 2023).

The aim of the programme was to reduce energy consumption through changes in user behaviour, and to raise awareness among employees and managers of the importance of the rational use of energy. It was strongly recommended that the project participation be visible in the facilities so that visitors are aware of the results obtained as a substantial part of the initiative's endeavour is focused on sharing knowledge and spreading the 50/50 method. The criteria for the selection of the buildings included many factors, such as the motivation of the manager and employees, the cooperation between staff and users, the potential for savings, and the ability to set an example for other public buildings (Diputación de Huelva, IEE & EURONET 50/50 max, 2014). Managers in public and private buildings and managers in institutions were usually inadequately informed about both the electricity use scheme and about the energy-saving potential of their facilities (Plesser et al., 2008). For this reason, the informative part was particularly important. At the same time, the economic viability was essential on the road to energy sustainability in buildings, as it was not always possible to invest large quantities of money. The 50/50 approach was very suitable in this regard because it operated without any initial capital investment. Economic savings arising from previous energy savings resulting from the occupants' change in behaviour were being used. The public building and the municipality (which payed the bills) came to an agreement: 50% of the financial savings were returned to the public facility in cash to be invested in further energy-saving measures; the other 50% went to the municipality as net savings (*Diputació de Barcelona*, 2016). The purpose of these initiatives were to promote compliance with the ambitious European energy efficiency targets and to encourage conscious consumption on the part of users.

The Euronet 50/50 max project ended in 2016. As a result of their experience, a web page was generated (EURONET 50/50 MAX, 2023) in which they collect resources to be able to implement this initiative in schools, non-educational public buildings and in municipalities, as well as a library with different training resources. Although the expected result was a reduction in energy consumption of 8% (Servole et al., 2014), it was finally possible to achieve a reduction in consumption of 11% (Motgé et al., 2016). This reduction was only obtained in 70% of the centres that participated. Furthermore, various European municipalities have decided to include the

50/50 methodology in local energy strategies and action plans as its application can significantly help achieve local climate and energy goals (4th Newsletter on the EURONET 50/50 MAX project, 2023). Finally, a Facebook page has been created in which the 50/50 network is generated, and the good practices carried out are shared, as well as the schedule of events (Join the 50/50 network!, 2023).

Objectives

The research that has been carried out was developed through a series of case studies, consisting of twelve schools of the Spínola Foundation spread across Spain. The aim was to demonstrate that there is a capacity for change without economic investment: that changing the habits of users can lead to significant energy and economic savings. Some studies had even shown that a significant change can be achieved in environments in which energy was not paid for and therefore there was no possibility of economic benefit (Bator et al., 2019). In this case, as it was implemented in the field of education it focused on the collective conscience, and the importance of teamwork, because it became evident that the more people that rowed in the same direction, the further they will go and the greater the change will be (Spires et al., 2021). This generated chains of knowledge, mainly among children and their families, making the application of this type of programme in educational environments very effective. It was just as important to raise awareness among users as it was to foster a sense of ownership and common responsibility. In this way, it was more likely that long-lasting processes will be developed (after the end of the monitoring provided by the 50/50 project), new habits will be maintained and more and more savings will be made, gradually turning the building stock into an efficient sector. This collective participation process can be followed in other fields, such as urban planning, in urban regeneration projects (Schurig & Turan, 2022). Therefore, we can say that the key objectives of the research were: to increase the energy efficiency of schools (reducing consumption by changing habits) and to disseminate the results obtained with the project so that it could serve as an example for the future. It was also intended to observe and determine the scope of this method in terms of energy savings without initial capital investment. The novelty of the study carried out lied in incorporating the reduction in water consumption by changing habits, in parallel to the work with energy developed in the 50/50 max project. Additionally, it was intended to delve into the most relevant causes that contribute to achieving greater success in reducing consumption and the economic savings obtained so that they could be replicated in new experiences to be developed in the future.

Methodology

The study was carried out over a whole school year and followed a series of steps, based on the 50/50 methodology. The case studies had been selected beforehand and had to fulfil a number of conditions, including: that there be a high motivation for change on the part of the manager and staff; that there be good communications between all the agents involved; that information about the building and its users be made available; and finally, that there be potential for savings (Diputació de Barcelona, 2016). The stepsfollowed were:

<u>1º Find the average consumption of the building</u>

The first step was to collect energy consumption bills - including electricity and fuel - and water consumption bills from the last three years from each educational centre. With this data, we found the average monthly consumption values for each building.

2º Building an energy team

The second step consisted of forming an energy team in each centre, which will be responsible for the follow-up and correct development of the project. Among others, its functions were: to coordinate the project and make decisions, detect strengths and weaknesses in the energy management of the facilities and propose improvements, monitor the energy consumption of the centre and inform users of the evolution of the project and promote energy savings (Diputació de Barcelona, 2016). It consisted of the project facilitator, who was a person with knowledge of energy saving in buildings, and representatives of the different groups in the school. A commitment agreement was signed which specifies the responsibilities of the school, the responsibilities of the administration in charge of the project, the method of calculating the savings, and how the school will be reimbursed for the savings (Pellegrino et al., 2022) (Groot, 2022) (Somerwill & Wehn, 2022) (Steg et al., 2015).

3º Make a calendar of work meetings

In each centre, two meetings of the energy team were held every month: one in which the facilitator participated, and another in which the facilitator was absent and only members of the school participated. In the meeting with the facilitator, the advances in the process and possible new ways of working were discussed. In the meeting without the facilitator, the implementation and start-up of the measures and the visualisation of the project for the users of the building were discussed, i.e. how to communicate the progress of the project in a creative and appealing way for the users.

4º Follow-up

With the initial data on the consumption of each building, the monthly energy savings were monitored. The consumption of the current year was compared with the consumption data of the last few years and the progress was visualised. In the work meetings, these data were looked into, criticised and the measures that were working were validated, whilst those that were not giving the expected results were questioned and improved, and new ways of saving energy were proposed. It was important that all data be provided to the energy team (and subsequently to the users) in a clear and understandable way for all. It was also important that the actors involved in the process remained motivated and interested in the project, and that they were empowered and took control (Pianosi et al., 2012) (Mankoff et al., 2014) (Batey et al., 2013) (Leipämaa-Leskinen et al., 2022) (Schot et al., 2016).

To avoid the effect that the Covid-19 lockdown had in the 2019-2020 academic year, the data for the 2020-2021 academic year had been obtained of the Covid-19 lockdown months in the previous academic year. To facilitate the interpretation of the data, they were presented as if they had been collected throughout the same school year, the 2019-2020 academic year.

5º Analyse the data collected

One year after the beginning of the partnership with the participating schools, the facilitator's intervention came to an end, and the savings data obtained were analysed.

6º Continue the process

At the end of the school year, the facilitator withdrawn and the process of change continued without him/her. A coordinator was appointed to replace the facilitator and the entity paying the bills offered a cheque to the school for 50% of the money saved to invest in new energy-saving measures. The aim was that the school's energy team became self-sufficient and could continue the process without external help, that energy savings continued to be achieved and with them, new measures were implemented to increase the school's energy efficiency (Starke et al., 2017) (Burchell et al., 2016).

Centres studied

Table 1 shows the descriptive data of the twelve centres: the constructed area (in square metres), the number of users, the occupancy, and the climatic area in which they are located.

Table 1. Data on the centres.

Centre	Constructed area (m2)	Users	Occupation (m2/user)	Climate zone
1	4,607	336	14	C4
2	6,589	745	9	B4
3	2,557	367	7	C4
4	1,686	165	10	C4
5	5,363	836	6	C4
6	18,171	1,354	13	D3
7	9,230	812	11	D3
8	11,813	1,200	10	A3
9	4,569	334	14	C4
10	3,114	349	9	D3
11	7,383	751	10	B4
12	9,837	1,271	8	B4
Maximum	18.171	1,354	14	
Median	5.976	748	10	
Minimum	1.686	165	6	
Range	16.485	1,189	7	

All schools have a surface area of between 1,000 and 11,000 m2, except the largest (school 6), which is the exception with 18,000 m2.

They can be grouped together according to the number of pupils in four categories: between 1,200 and 1,350 pupils (schools 6, 8 and 12), between 700 and 850 pupils (2, 5, 7, and 11), between 300 and 400 pupils (1, 3, 9 and 10) and between 150 and 200 pupils (4).

In terms of the occupancy of the centres, the median value is within the Technical Building Code for this type of building (10 m2/user). The dispersion of values is symmetrical and the most extreme cases on both sides correspond to centres with a surface area close to the median.

The educational centres are distributed throughout the 4 winter climate zones present in the Iberian Peninsula, represented by the letters A, B, C, and D. The only climate zone in which there are no centres is the most severe climate zone, zone E. The summer climate zone is less relevant as the schools studied do not have air conditioning. There are only schools located in the 2 most demanding summer climate zones, represented by numbers 3 and 4. There are no schools in zones 1 and 2, with a milder summer climate. These climatic zones have been classified according to the Technical Building Code (Ministerio de Fomento, 2017). As regards the Köppen-

Geiger climate classification, all the centres are in the CSa climate type: temperate climate with a hot and dry summer.

Changes in user behaviour carried out

Throughout the development of the study, the following actions and information aimed at changing user behaviour have been carried out:

- Report the savings that have been achieved during the month, thanks to the actions that are being carried out by the energy team at the monthly meetings.

- Make an informative panel of the study that is being carried out, of the members of the energy team and of the reduction in consumption, updated monthly.

- Prepare posters that remind students of the need to close windows, doors and taps, turn off the lights and disconnect computer equipment when the classrooms are no longer in use.

- Appoint a rotating person in each classroom who is in charge of verifying that when the classroom is no longer in use, the doors and windows remain closed, the lights are off, and the computer equipment is disconnected.

- Carry out a survey into the sensation of thermal comfort in the different classrooms, as well as taking measurements of the temperatures throughout the day so that a thermal map of the educational centre is generated, identifying those classrooms that have excessive heat, those that have a lack of heat and those that are in adjusted temperature conditions.

- Study the management of the on and off schedule of the heating boiler, so that it can be adjusted according to the outside temperature.

- Study the possibility of regulating the radiators to adjust their operation according to the needs.

- Carry out a measurement of the flow of water that comes out of the taps in the sinks and the time that the timers remain open in order to identify the efficiency of the different taps.

- Make informative posters about the correct use of the pushbuttons in the toilet cisterns that have double pushbuttons.

- Carry out a measurement of the lighting levels in the different classrooms to establish a lighting update criterion, prioritizing the increase in the lighting level in those cases that present a deficit, and the reduction in the cases that present an excessive lighting level.

- Carry out a measurement of the consumption of the equipment when they are on stand-by in order to insist on their total disconnection to avoid electricity consumption when they are not being used.

- Develop an energy shutdown protocol for the educational centre the day before the holiday periods.

- Students make short videos in which they explain the measures they are taking.

- Establish working groups to promote the different measures in each area: water, electricity, heating and communication.

Electricity consumption results

Table 2 below shows the electricity consumption data. This table includes the average electricity consumption per square metre, 2019-2020 electricity consumption per square metre, electricity savings per square metre, percentage of electricity savings, electricity cost per square metre and economic savings in electricity cost per square metre.

Table 2. Electricity consumption and cost data.

Centre	Average electricity consumption (kWh/m2)	2019-2020 electricity consumption (kWh/m2)	Electricity savings (kWh/m2)	Electricity savings (%)	Electricity cost (€/m2)	Economic savings in electricity cost (€/m2)
1	6.1	5.6	0.5	8%	1.04	0.20
2	5.5	4.2	1.3	24%	1.22	0.59
3	9.3	7.3	2.0	22%	1.80	0.57
4	14.2	11.9	2.2	16%	3.18	0.86
5	8.6	7.4	1.1	13%	1.80	0.85
6	11.4	11.1	0.3	3%	1.90	0.40
7	9.5	9.1	0.4	5%	1.75	0.05
8	8.3	7.5	0.8	10%	2.18	0.08
9	4.6	4.8	-0.2	-4%	1.08	0.30
10	5.4	4.9	0.5	9%	1.32	0.28
11	7.9	6.7	1.2	15%	2.07	0.41
12	7.4	6.8	0.6	8%	1.57	0.43

Maximum	14.2	11.9	2.2	24%	3.2	0.9
Median	8.1	7.1	0.7	9%	1.8	0.4
Minimum	4.6	4.2	-0.2	-4%	1.0	0.0
Range	9.6	7.8	2.4	28%	2.1	0.8

Heating consumption results

Table 3 below shows the starting conditions in terms of historical heating consumption based on the centre´s climatic zone.

Table 3. Heating consumption data depending on the climatic zone.

Centre	Average heating consumption (kWh/m2)	Climate zone
8	0.0	A3
12	207.6	B4
2	48.5	B4
11	0.0	B4

5	404.0	C4
4	290.8	C4
9	177.2	C4
3	31.3	C4
1	17.1	C4
6	105.0	D3
7	31.5	D3
10	30.6	D3

Table 4 below shows the heating consumption data. This table includes the climate zone, average heating consumption per square metre, the 2019-2020 heating consumption per square metre, heating savings per square metre, percentage of heating savings, heating cost per square metre and economic savings in heating cost per square metre.

Table 4. Heating consumption and cost data.

Centre and climate zone	Average heating consum-ption (kWh/m2)	2019-2020 heating consum-ption (kWh/m2)	Heating savings (kWh/m2)	Heating savings (%)	Heating cost (€/m2)	Fuel	Economic savings in heating cost (€/m2)
1 (C4)	17.1	14.8	2.3	14%	1.37	diesel	0.19
2 (B4)	48.5	33.2	15.2	31%	0.32	gas	0.19
3 (C4)	31.3	25.0	6.3	20%	2.42	diesel	0.48
4 (C4)	290.8	274.3	16.5	6%	2.42	diesel/ propane	0.13
5 (C4)	404.0	411.3	-7.3	-2%	2.02	gas	0.24
6 (D3)	105.0	101.3	3.7	4%	4.02	gas/diesel	0.47
7 (D3)	31.5	28.0	3.5	11%	2.25	gas	0.18
8 (A3)	0.0	0.0	0.0	0%	0.00	-	0.00
9 (C4)	177.2	137.2	40.0	23%	0.97	gas	-0.02
10 (D3)	30.6	28.2	2.4	8%	2.42	diesel	0.19
11 (B4)	0.0	0.0	0.0	0%	0.00	-	0.00
12 (B4)	207.6	138.3	69.3	33%	1.18	gas	0.52
Maxim.	404.0	411.3	69.3	33%	4.02		0.52
Median	76.7	67.2	5.0	12%	2.1		0.2
Minim.	17.1	14.8	-7.3	-2%	0.3		-0.02
Range	386.9	396.5	76.6	35%	3.70		0.54

Water consumption results

Table 5 below shows the water consumption data. This table includes average water consumption per user, 2019-2020 water consumption per user, water savings per user, percentage of water savings, water cost per user and savings in water cost.

Table 5. Water consumption and cost data.

Centre	Average water consumption (m3/user)	2019-2020 water consumption (m3/user)	Water savings (m3/user)	Water savings (%)	Water cost (€/user)	Economic savings in water cost (€/user)
1	2.7	2.4	0.3	11%	5.0	0.5
2	1.7	1.3	0.5	29%	5.4	0.9
3	5.0	3.8	1.2	24%	11.7	2.9
4	3.6	2.7	0.9	25%	5.4	-2.0
5	2.4	1.9	0.5	21%	6.9	5.0
6	8.7	6.9	1.8	21%	17.5	5.2
7	2.3	2.1	0.3	13%	4.0	0.4
8	3.4	3.7	-0.3	-9%	8.7	-0.6
9	6.7	5.0	1.7	25%	8.1	-4.0
10	2.6	2.0	0.6	23%	6.0	1.7
11	2.5	2.3	0.2	8%	3.4	-0.6
12	1.3	1.4	-0.1	-8%	3.1	0.4
Maximum	8.7	6.9	1.8	29%	17.5	5.2
Median	2.7	2.4	0.5	21%	5.7	0.5
Minimum	1.3	1.3	-0.3	-9%	3.1	-4.0
Range	7.4	5.6	2.1	38%	14.4	9.2

Electricity, heating and water consumption savings

Table 6 below shows electricity, heating and water consumption savings as a percentage. The centres are arranged from highest to lowest savings.

Table 6. Consumption savings.

Centre	Average savings (%)	Electricity savings (%)	Heating savings (%)	Water savings (%)	Users
2	28%	24%	31%	29%	745
3	22%	22%	20%	24%	367
4	16%	16%	6%	25%	165
9	15%	-4%	23%	25%	334
10	13%	9%	8%	23%	349
11	12%	15%	-	8%	751
1	11%	8%	14%	11%	336
5	11%	13%	-2%	21%	836
12	11%	8%	33%	-8%	1.271
7	10%	5%	11%	13%	812
6	9%	3%	4%	21%	1.354
8	1%	10%	-	-9%	1.200

Finally, table 7 below shows the total economic savings that have been obtained in this study.

Table 7. Economic savings.

Centre	Constructed area (m2)	Users	Economic savings in electricity cost (€/m2)	Economic savings in heating cost (€/m2)	Economic savings in water cost (€/user)	Total economic savings (€)
6	18,171	1,354	0.40	0.47	5.2	24,122
12	9,837	1,271	0.43	0.52	0.4	10,739
5	5,363	836	0.85	0.24	5.0	6,754
7	9,230	812	0.05	0.18	0.4	3,648
3	2,557	367	0.57	0.48	2.9	3,519
2	6,589	745	0.59	0.19	0.9	3,174
1	4,607	336	0.20	0.19	0.5	1,919
10	3,114	349	0.28	0.19	1.7	1,777
4	1,686	165	0.86	0.13	-2.0	108
11	7,383	751	0.41	0.00	-0.6	-451
8	11,813	1,200	0.08	0.00	-0.6	-720
9	4,569	334	0.30	-0.02	-4.0	-1,519
Total	84,919	8,520				53,070

Electricity consumption discussion

A research carried out in educational buildings in Slovenia documented an average electricity consumption of 16 kWh/m2 (Butala & Novak, 1999). The consumption documented in this investigation is significantly lower.

The 50/50 max project achieved a reduction in consumption in 70% of cases. This study has documented a reduction in electricity consumption in 11 centres out of the 12 analysed, which represents 92% of the cases.

The 50/50 max project expected a reduction in consumption of 8%. Finally, a reduction in consumption of 11% will be achieved. In the case studied, the average reduction in consumption obtained is 9%. If we find the average of the centres that have obtained savings, this figure rises to 10%, a value very similar to that obtained by the 50/50 max project.

However, there are two centres that have obtained a reduction in consumption of more than 20%: 2 and 3. These are centres that have a medium and low area, but not the smallest. As regards the number of users, they are in the average and in the low section, but not in the section with fewer users. As regards electricity consumption, they are in the middle and the low section. Therefore, it cannot be inferred that the starting conditions have influenced the result obtained.

The next two best centres, 4 and 11, have obtained a reduction in consumption of more than 15%, also above the 11% achieved in the 50/50 max project. Centre 11 also has median values for area, users and electricity consumption. Centre 4 is the smallest building, with the lowest number of users and the highest electricity consumption. In principle, it could be expected that, with these conditions, it would obtain the best results, given that it has significant savings potential and that it has a very small group of users, which facilitates internal communication.

The centre that has not managed to reduce its consumption is centre 9, the centre with the lowest consumption. It consumes approximately 50% of the sample median. It has a very efficient use of electricity and it is difficult to improve it.

The two centres that have reduced their consumption the least, 6 and 7, are below 5%. Centre 6 is the largest centre, with the most users and the second centre with the highest electricity consumption. The high consumption implies that there is significant room for improvement, but the large number of students makes internal communication difficult, which is essential to achieve the involvement of all users. The other two largest centres with the largest number of users, 12 and 8, have obtained a reduction in consumption of 8% and 10%, closer to the expected values and obtained by the 50/50 max project. These results suggest that the larger size of the centre and the greater number of users makes it difficult to obtain better results than the average.

As regards the cost of electricity consumption per square meter, the worst centre is 4. It is the smallest centre, with fewer users and the highest electricity consumption. The reduction in consumption has been the third largest and has obtained the greatest economic savings per square meter. It started from the worst conditions, so the important work carried out has had a greater economic impact.

The next centre with the highest cost per square meter is 8. It is a large centre in terms of surface area and a large number of users. However, its consumption is close to the median. In this case, despite achieving a reduction in consumption above the median, the economic savings obtained are among the lowest. This suggests the importance of periodically studying whether it is possible to optimize the contracted rate.

The centre with the lowest cost per square meter is 1. Despite reducing consumption by 8%, the economic savings are also among the lowest. Centres 7 and 10 have a reduction in consumption of 5% and 9% respectively, while their financial savings are very low. These centres have a cost per square meter close to the median or slightly lower. This situation affects the need to periodically study whether it is possible to optimize the contracted rate. Reductions in consumption close to the median obtain lower economic savings than other centres with similar reduction in consumption. It is worth noting the importance of the rates that are contracted in the economic impact of the efforts made to change habits. The lower reduction in consumption, when the rate is optimized, the greater the economic savings are achieved.

Heating consumption discussion

There are two centres, 8 and 11, which do not have a heating installation and are located in the mildest areas in terms of winter weather conditions: A and B.

The first thing that stands out is the difference in heating consumption, for centres that are located in the same winter climate zone. The two centres located in climatic zone B have a heating consumption of 208 and 49 kWh/m2 respectively. The five centres located in zone C have a heating consumption of between 17 and 404 kWh/m2. Finally, the three centres located in zone D register consumption of between 31 and 105 kWh/m2. Normally, buildings located in colder climatic zones have a better thermal performance, which would explain why the worst building located in zone D has a lower consumption than the worst building located in zone B. What is surprising is that both the worst buildings located in the intermediate zone, zone C, significantly outperform buildings located in more extreme zones.

In a research carried out in educational buildings in Luxembourg the heating consumption range was from 24 to 197 kWh/m2. In the present investigation, data were obtained from 2 educational centres with worse behavior than Luxembourg centres (Thewes et al., 2014). In a research carried out in educational buildings in Finland the heating consumption range was from 80 to 319 kWh/m2. In the present investigation, data were obtained from 1 educational centre with worse behavior than Finnish centres (Ruusala, Laukkarinen, & Vinha, 2018)

However, what the data in table 3 shows is that, for buildings located in the same climatic zone, with a similar use and a similar construction, such a difference in heating consumption could be significantly reduced depending on how it is use this facility.

The 50/50 max project achieved a reduction in consumption in 70% of cases. This study has documented a reduction in heating consumption in 9 centres out of the 10 that have heating facilities, which represents 90% of the cases.

The 50/50 max project expected a reduction in consumption of 8%. Finally, a reduction in consumption of 11% was achieved. In the case studied, the average reduction in consumption obtained is 12%, a value very similar to that obtained by the 50/50 max project.

However, there are two centres that have obtained a reduction in consumption of more than 30%: centres 12 and 2. Centre 12 has a surface area, a number of users, and high heating consumption. Centre 2 has a medium area and number of users and low heating consumption. Both centres have in common that they are located in the mildest winter climate zone, zone B. This indicates that, despite the starting conditions in terms of heating consumption, the buildings located in the more climatically benign zone have a greater possibility of reducing said consumption.

The five centres located in climatic zone C present an unequal reduction in consumption. The three centres with the lowest consumption are the centres that reduce their consumption the most after the centres located in zone B. The first two exceed 20% and the third 14%. This behaviour reinforces the idea that the more benign in the climatic zone, the more reduction in heating consumption is possible. However, the other two centres located in climate zone C do not follow this pattern. These are the two centres with the worst initial performance. Centre 4 achieves a consumption saving of 6% while centre 5, with the worst initial consumption of all the centres, increases its consumption by 2%. These results indicate the need to analyse in greater depth what facilities these centres have and how they are being used to find out the causes of the little improvement obtained with starting data that would allow a greater margin for improvement.

As regards the three centres located in climatic zone D, they are the ones that least manage to reduce their consumption. However, the same thing happens with the centres located in climatic zone C. The two centres with the lowest initial consumption reduce their consumption by 11% and 8% respectively, while the centre with an initial consumption that triples that of the centres that share its climatic zone, only manages to reduce its consumption by 4%. It is necessary to analyse the type of heating installation that the building has and how it is being used to find out the causes of the little improvement obtained with starting data that would allow a greater margin for improvement.

Regarding heating savings values, 33% of the centres achieved values higher than 10.4 kWh/m2 obtained in a research carried out in Finnish school buildings (Sekki, Airaksinen, & Saari, 2017).

When paying attention to the cost per square meter, the difference between the centre that pays the most, centre 6, with a cost of €4.02/m2, and the next three centres, centres 10, 4 and 3, whose cost is €2.42/m2. The four that pay the most use diesel for heating. But the consumption of the four centres is very uneven. Centre 6, whose cost is 166% higher, consumes 105 kWh/m2, while centre 4 consumes 291 kWh/m2, 277% more and has a 60% lower cost. The same cost is supported by centres 10 and 3, but with a consumption of 31 kWh/m2, 30% lower than the consumption of centre 6. Using the same fuel, diesel, whose cost is higher than the centres that use gas, there is not a direct relationship between consumption and cost. It is necessary to analyse the characteristics of the heating installation, how it is used and the fuel rate in centres that use diesel to find out the causes of the cost differences that are not related to their consumption.

Centre 1, however, using diesel, has a cost of €1.37/m2, 57% cheaper than centre 3, the next centre that uses diesel and has a lower cost. In this case, its consumption is 17 kWh/m2, 55% less than the consumption of centre 3. Here, the expected proportionality between consumption and cost is detected, using the same fuel.

As regards the centres that use gas, the three whose cost is lower, centres 12, 9 and 2, maintain proportionality between consumption and cost. The same does not happen with centres 7 and 5. Centre 7 has a consumption of 31.5 kWh/m2 with a cost of €2.25/m2, while centre 5 has a consumption of 404 kWh/m2 with a cost of €2.02/m2. Neither cases maintain the proportional relationship of the rest of the centres that use gas, centre 7 due to excess and centre 5 by default. It is necessary to analyse the characteristics of the heating installation, how it is used and the gas rate in centres 7 and 5 to find out the causes of the cost differences that they present that are not related to their consumption.

On the other hand, the fact that the centre with the lowest consumption is not the one that pays the least for heating consumption, but the fourth that spends the least, and the fact that the centre with the highest consumption of heating is the fifth that spends the least, discourages the reduction in heating consumption. The type of fuel used has more influence on the cost than the consumption.

As regards the economic savings per square meter obtained, it is worth noting that they are not linked to the percentage of savings that has been achieved, with the initial consumption from which they started and with the type of fuel used and they use gas, diesel and both fuels. The three centres with the greatest economic savings, around €0.5/m2, have reduced their consumption by 33%, 20% and 4% respectively, starting from a consumption of 207.6, 31.7 and 105 kWh/m2. They were in the high part in terms of heating costs, but other centres with similar costs have had more modest financial savings. In this sense, it is worth mentioning that centre 9, with a 23% reduction in consumption, has seen its spending increase by 2%, as a result of the increase in the cost of the fuel used.

Water consumption discussion

The 50/50 max Project did not address saving water by changing user habits. In this study, water savings have been achieved in 10 of the 12 centres analysed, representing 83% of the total. This value is above the 70% reached in the 50/050 max project in relation to energy savings.

The 50/50 max project expected a reduction in consumption of 8%. Finally, a reduction in consumption of 11% was achieved. In the case studied, the average reduction in water consumption obtained is 15%. This value is above the electricity and heating savings obtained, which shows that with the change in habits a greater reduction in water consumption is achieved.

Average water consumption in Spanish schools is 1.7 cubic meters per year per user, ranging between 0.7 and 4.0 cubic meters per year per user (Barón & González, 2003). There are only two centres with lower water consumption than the average registered by Barón. Although there are seven other centres whose water consumption is within the range registered by Barón. The three centres with greater water consumption than the aforementioned reference range, centres 6, 9 and 3, should be analysed in depth to find out what has caused their overconsumption.

As regards savings in water consumption, the centre with the lowest water consumption, centre 12, suffered an 8% increase in consumption. Even so, its consumption continues to be below the referenced average value. However, the centre with the second lowest water consumption, centre 2, was the centre that presented the highest percentage reduction in consumption: 29%.

Six centres have reduced their water consumption between 21% and 25%. Among them are the three centres with the highest water consumption.

This means that the reduction in water consumption does not depend on the initial situation, since the two centres that consume less water are at different extremes in terms of the percentage of the reduction in consumption and the centres that consume the most water obtain reductions in consumption similar to other centres with mean consumption values.

Three centres present a reduction in consumption of between 8% and 11%, while there are only two centres that fail to reduce their water consumption. Centre 8, despite having water consumption above the median, increased its consumption by 9%. It would be necessary to study in depth the circumstances that have led to this increase in consumption.

The centres that manage to reduce their consumption do so with a minimum reduction of 8%, a value above what happens in the consumption of electricity and heating. Changes in water consumption habits produce greater reductions in consumption than changes in energy consumption habits.

As regards the cost of water consumption, it is observed that there are no great differences depending on the consumption. Centre 2 has a high cost and centre 9 has a lower cost. This is due to the difference in water rates in each municipality. It is not possible to act on this parameter from the centres themselves. This is a factor that discourages the adoption of changes in habits, since it is precisely the centre with the second lowest consumption, centre 2, which is the one with the highest rate.

This situation translates to a reduction in cost. Centre 2, which presents the greatest reduction in consumption, is fifth in terms of a reduction in cost. It should also be noted that there are four centres that increase the cost despite the fact that three of them achieve significant reductions in consumption. While a centre that increases consumption achieves reduction in cost. The reason is the change in the rate that has occurred.

Electricity, heating and water consumption savings discussion

Despite the fact that one centre has not been able to reduce electricity consumption, another centre has not been able to reduce heating consumption and two centres have not been able to reduce water consumption, all centres have obtained an overall reduction in their electricity, heating and water consumption as a whole. This result of 100% of centres that reduce their consumption is higher than the 70% obtained in the 50/50 max project.

The average reduction in consumption for electricity, heating and water has been 13%, 2 points above the 11% reached in the 50/50 max project, which indicates that the fact of including the reduction of water consumption in this study improves the results obtained compared to the 50/50 max project.

Centres with more than 1,000 users achieve lower reductions in consumption. Centres with between 700 and 850 users are in the middle of the table. Centres with fewer than 400 users are at the top of the table. The only exception is centre 2, which has 745 users and is the centre with the greatest savings.

This means that the smaller the number of students, the easier it is to carry out the changes in habits that are proposed by the energy team. For this reason, it is worth noting the importance of communicating the proposals of the energy team so that they reach all users of the centre. Despite this, it is possible to obtain better results with a larger number of students. Undoubtedly, the motivation of the energy team to get all the users of the centre involved is a more determining factor.

As can be seen, the greater total economic savings are not directly related to the percentage reduction in consumption that has been carried out. The centre that achieves the most savings is centre 6, with three times the surface area of the median, despite being the penultimate in terms of reduction in consumption with 9%.

However, the size of the centre is not the only data that influences the economic savings obtained. The second largest centre, centre 8, is the second worst centre in terms of economic savings. This is because it is the worst centre in terms of reduction in consumption with 1%.

Nor is the reduction in consumption percentage the only data that influences economic savings. centre 2 with the greatest reduction in consumption, 28%, is the sixth in terms of economic savings, despite having 6,589 m2. It is surpassed in economic savings by centre 3 with 2,557 m2 and a reduction in consumption of 22%.

Obtaining a significant reduction in consumption is just as important, an action that can be influenced by the work carried out in this study, such as optimizing electricity and fuel rates, since it is not possible to modify the water rate.

Discussion about the implementation of the methodology

The educational centres in which the best results were achieved have been those in which greater involvement of the energy team had been achieved. The involvement of different teachers was achieved, who carried out initiatives in line with the methodology that was implemented in different subjects with students of different ages. The involvement of students of all ages was achieved and dynamic work teams were formed in each of the work areas: electricity, heating, water and communication of results. The involvement of the building maintenance manager was achieved to be aware of introducing the small improvements that were indicated by the energy team. The involvement of the person responsible for the centre's administration was achieved, who quickly provided the billing data, which allowed fluid communication of the evolution of the process as it was carried out. The energy team coordinator knew how to encourage the participation of all agents and follow the process so that it was carried out successfully.

The educational centres with the worst results had greater difficulties in implementing the methodology due to delays in the start, reluctance on the part of members of the energy team to implement the methodology or attend meetings, and work overload with other simultaneous initiatives. There were also difficulties in terms of communicating the results that were being obtained from the energy team to the entire educational community.

Discussion of limitations of the research

One of the limitations of the research that was carried out is the difficulty of knowing if there was any significant change in educational centres that could have modified the consumption of electricity, heating or water regardless of the change in consumption habits that was worked on with users. To minimize this limitation, billing for the last 3 years was requested, instead of requesting billing for the last year, which was intended to minimize the distortion of the initial data, ensuring that they were more reliable.

Another limitation offered by the research is that the heating consumption data do not allow comparison between centres, due to the different climatic conditions that affect them, as they are located in different places in Spain. To minimize this limitation, the results have been analyzed by comparing the centres with others located in the same climatic zone.

The consumption carried out in the buildings was analyzed based on the billing data. The electricity bill collects monthly consumption data. The gas bill includes the heating consumption that occurs in two months. The diesel tanks are filled 1 or 2 times a year. The water bill includes the consumption that occurs in two months. In order to understand in greater depth the profile of consumption that took place in the centres, it would have been desirable that said consumption had been monitored in order to have hourly data and have been able to discriminate the consumption that took place during school periods, in the hours in which the educational centre was being used, during the hours it was not being used, on weekends and holiday periods. Such information would allow a greater capacity for analysis and the adoption of measures more in line with what happened in each center.

Conclusions

Environmental challenges require us to reduce our carbon footprint on the planet. To do this, we need to optimise our human behaviour, improve our consumption habits, and work collaboratively towards a future in which our energy use is as efficient as possible. The results of the research show that projects in line with the 50/50 methodology are indeed effective in achieving economic and energy savings. This study has been carried out in 12 centres located in different parts of Spain with a total area of 85,000 m2. Work has been done to raise awareness and change the habits of energy and water consumption of a total of 8,500 people in educational centres, with a multiplier effect by transferring the work carried out to their respective domestic environments.

The 50/50 max project achieved a reduction in consumption in 70% of cases. This study has documented a reduction in 100% of the centres in the joint consumption of electricity, heating and water. The motivation and follow-up work carried out by the management of the Spínola Foundation, the private foundation that owns the centres, has achieved greater success in terms of the involvement of the centres than the 50/50 max project, carried out in Public Buildings.

In this study, an average reduction in energy and water consumption of 13% has been achieved, surpassing the 11% reduction in energy consumption obtained by the 50/50 max project. Expanding the scope of the 50/50 max project, including changing water consumption habits, contributes to achieving better results. The financial savings obtained are €53,000.

A significant difference has been characterized in terms of the consumption of the centres. In the case of electricity, the difference between the maximum and minimum consumption per square meter compared to the median is 60%. In the case of 250% heating in the same climatic zone. In the case of water, 140%. These differences highlight that those centres whose consumption is higher have room to reduce their consumption.

In the case of electricity, it has been found that larger centres with a greater number of users have more difficulty in reducing their consumption. This happens regardless of the consumption they made before starting the work with the users. This result shows the importance of working on internal communication in this type of initiative in order to involve the largest possible number of users.

In the case of heating, the results obtained in this study show that, regardless of the starting conditions in terms of heating consumption, the more benign the climatic zone, the greater the reductions in consumption are obtained. Buildings require less thermal insulation the less severe the winter, so the changes in habit that are introduced have a greater impact than in buildings that are better prepared for the cold of winter.

It has been verified that the change in water consumption habits produces greater reductions in consumption than the change in energy consumption habits, so its inclusion in this type of project has a motivating effect, since, in general, it gets better results.

As regards the economic repercussion of the reductions in electricity consumption that have been registered, it is worth noting the importance of the rates that are contracted in the economic impact of the efforts made to change habits. In the case of heating, the type of fuel used has more influence on the cost than the consumption made. It confirms what was already known: using gas is currently cheaper than using diesel.

It is just as important to obtain a significant reduction in consumption, an action that can be influenced by the work developed in this study, such as optimizing electricity and fuel rates, since it is not possible to modify the water rate.

In order to avoid the disincentive effect for changing habits that involves reducing consumption and paying more despite this, it would be more desirable to use an indicator other than the indicator of economic savings that has been used that compares the average cost of the three previous school years with the cost of the course in which the intervention is carried out. The indicator proposed for future research is the economic extra cost that would have to be paid for what has been stopped by applying the rate for the academic year in which the reduction in consumption has occurred. In this way, a reduction in consumption would always lead to economic savings.

As regards policies aimed at energy efficiency, the study carried out shows the great importance of including, along with the measures to be carried out in buildings and their facilities, work with building users in terms of their awareness and their energy consumption habits. Significant results are achieved by incorporating this dimension, as has been demonstrated.

For the facility managers of schools, the motivation for the implementation of this type of initiative, as well as its follow-up and promotion throughout the process, are of great importance in achieving the involvement of all the centres in which they are involved, as has been reflected in the present study.

The results of the research carried out indicate that consumption habits are fundamental in the path towards energy efficiency. By working on them, raising awareness and involving the users of the centres, significant reductions in consumption and significant economic savings are obtained with which to reinvest in energy efficiency to achieve a better equipped building stock and a society that is more aware of fighting climate change.

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