Sustainable Development
In Basketball Arenas

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Energy-Saving Systems

In recent years, the growing importance of the energy problem has led to a need for rational use of energy and, accordingly, a need to reduce and contain the cost of the energy needed for setting up activities in stadiums.

Prompted by Agenda 21, a world-wide programme directed by the United Nations, many countries have agreed to adopt policies aimed at sustainable development. In recent years, the International Olympic Committee (IOC) has also focused on environmental protection and sustainable development, leading to the adoption of the Olympic Movement's Agenda 21. The section on "Sport and the Environment" states that energy saving in sports facilities is a priority issue.

Most industrialised nations have ratified the Kyoto Protocol, thereby undertaking to reduce greenhouse gas emissions (carbon dioxide and five other greenhouse gases, that is, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) by at least 5.2% in 1990 – regarded as the reference year – during the 2008-2012 period. In recent years, there has been extensive research into methods, technologies and strategies to reduce energy consumption. This has led to the growth and spread of an environmentally beneficial energy-saving culture ultimately aimed at limiting the release of carbon dioxide into the atmosphere. At the **21st United Nations Climate Change Conference** (*COP 21*), held in Paris in 2014, 195 countries came together to draft a replacement for the Kyoto Protocol. This is a summary of the key areas of the agreement in four issues:

1. **Targets:** To achieve the objective that the average temperature increase by the end of the century will be between **1.5 and 2 degrees**, it was established that all countries should achieve a ceiling for their greenhouse gas emissions as soon as possible.
2. **Mitigation:** The principal instrument on which the so-called **nationally determined contributions** are based. At the present time, 186 of the 195 countries negotiating have presented plans to reduce their emissions.
3. **Binding nature:** It has been officially reiterated that **the agreement will be binding**. What will not be binding are the emissions reduction targets of each country.
4. **Finance:** In order that countries with fewer resources may adapt to the effects of climate change and may also reduce their emissions, **an obligation was established for international aid to be available**.

Building planning methods have also been influenced by this action to protect the environment because the energy consumption tendencies of a building can be anticipated at the planning stage, thus allowing energy needs to be defined beforehand. The choice of energy sources can be foreseen, studied and optimised from the start of a project on the basis of traditional innovative sources or renewable energy sources (sun, wind, geothermal energy, etc.).

Other technological methods or systems may also be regarded as renewable energy sources if they are derived from raw materials, such as sugar or wood biomasses, obtained in a sustainable manner, and provided they help to reduce energy consumption. At the present time, research and experimentation are working toward how to improve processes that exploit organic waste to produce thermal energy.

There is a wide range of opportunities available for the reduction of energy consumption. In this chapter, we consider the most common aspects and the methods most often used for sports facilities.

The advisability of using one or more sources of renewable energy varies from one country to another depending on the geographic position, sun exposure, available materials, national energy policies, the type of management and the duration of the sports facility.

In sports facilities, energy is used to create the artificial environmental conditions required for the various activities.

Energy consumption can be divided up follows:

- Air conditioning.
- Hot water.
- Internal lighting for sports facilities, auxiliary services and installations, offices, etc.
- External lighting: parking, pedestrian paths, green areas and fences or walls.
- Power for various machinery.

A number of different factors can have a significant impact on energy consumption:

- The relationship between the building and the environment, such as position, exposure to wind, the local climate, the presence of natural and artificial barriers and sun exposure.
- Construction specifications: volume, area size and the characteristics of the external surface areas, internal layout, in relation to the internal environmental characteristics and the technological systems.
- Technological characteristics: construction method, specifications of materials, installations, insulation and accessories.
- Environmental characteristics: temperature, relative air humidity, hot water temperature, light level and noise level.
- Machinery characteristics: quantity, energy efficiency, type of power, installation methods, graphic documentation.
- Application procedures: thermo-technical controls, lighting and noise level, type of maintenance and method.

Energy-saving strategies

In high-level basketball facilities, most of the energy consumption (98-99%) is used to heat the dressing rooms, auxiliary service areas and public facilities, offices, etc., and also to produce hot water for bathrooms. 72-78% of this thermal energy goes on the air conditioning and ventilation systems and the rest by the production of hot water.

On the basis of these observations, and considering that an open-air sports facility or sports complex represents a particular type of building or structure, which is complex in terms of structure and the activities carried out, the most common energy-saving methods used at the planning stage are inspired by bio-architecture. These methods include:

- Increasing the building's thermal inertia (avoiding thermal dispersion through the outer roof and floors, and preventing the formation of heat bridges).
- Allowing construction materials to breathe.
- Using natural ventilation for cooling in summer or for air exchange, taking advantage of room position according to the building's orientation and dominant winds.
- Adapting all façades prone to overheating and solar brightness by the use of an appropriate projection.
- Planting trees and green areas to protect the building from wind and to humidify the external temperature.
- Collecting and recycling rainwater to clean the bathrooms, water the green areas and clean the communal areas.
- Uses of glass surfaces for natural lighting.
- Uses of sources of renewable energy and geothermal energy.

These principles suggest that:

- Solar radiation may be used for heating and lighting if the position of the various parts of the building can be planned along with window surface areas and made to produce electricity based on photovoltaic cells.
- Sports facilities that require a form of heating must be located in areas protected from the wind and strategically positioned in relation to other buildings, terraces, barriers and trees. Sports facilities that require air conditioning must be located in windy areas with little exposure to the sun.
- The best solutions must be found for construction and architectural plans in order to reduce as much as possible the volumes to be heated and cooled, thus eliminating heat bridges.

In the case of already existing buildings, fulfilment of these objectives may involve significant changes and investments. If a facility needs renovation, it is generally advisable to choose the most economic measures, in particular, as regards the correct use and maintenance of the systems. Economic profitability must be estimated according to the cost basis.

The principal strategies for reducing energy consumption in existing facilities may be summarised as follows:

- Confirm that the room temperature is appropriate for the proposed activities (16º C - 19º C for basketball and 18º C - 20º C for all other activities). The temperature in other areas must not exceed 20º C.
- Keep machinery in good working order. For example: regular cleaning of boilers, drainage pipes, burners and filters.
- Adjust thermostats and other control and adjustment devices.
- Heat or cool only the areas actually being used.
- Eliminate air dispersion through doors and windows.
- Make the most of natural lighting by keeping internal surface areas and windows clean.
- Keep lamps and lighting devices in good working order with regular cleaning and replacement of light sources.
- Avoid increasing the power of light sources when replacing them. (Reduced efficiency is mainly due to ageing or lack of cleaning).
- Only light areas in use and adjust the lighting level to the needs of the activities performed.
- Reduce hot air stratification by calibrating the inlet and outlet distributors on the heating units.
- Adjust the air supply in accordance with the number of users present in the facility, allowing for at least two exchanges in the case of maximum occupancy (users and spectators) and normal occupancy (only users) equal to 30 m^3 per person and hour.

Close the outside air inlets when switching on the systems so as to reduce the time needed to reach the optimum temperature.

Other similar suggestions relate to the production of hot water with a traditional system:

- Limit the water temperature according to the user’s needs.
- Only activate the circulation pump when the showers are in use.
- Keep water production devices and distribution equipment in good working order (water heaters, thermostats, taps, etc.).

These simple suggestions are part of the standard and ongoing maintenance of the facilities. Monitoring can lead to a reduction in energy costs of between 20% to 30% or more.

The main interventions in some technological installation subsystems include:

For air conditioning:

- Installation of the control unit and distribution ducts.
- Use of economic fuels or fuels with a low maintenance cost (for example, methane instead of diesel).
- The various generators must provide the necessary heat supply.
- Installation of a device to recapture the heat from air expelled by centralised systems.
- With regard to non-centralised systems or parts of systems, more efficient devices must be adopted (convection fans instead of convection heaters to reduce the heat-up time).
- Increase thermal inertia with non-conductive materials, double glazing or double doors and windows.
- Use of devices to generate more efficient heat, for example, condensing boilers or boilers that use low-temperature heat sources, such as heat exchange pumps.

To heat water:

- Combination of boilers. Equipment capable of supplying both heating and hot water for bathrooms.
- Installation of the heat pump water heater.
- Heat recovery unit.
- Use of solar collectors.

For lighting:

- Use of pale colours for walls and ceilings.
- Use of high-efficiency bulbs such as bulbs with LED technology.
- Reduction of lighting points and use of closed circuits to use lights only when necessary.
- Use of security cameras and other similar devices with low consumption ratings.
- Use of devices for electricity and heat cogeneration if the facility uses electricity and thermal energy together.

Exploitation of solar energy

The sun is the most used source of renewable energy.

At the present time, thermal solar and photovoltaic solar systems are the most used systems in the tertiary sector and, in particular, in sports facilities. The thermal solar system is used specifically to heat water for bathroom facilities.

Thermal solar systems include:

- Collectors.
- Accumulation tanks.
- A distribution circuit.
- Additional traditional devices.
- A control unit.

The size of the collectors and, as a consequence, of the accumulation tanks depends on a series of factors and, in particular, on the planned use. With regard to sports facilities, it is important to take into consideration the actual consumption and the time of day when the energy is used. For all thermal solar systems, a traditional supply must also be provided to meet requirements during exposure to reduced daytime light.

Photovoltaic solar systems: A photovoltaic installation requires a series of four principal subsystems to work:

- Catchment subsystem: comprised of solar panels. Their task is to capture solar energy and transform it into electricity.
- Storage subsystem: comprised of batteries. Makes sense in isolated facilities not connected to the electricity grid. Accumulates energy from the continuous catchment system so that it can supply it when it is required because it is not always consumed instantaneously.
- Regulation and control subsystem: comprised of the regulator. Its task is to protect the batteries from overload.
- Distribution and consumption subsystem: comprised of cables and inverter. The cables are the means by which the electricity is carried to the points of consumption, whilst the inverter transforms the continuous electricity that comes from the panels (multiples of 12 volts) as alternating current to a voltage and frequency that depends on the country in question.

Systems connected to the grid use an interactive inverter on the photovoltaic system to change the continuous current (CC) produced by the solar panels to alternating current (AC), synchronise with the grid and inject energy into it. These systems do not need accumulation batteries to store the energy produced because the electricity grid has infinite capacity. Photovoltaic cells can supply consumers and the electricity grid directly, allowing other consumers to benefit from the excess energy.

Recently, many sports facilities have started to install photovoltaic solar panels on their own roofs. Their extensive surface area lends itself to involvement in urban plans for the production of renewable energy, which ensure energy for the sports facility itself and also for a reasonable number of homes in the area. This serves as a perfect example of how a sports facility can be meaningful and useful.

In energy-saving systems, for both sports buildings already in use and new complexes, it is not only the use of appropriate materials, insulation and renewable energies that is important, but also the efficient, regular use of available natural and existing resources, to the extent that we will explain below how to care for water and energy.

Energy efficiency in sports areas

For the purposes of social, personal, ecological and financial responsibility, it is important to know what to do to reduce the demand for water in a sports facility or centre, and this section will attempt to report on techniques and systems that will allow directors, managers and technicians in this type of facility to minimise the consumption of water and energy.

The target applicable to this type of plan and project is not only to minimise consumption but also to know how to use, capture or re-use water invested in other processes, and also how to avoid using it altogether by employing more modern equipment and technologies that do not even use water now and that are not expected to diminish the service offered or change the substantial use of the facilities.

Preliminary action and considerations for water and energy-saving

Within the countless possible activities and issues to be considered, we set out below some of the most important by way of example:

- When fitting taps, for both hot water for bathrooms (HWB) and cold water for human consumption (CWHC), it will be necessary to bear in mind that, when they are designed or changed, efficiency, design and ergonomics are all regarded as very important. The most advanced techniques available must be used because, once the fitted facility is built, it will be in place for many years. The ease of maintenance and the costs thereof should not be overlooked.
- Anticipate production water needs and define processes where heat or cold exchangers could be used so that energy from some processes can be used for others, including mixing heating or air conditioning systems, with industrial or building service processes.
- If, at the design stage or when an alteration is made, the re-using and/or recycling of grey water are not considered, this is not usually feasible at a later stage because of the high costs involved since the structure and piping/wiring is not prepared for this. If it is included in the project, the cost will be minimal and a number of advantages will become apparent:

For example, if a new building is designed, it is necessary to take into account the preparation of two water supply circuits. One can be called the clean water circuit and the other the recycled water circuit to supply the toilets or WCs.

This is obtained by collecting, decanting and filtering the water from the washbasins, showers and drainpipes from the roofs so that water saving in excess of 30% can be achieved for the whole lifespan and with a very low investment. This measure means that nearly 95% of the water used in those processes can be taken advantage of and can also be used for watering, after it has been left to settle for a couple of days.

- The installation of meters (if possible, electronic meters) is of great interest. They allow the segregation and control of consumption and leaks, adapting diameters to actual needs, and there are no excessive safety margins that increase the price of the water but add nothing in exchange.
- Catchment of rainwater through porous and filtering surfaces, runoff water collectors and interception from drainpipes or drainage gutters from roofs using separate overflows will mean that, in the future, second-rate water is available for processes or demand where treated hydrant water is not required and carries a much higher cost.
- Another element to be considered is the type of taps used. We will look at this below, taking new technologies into account.
- Implementation of preventive maintenance programmes that enable correction and immediate detection of irregularities, excessive consumption, leaks, etc., with checks of pipe insulating shields every six months or whenever an operator performs any maintenance work.
- Plan, schedule and check HWB heating-up temperatures, accumulation and distribution, adapting these to the expected water demand. It is illogical to have water that will not be used.
- If water treatment systems are used, check the quality of the water and its composition every so often and, mainly, during summer periods because, if its composition changes, it will require dosing or different cycles. Use the occasion to inspect the condition of resins, salts, etc. in the various tanks, checking the final result of the treatment.
- Conduct environmental awareness campaigns within the sports establishment, centre or facility and train personnel to resolve the most common problems that may arise, thus demonstrating to clients and visitors that they are aware of and concerned about the issue and this will improve the centre's public image.

Technical possibilities for saving water and energy

In the vast majority of cases, the managers of this type of centre or facility experience a problem of a lack of technological know-how because it is impossible nowadays to remain up to date with these issues of market diversity, and this, sometimes added to fear of new technologies or their social acceptance, means that techniques that are widespread in other areas, countries or sectors are not implemented.

The purpose of this section is to review the most successful technical possibilities that are easiest to implement, both in terms of work or major alteration and easily implemented accessories or equipment, with the quickest amortisation (with reference to water economisers, for HWB and CWHC).

From the technical point of view, the two points of view mentioned above are reviewed, starting with the implementation of low-cost corrective measures in use, both for new construction projects and for already existing facilities.

In other sections, we will look at techniques and solutions where the investment is usually higher but no less interesting, although their amortisation period is longer.

Water and energy-saving equipment

First, we must split the various types of the most used sanitary water supply equipment into two large groups: complete equipment and accessories or adapters for equipment already in existence. The latter contribute economising technology when retrofitted to taps already in use, at a lower cost and using the equipment to which it is applied, whilst the former are designed for new construction or remodelling.

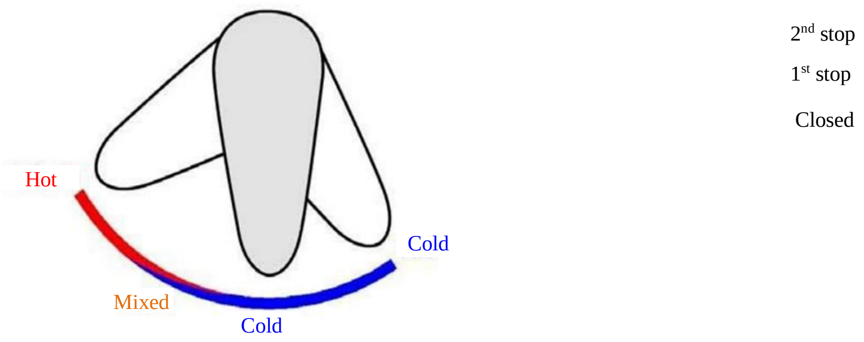
The following sections aim to cover most of the existing technologies, by way of a basic guide to the most widely-used, and those that are the most effective, although they may be unknown, and, although we do not include all existing technologies, the most important or widely-used are included.

1. Traditional mixer taps

These are, at the present time, the most widely-used type of tap *par excellence*, but this does not mean that there are no economising techniques and technologies that can improve the water and energy consumption of this type of sanitary ware, which is so widely in use.

The fact that the water used in a mixer tap is cold does not mean that it does not contain heated water. For example, in a washbasin mixer tap, because the control or lever is positioned in the centre, every time it is opened, it uses 50% cold water and 50% hot water, although the latter does not have time to come out of the faucet.

This problem has been cross-checked and demonstrated and the finding is that, in general, people who use a washbasin in a public centre do so by opening it in its central position for an average time of less than 30 seconds, and they do not hold the lever but push it upwards, as far as it will go, knocking it gently downwards to adjust the flow, if the flow is very strong. Nowadays, there are technologies that allow reduction of the consumption of water from these taps and, in turn, divert the unplanned use of hot water into the use of cold water.



Graphic explanation of Ecological Cartridges

The solution lies in replacing the classic ceramic cartridge with an “Eco-friendly” cartridge that opens at cold in its central position and has a brake that stops it in two positions.

As shown in the figure above, when the lever is activated its brake function keeps it in its central position and, in addition, it only supplies cold water so that the lever has to be turned to the left in order to obtain a warmer water temperature.

This device offers general savings in excess of 10% of the total average energy that a normal washbasin will usually use and a water saving of 5%, approximately.

For this equipment, or any other type of tap, whether on a washbasin, sink, etc., if it is also less than 20 years old, a filter is added to its faucet, called an aerator filter or aerator, which is intended to stop the water splashing as it leaves the tap.

Another available solution for saving water and energy is to replace this aerator with a flow regulator which, in addition to fulfilling the above objective, has other advantages, for example, it is more effective with liquid soaps, it is more pleasant and comfortable, more water appears to come out than really does and, of course, it economises water and the energy used to heat it.

These technologies guarantee savings of at least 50% and, on occasion and depending on pressure, achieve savings of 70% of usual consumption. There are normal versions and anti-theft versions for places where sabotage, possible theft or vandalism are concerns.

The implementation of water flow regulators on washbasins, bidets, sinks, etc. reduces consumption and makes the establishments more ecological and more environmentally friendly and observant and, of course, much more economic in terms of their use, without reducing the quality and/or comfort of the service offered.

Existing technologies create water acceleration and turbulence without producing air in shower heads and this improves comfort because the turbulence creates the sensation of hydro-massage and much less water is used than with traditional massage systems because of the quantity and pressure of the water. Up to 65% of the water presently used by some equipment is saved without any loss or detriment to the service.

2. Thermostatic taps

This is possibly the most expensive equipment, after the infrared automatic activation taps, but also the most efficient from the point of view of energy consumption because it automatically mixes hot and cold water to achieve the temperature selected by the user. They provide a high degree of comfort and quality of life or service offered, prevent accidents and, in addition to the energy-saving function, are also available with water-saving equipment.

3. Electronic taps

These are possibly the most eco-friendly taps because they adjust water demand to the user's needs, activating supply and interrupting it depending on whether or not the user is present.

It has been shown that the saving that they usually generate exceeds 65-70% compared with traditional savings, and this is ideal when both hot and cold water are used because the cost of supplying hot water means that there is much quicker amortisation than with cold water only. The cost of this type of equipment varies according to the manufacturer and quality because there are very simple and very sophisticated versions that can act to prevent and combat Legionnaire's disease. There are two very similar techniques of automatic presence detection activation: infrared and microwave. The former are discussed below.

3.1. Infrared activation

This equipment is available for almost any need and is principally used for operation in toilets for disabled persons and in places of heavy traffic where users forget to turn off the equipment or operate it improperly, which reduces the lifespan of normal equipment. It has been shown that this equipment takes the best advantage of supply because it adjusts them to the user's actual need and avoids even minimal waste.

Minimalist electronic infrared hot and cold taps for washbasin.

There are versions for washbasins, sinks and fixed showers, both normal and with thermostatic equipment. There are also versions for toilets and urinals, covering almost any need that may arise. Investment can be 10 times more expensive than traditional equipment but the effectiveness, efficiency and lifespan of the products is justified if the intention is to have an innovative and eco-friendly image that is economic in terms of consumption, and amortisation is within an average of between 3 and 5 years.

There are variations that bring down the cost of newly constructed facilities with these technologies. They consist of centralising the electronics and using electro-valves, detectors and normal taps, separately. Maintenance is much simpler and investment is significantly reduced, whilst wet areas can be designed using designer taps. They are mainly recommended when use is very high, more than 80-100 uses a day.

3.2. Tactile activation

The most advanced technology for self-closing eco-friendly taps is also vandal-proof and it represents an improved alternative to the timer taps known to date. An establishment seeking maximum saving, self-closing taps either chose electronic infrared taps or there was no other alternative but to use pneumatic timer taps. The TEHSAPRES technology covers an intermediate need on the sanitary ware market because it has the advantages of vandal-proof taps but at a low cost and hitherto unknown functions.

The tactile activation technology used allows activation and deactivation of supply at will (something that other technologies do not allow) and automatic closure can also be programed for when the user does not turn off the taps.

Tactile timer tap.

This is the ideal solution for small washbasins in public lavatories, where traditional or standard timer taps would take up a lot of space and would be uncomfortable to use.

This is a profitable, durable and reliable solution that is an improvement on mechanical or pneumatic timer taps, at a lower cost than infrared systems, with advantages not enjoyed by any of the above, not only because they open and close manually or voluntarily but also because of their involuntary closure programme (which the fitter can programme at between 1” and 60”), thus preventing consumption caused by forgetting to turn off the equipment.

Tactile Timer Electronic Tap.

Piezoelectric technology is based on piezoelectricity, which is a phenomenon of certain crystals which, in response to applied external force and buckling, produce power differences. That very rapid and powerful stress that is generated is used to command the control electronics of the equipment.

Its strength, stability, durability and simplicity mean that the use of quartz crystals for these piezoelectric functions allows functions that were not, until now, possible for taps but, because they have been made so much smaller, they now appear on the market.

The equipment is designed to be activated by touch with minimal pressure or touch with the palm of the hand, a finger or anything else, so that, when touched, the equipment starts to supply water, and this supply can be cut off at any time by touching it again. If it is not turned off, it will simply turn itself off after the programmed time (6-8 seconds, at origin).

The technical specifications are as follows:

- Timer taps with programmable time.
- Easily programmed by fitter or maintenance personnel.
- Reprogrammable, as needed.
- Opens and closes manually or voluntarily by touch.
- Programmable water supply times of from 1” to 60”.
- Low battery indicator and opening block.
- Solid brass construction and polished chrome finish.
- Supplies cold or pre-mixed water.
- Maximum water temperature of 70ºC.
- Operating pressure of between 0.5 bar and 8 bar.
- Low voltage 9 V feeder or batteries (6 x 1.5 V AA).
- Battery lifecycle of more than 500,000 operations.
- IP65 water resistance protection for battery case.

4. Timer taps

Timer equipment or taps cover most of the concerns relevant to public places: damage caused by vandalism, the need for increased durability because of high levels of use and excess consumption because users forget to turn off the taps.

There are countless manufacturers on the market who offer very varied solutions. When it comes to choosing a tap with these features, the following points must be taken into consideration:

- It must be possible to regulate or pre-adjust the flow.
- Incorporation of the flow regulator into the faucet. This will give an apparently increased flow, using much less water, and it will be more effective with liquid soap, which is the most commonly used soap in public centres.
- Timing adjusted to demand (6” for washbasins and 20-25” for showers).
- Easy maintenance with interchangeable anti-calcareous heads.
- Anti-block, for problematic places or places with vandalism.
- Anti-water hammer device, for places with pressure problems.
- Smooth operation or touch, to be used by children or the elderly.

It will also be very important to have certificates, badges or trials that demonstrate that consumption is within parameters that may be called “eco-friendly” and that, for each of the different types of use, the water flow to be supplied by cycle or touch is less than:

- 0.6 litres for washbasins.
- 4.1 litres for showers.
- 9.0 litres for toilets.
- 0.9 litres for urinal timer flush-buttons.


Possible improvements to timer taps.

In relation to this equipment, it is possible, using specialist maintenance personnel or specific professionals, to optimise and regulate consumption, reducing it by between 20% and 40% because most manufacturers put excessively long times on the equipment which often generates up to three triggers per user, of between 12” and 18” each, when a 6” touch would be ideal to prevent water coming out during intervals when the hands are being soaped, rubbed together and rinsed. And, although it is true that many users only use it once for wetting and then rinsing their hands, a user very often goes off and leaves water running.

Another very common use of this equipment is in urinals and built-in showers where the most important issue is that the water supply should cut off after a particular time and/or that users can be prevented from forgetting to turn it off.

5. Flushometers for toilets and slop sinks

Flushometers are similar to timer taps for public lavatories although they tend to be fitted in slop sinks and squat toilets. This equipment uses the same operational principle as timer taps and is designed for high traffic public places.

In general terms, flushometers require special features if they are to be fitted and we have to remember that flushometers and traditional taps cannot be fitted to the same spur or line because of the high pressure involved, the water speed and possible water hammer effect that may be caused during use, which, added to losses of pressure, would cause serious problems for the use and comfort of the facility.

All this means that it is obligatory to calculate and design a special, distinct and separate system, calculated for this purpose, when the use of flushometers is intended, which is increasingly common for wastewater recovery and recycling for this type of service, because they are easy to implement and they create savings for life.

The increased consumption of this equipment and some supply problems tend to derive from very specific factors, such as improper design of the facility, change in the supply pressure and failure to maintain the component itself.

The design of a flushometer system requires specific diameter lines and calculations to avoid loss of pressure, as they are frequently extended or changed, or inlets made for other types of sanitary ware, which means that consumption or pressure is unstable. In other cases, the supply pressure increases and so operation times and supplied flows are excessive, even upwards of 14 litres.

Ecological pistons for flushometers.

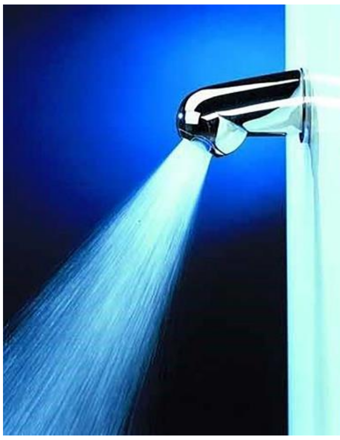
Another of the most common problems for these fittings is the absence of equipment maintenance when, simply by stripping it down and cleaning and greasing it with specific glycerines, removing possible obstructions from the inlets, this equipment can be kept in its original condition, saving more than 30% and preventing the shaft or piston from seizing up, caused by sedimentation, and/or taking too long to turn off the supply.

At the present time, there are dual flushometers that allow partial or complete flush depending on the part of the button that is activated and this is the ideal solution for new construction or renovations, and, in particular, in ladies' lavatories, as they use the toilet for both urination and bowel movements and the former requires much less water than the latter.

6. Rain shower heads, shower heads and hand-held shower heads

For the purpose of saving water in showers, it is usually easier to address water outlet rather than taps. Some of these techniques can be operated on timer-activated showers, but they use rain shower heads or normal shower heads, combining optimised water outlet supply with timer shut-off. By changing the shower head, consumption can be reduced by at least 20%.

The first classification to look at would be the type of shower head or rain shower head used, regardless of the taps that activate and regulate it, and they can be divided into two: shower heads or rain shower heads affixed to the wall and hand-held shower or telephone heads attached to the tap outlet with a hose.



High efficiency eco-friendly wall shower (turbulence hydro-massage)

The Table below shows the most common solutions or actions for fixed or wall showers.

Most common solutions for reducing consumption in fixed showers.

Type of equipment and solution	Savings generated	Picture of the equipment
Change of rose or sprinkler	**30% - 65%**	
Insert a fixed volume reducer at the entrance	**20% - 35%**	
Insert a volume limiter in the entrance pipe or body	**15% - 20%**	

In the case of hand-held shower heads, the most common approach is to replace them with another one, although there are other options that are specified in the table below:

Most common solutions for reducing consumption in hand-held or telephone heads.

Type of equipment and solution	Savings generated	Picture of the equipment
Change hand-held shower head for another one with water acceleration techniques and turbulence hydro-massage	**50% - 60%**	
Change the hand-held shower head for another with high-performance features in terms of water acceleration and multiple supply functions	**40% - 60%**	
Insert a rotating volume reducer between the tap and hose	**25% - 40%**	
Insert a rotating flow regulator between the tap and hose of the hand-held shower head	**15% - 25%**	
Insert a rotating flow interrupter between the tap and hose of the hand-held shower head	**15% - 20%**	
Insert a flow limiter at the head entrance. (Only valid for some models).	**15% - 20%**	 

We should not forget that these components represent 50% of the equipment and good selection of the shower rose or hand-held head will generate significant savings but, if combined with a good tap, the mix will be perfect. Accordingly, depending on the type of service for which the equipment will be used, the decision will have to be made as to whether it is fitted in combination with a mixer, a timer button, a thermostat or an infrared tap or system, which would provide significantly increased efficiency.

7. Toilets (WC)

The toilet is the sanitary ware that uses the most water in daily life or domestically and, also, publicly, although not in terms of its energy value because it only uses cold water. Its average output per flush is usually 9-10 litres. When flushometers are used, this figure tends to be higher and can rise to 18 litres for some American equipment.

Toilets in ladies' lavatories are used for both urination and bowel movements and so, if the sanitary ware does not have components for selecting the type of flush, this will be the same for removing solids and for removing liquids, when these latter could be eliminated using only 20 or 25% of water.

Any measure that makes it possible to choose whether one wishes to remove solids or liquids, depending on the use applied, will enable savings of more than 40% of the tank or flush content.

If we analyse the various systems that tend to be used, having described above the possibilities available for flushometers (greatly in use in the 1990s), fitted flush systems are now more fashionable and they generally go with highly effective porcelain that usually uses, at the most, 6 litres per flush.

Nearly all manufacturers who supply fitted toilets or tanks offer the option of dual-flush devices, which are highly recommended because users tend to go to the WC on average five times each day: four times for urination and once for a bowel movement. In this regard, saving water is easy if the flush can be differentiated, because only 2-3 litres are needed to eliminate liquids and a full tank is only needed when removing solids.

Of course, this demand is statistical, and so we can quite justifiably state that more than 40% of the centre's consumption will be saved and, if the centre is for public use, the saving will be more because, the more people who use it, the greater the likelihood that they are using it because of the need to urinate.

The technical possibilities available for producing this flush selection are the following:

Tanks or toilets with interruptible flush-button

These tend to be part of recent facilities, 8-9 years old, and, externally, they are no different from normal flush-buttons, so the only way to distinguish them without removing the lid is by pressing the activation button and, as soon as the flush starts and the water begins to come out, pressing the button right down again, so that it is possible to see whether or not the flush is interrupted.

If so, the simple use of some stickers explaining the correct operation of the toilet, whilst using the opportunity to conduct a campaign on awareness and the centre's interest in the environment and social responsibility, will improve the centre's corporate image and will save more than 30% of the water that is presently used.

Most users do not know that a flush can be interrupted.

Tanks or toilets with handles

As in the previous case, and from the same period, some of the most famous manufacturers started to incorporate the possibility that their handle mechanisms could be interrupted to save water. This is very easy to recognise because, when the handle is pulled, it stays in a raised position and, in order to interrupt a flush, it has to be pushed downwards, whereas, if they go down on their own, this is a sign that the mechanism cannot be interrupted and will flush completely.

A counterweight can be connected to both those that are interruptible and those that are not, which resets the system automatically, causing the mechanism to close quickly, deceiving it so that it appears that all the water has left the tank, allowing savings of more than 60% of normal consumption.

In any event, it is always to be recommended that stickers be attached to explain correct operation, whilst making users aware and improving the centre's image, so as to explain both interruptible devices and whether stainless steel counterweights should be fitted so that they operate automatically.

Tanks or toilets with dual buttons

This is without doubt the most eco-friendly and rational option for the use of toilets. Unfortunately, some manufacturers do not allow selection and adjustment of the type of flush. In other cases, it is hard to know which button flushes one part or the other. There are even some devices where it is necessary to push both buttons at the same time in order to produce a complete flush.

- It should be designed for public places, because most are for domestic use and their lifespan is much shorter.
- The warranty, which should be for 10 years, must be for at least five.
- The buttons should be clearly identified, visible and easy to operate.

Regardless of the possible steps to be taken, mentioned above, it will be vitally important for people to take responsibility for maintenance and to check for the possible presence of water leaks, either by noticing that the ballcock overfills the tank (which can be resolved by simple adjustment) or because the rubbers on the mechanism have become flattened, hardened or worn, allowing water to leak through their seating. (It is very easy to change them and the cost is very low). It is also recommended that stickers be attached for the reasons stated above.

8. ECO-WC: Ecological toilets

The essential special feature of this new range of toilets is their low water consumption because they only use 2.3 litres per flush – in other words, 62% less than any other equipment existing on the market, exceeding 74% of savings when compared with the traditional toilet, and up to 81% when compared with some American toilets.

Until now, the most that could be done to save water in toilets was to provide them with a dual-flush button to distinguish between urination and bowel movements, which, compared with a traditional system, gives significant savings but, nowadays, research continues and more could still be saved.

Various models of ECO-WC with maximum flush of 2.3 litres.

The Table below gives a comparison of the statistical average consumption of two public bathrooms which a total of 25 people visit each day, including men and women, and five of them use the toilet for bowel movements and the rest to urinate. Moreover, it is assumed that they use the dual-button device properly.

Type of sanitary ware, annual consumption, water savings and comparative percentage of savings.

	Ann. Cons.	CTA-10L	ITB-9L	ITB-6L	ITBDP-9L	ITBDP-6L	ECO-WC
CTA-10L	73,000		10%	40%	46%	64%	77%
IT B–9L	65,700	7,300 L less		33%	40%	60%	74%
IT B-6L	43,800	29,200 L less	21,900 L less		10%	40%	62%
IT BDP-9L	39,420	33,580 L less	26,280 L less	4,380 L less		33%	57%
IT BDP-6L	26,280	46,720 L less	39,420 L less	17,520 L less	13,140 L less		36%
ECO-WC	16,790	56,210 L less	48,910 L less	27,010 L less	22,630 L less	9,490 L less	

CTA-10L	High-tank toilet with 10 litre tank load.
IT B–9L	Traditional toilet with 9 litre tank load.
IT B-6L	Modern toilet with 6 litre tank load.
IT BDP-9L	Traditional toilet with 9 litre dual-button.
IT BDP-6L	Modern toilet with 6 litre dual-button.
ECO-WC	ECO-WC, toilet with 2.3 litres per flush.

The red column shows the annual consumption of each piece of equipment. The yellow squares list the saving (%) offered by the equipment shown in the column compared with that stated in the row. On the other hand, the green squares list the saving (l) generated by the equipment in the row compared with that stated in the column.

In addition to being the system with the lowest water consumption on the market thanks to its pressured water aerodynamic ejection system, flushing with only 2.3 litres, the main advantages of this equipment are:

- Its high and rapid refill process, which is much quieter than any other because it has a tank inside another tank made of porcelain.

- Especially designed to prevent leaks and water losses using a special piston system.
- Capacity to remove floating objects, which can be difficult with some traditional models.

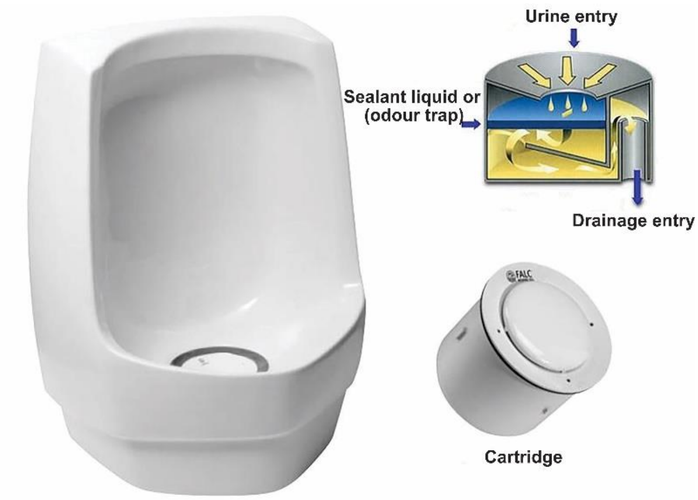
- Modern and innovative design, with integrated lid and pneumatic fall brake.
- Large-size central single button so easy to operate for disabled people.
- Similar maintenance to any other toilet.
- Lower water and drainage inlets. The distance from the wall to the drainage shaft is 21 cm (standard).

9. New non-water techniques

Nowadays, there are technologies that eliminate the need to use water for sanitary processes, as in the case of urinals, which are used three times more than toilets and are a great source of consumption.

At the present time, dry urinals are available that do not need to use or consume water. The technology for this consists of a series of cartridges that collect the urine, which passes through an oily liquid which acts as a trap for odours, sealing in possible evacuation or drainage gases and avoiding bad smells.

The photograph below shows a picture and the operation of one of the most used models on the American market.



Dry urinal.

The only maintenance that this technology requires is daily cleaning of the porcelain walls with a cloth soaked in a cleaning liquid that does not damage the smell trap because, if water or other agents are used, it would be damaged or would lose its qualities.

This maintenance needs to be reviewed every so often, depending on use, to replace the sealant liquid part that might have become lost or worn and to replace the cartridge when necessary (according to some manufacturers, every year).

For certain facilities or sports centres that are used only on certain days but very intensively, for example, stadiums, this equipment can be valid and experts

will have to assess the advantages and disadvantages depending on cleaning and maintenance personnel available in the facility, and also amortisation.

10. Technology for distribution systems

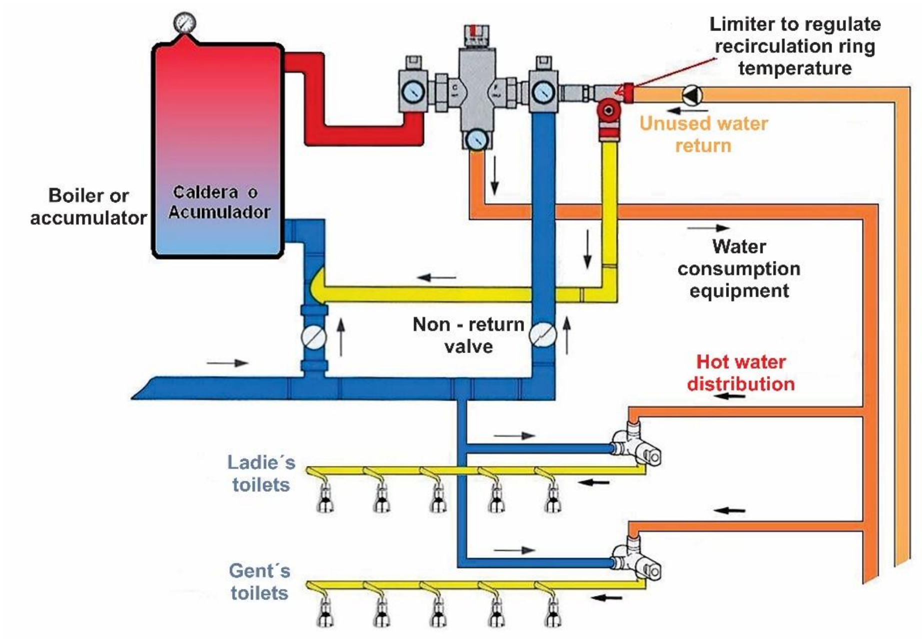
The consumption of water and the energy used to heat it is very much affected by distribution circuits, in terms of their design, protection, diameter, flow and, of course, work pressure, which means that all these factors have an extraordinary impact on water management and, therefore, on appropriate or excessive consumption. We describe below how sports centre facilities could be optimised, with communal areas and/or dressing room, shower, etc. areas.

The energy used in the various and varied processes in many cases requires water to be heated and so a direct way of reducing production costs would be to optimise the heating or cooling and adapt the temperatures and flows to those needed.

The use of thermostatic mixers to obtain water at a particular temperature, sensors and thermostats that detect substantial changes in temperature, liquid level meters and endless technologies available on the market should be examined by the managers or maintenance technicians of these facilities in order to determine how water and energy consumption in the facility can be reduced.

First, for the purpose of analysing a distribution and supply circuit, bear in mind that, if it is for hot water, this circuit should be as short as possible and, if the distance from the heating point to the ultimate consumption point is long, it would be advisable to add a recirculation ring to avoid wasting water until hot water comes out and to minimise the waiting times until it starts to appear at the appropriate temperature.

It is advisable for this ring to be as short as possible and to be fed with hot water, surplus water from the return (as colder water) and the inlet water from the heater or accumulator. In this way, the ring will easily achieve the pre-set temperature as demand ceiling, avoiding accidents or scalding. The ideal composition would be to insert a thermostatic mixer, with return inflow, as shown in the figure below, where the unused water returns to the mixer as available cold water so that, when mixed with the hot water, water can be offered at the desired temperature.



Optimised circuit for thermostatic control of hot water with recirculation ring.

This circuit is highly effective whether the taps offer the user an adjustment capacity or whether the water is pre-mixed without any possibility of the user choosing the temperature (used frequently with timer taps). In this second case, it is recommended that a thermostatic mixer be included for more precise temperature adjustment, both in summer and in winter, because the temperature difference changes by more than 10º C from one season to another.

The installation of recirculation rings using return water and thermostatic mixers makes it possible to adjust the amount of water used to the minimum necessary. Energy conservation is at the maximum possible, offering energy savings in excess of 16% compared with traditional systems and reducing the demand for water that, traditionally, is wasted with other systems because of the need to wait for the water to come out at the temperature that the user desires.

Regardless of the temperatures for use and the distribution system, another of the points of high water and energy consumption is caused by the pressure of the circuits and loss of pressure when water is consumed at the same time at various points.

In the first case, excess pressure can cause increased water consumption that can be precisely set at 15% for each 1 bar pressure increase, where 2.5 bar is regarded as the average pressure.

For example, a traditional shower will use, on average, some 12.5 litres/minute at 1.5 bar, around 16 litres/minute at 2.5 bars and around 18.5 litres/minute at 3.5 pressure bar.

As we can see, the same piece of equipment will use more or less depending on the pressure to which supply is subjected. In order to resolve this situation, it is recommended that pressure regulators are fitted because the distribution lines have to take account of the necessary flows so that they can supply the entire water demand at the same time, although, as a general rule, technicians, engineers and architects use standardised formulae that are not in line with the actual situation and there is a very high percentage of excess pressure, with the attendant increased consumption.

Therefore, general pressure should not be reduced, which is, in some cases, a valid solution but these regulators should be inserted into the final distribution spurs and they will adjust the pressure as desired and it will be possible to distinguish areas where more or less is required, without this affecting properly calculated or appropriate lines. These measures are recommended for both cold water and hot water because it often happens that there is a difference in pressure between one supply line and another (pressure imbalance) and this can cause very severe problems in the quality of the service offered because of temperature instability. Users complain that the water no sooner comes out cold than it comes out very hot, or that the temperature has to be constantly adjusted.

This is because higher pressure water invades the contrary supply circuit, occupying and cooling down the pipes until the pressures are balanced and the original water suddenly arrives when the water that invaded the contrary pipes has been used up, so that the user is startled by the change by various degrees in the temperature.

The solution lies in balancing pressures or, if this is not possible, inserting non-return valves in the taps, because that is where this water mixes and where the move from one pipe to another takes place.

This problem, in addition to its seriousness in terms of the quality of the service offered, means that much more water is used and the adjustment waiting times are longer, so that water consumption may be increased by more than 10%. Accordingly, if it is tackled, this will provide benefits in terms of economics and the quality of service that is offered to the facility users.

Finally, we should not forget that poor protection or an inadequate or non-existent covering for the hot water distribution system can generate losses in excess of 10% of the circuit performance, and thus correct protection and maintenance will be key to reducing the centre's energy bill.

Water control and use techniques

Up to this point, we have looked at various technical possibilities for saving water and energy. Below we shall study ways to control consumption and detect problems, excess consumption or leaks, and how to capture or re-use water for other applications where the same quality is not required.

The rationalisation and responsible use of water should not be restricted simply to reducing consumption but must concentrate on the use of water in any area or on possible activities aimed at using, re-using or recycling water.

1. Use of rainwater with roof collectors

Roofs, used to establish and employ space for new technologies such as satellite receivers, antennae, solar panels, air conditioning equipment, etc. may and should, for the future, be used as rainwater collectors. There are porous, traversable floors that channel clean water to disposal drains so they could also take the water to cisterns or tanks so that it can be used.

There are companies that offer under-roof tank solutions. These tanks insulate and protect the building at the same time as allowing water from any rainfall to be captured and accumulated. Thus, the insulation and air conditioning are improved and simple self-regulated cisterns become available.

As well as pumping water to high tanks to be used when the supply is cut off, rainwater could also be available for other types of service that do not require the water to be treated for use.

Rainwater collectors for drainpipes and gutters

Pipes are usually found descending from traditional roofs, on the outside of the façades. After collecting fallen rainwater that travels through gutters which connect to drainpipes, it either runs down onto the building's pavement or into the manholes or collectors of the area's drains.

This water can be collected at a very low cost and even stored, after being filtered, and used with buoyancy systems that, at practically no treatment cost (apart from the cost of maintenance and pumping) would allow it to be used for processes where treated water quality is not required but where, because of its purity and the absence of lime, it would be much more profitable than treating water from wells, etc.

The classic gutters or drainpipes on a lot of buildings can be intercepted by this type of equipment and used to collect rainwater, however little, which can be filtered using the same equipment, employing the drainpipe itself to take the water to a tank, drum, etc. From this store, it can be used for watering, washing clothes, supplying air conditioning equipment, supplying toilets, etc.

General advice for water and energy saving

As a technique for incentivising the personnel or employees responsible for these technical departments, business consultancy experts use the reduction in energy and supply bills to establish reduction challenges that, if achieved, would translate into increases in their production bonuses.

Similarly, employees must be rewarded and given incentives if they suggest ideas as to how to improve or use the areas in which they work and which they control. We should not forget that the machinery industry, in general, developed thanks to the fact that the maintenance technicians who visit companies to conduct their maintenance, listen and seek solutions and improvements to the problems and ideas put to them by employees who use them in their daily work, collecting and using all that know-how for their own knowledge and to upgrade their equipment.

It is not easy to undertake this type of initiative in administrative facilities, but it is important to be alert to any opportunities that arise to do this and if, for example, a promotion or awareness campaign is conducted, to make available or plan a series of internal initiatives that will reward officials or contracted personnel and even subcontractors, through brainstorming, for any proposals made.

The following may be some specific advice according to area:

In boiler and distribution rooms

- Boilers and burners must be cleaned and checked regularly by a qualified technician.
- Order regular inspections of the boiler, highlighting the following points:
    - Warning lights.
    - Signs of leaks in pipes, valves, connections and boiler.
    - Damage and burn marks on the boiler or chimney.
    - Abnormal noises in the pumps or burners.
    - Blocked air ducts.
- Inspect the expansion tank and feed regularly. If water can be heard coming through the filling valve, there are leaks in the system.
- If leaks are suspected, call a specialist immediately to repair them.
- The inspection should include a check of the combustion efficiency and the adjustment of the air/fuel proportion of the burner in order to obtain optimum efficiency.
- Tell the technician to optimise the efficiency of the boiler and to submit a test sheet with the results.
- Consider the possible installation of a thermometer in the chimney. The boiler needs to be cleaned when the maximum temperature of the gases in the chimney increases more than 40º C over the temperature recorded during the last service.

- Adjust the HWB temperatures in order to supply water in line with the temperature of each season of the year.
- Insulate distribution pipes that do not assist in heating the work areas.
- If there are HWB recirculation rings, measure, check and adjust the proportions of recycled water during the various hours of demand, peak and off-peak, to the most appropriate proportion, in order to guarantee the service with the minimum stress on the boiler. (If the peaks are excessive, consider the implementation of an operation programmer that will make temperature changes automatic).

At consumption points

- Install thermostatic equipment whenever possible because it increases comfort and adjusts energy consumption to actual demand.
- Timer equipment is ideal when working with young people and teenagers because it prevents oversights in turning it off and better withstands possible vandalism.
- Install or implement corrective measures in terms of consumption, such as flow regulators, eco-friendly shower roses, volume reducers, etc., which will reduce consumption quite significantly.

Air conditioning energy saving in sports facilities

The purpose of this chapter is to set out and present the principal lines of action aimed at increasing the energy efficiency of air conditioning facilities in general, with particular bearing on those in sports use.

These lines of action, associated to many occasions, aspects and developments, are grouped into three basic areas:

- Design and use of facilities.
- Improvement of energy efficiency in the refrigeration cycle.
- Use of more effective saving control systems.

A brief explanation will be offered for these three sections.

Design and use of facilities

Human comfort is based on the control of five fundamental variables:

- Temperature.
- Humidity.
- Air speed.

- Indoor air quality (IAQ).
- Noise level.

In addition, there are various special features as far as sports facilities are concerned:

- A large number of people in a small space. This situation can apply over very few hours. (Remember here that this chapter will discuss air conditioning in closed sports facilities, so it does not include those that perform their activities outside).
- Great physical activity. Tremendous sensible and latent heat load.
- Great emission of organic volatile components (of human origin).

These all contribute to the need to provide a significant volume of external air to avoid the accumulation of odours. That considerable quantity of external air has to be treated with special care so there is no negative effect on any of the other four comfort variables.

Sports facilities will require average air quality. These facilities can be classified as "local with high metabolic activity" and as "spaces not intended for permanent human occupation", and so there is a choice of two possible methods for determination of the minimum ventilation flow:

- Direct method by concentration of CO^2, where it will be necessary to establish the minimum CO^2 concentration at approximately 800 ppm.
- Indirect method of air flow per surface unit, where it will be necessary to establish a minimum ventilation ratio of approximately 0.55 $dm^3/s\ m^2$.

This external air will need a specific filtration level, depending on the quality of the external air. (This quality is structured at five levels according to the concentration of solid particles and gaseous pollutants, from level ODA 1 to ODA 5).

Similarly, these ventilation levels will require the consequent extraction of internal "foul" air to keep the facilities in line with the required pressure system. This extracted air will be used for necessary energy.

In the case of noise level, as in any place of public activity, levels must be observed that will not disturb the normal development of local sleep-wakefulness cycles.

The conditions to be met outside for a sports stadium should not exceed 70 dBA.

Reduction of the noise level is a factor to be taken into account in any project. At the least, it should be borne in mind that areas for noise level corrective measures must be provided in case of future Regulations.

Outside, the measures are:

- Fans and low noise level compressors.
- Acoustic enclosures.

Inside, they are:

- Proper insulation of fans and compressors (anti-vibration).
- Good duct installation practices.

There is an enormous variety of ways in which owners, consultants and fitters tackle the project, which basically depend on the priorities established by these participants. For some, user comfort will be important whilst, for others, equipment positioning rights may be more important and, inevitably, for some, only the cost will be significant.

Priorities and subsequent decisions restrict the path to be followed to complete the project, for example, the absence of an appropriate roof structure may lead to the need to avoid central energy equipment. The absence of areas for pipes to pass through can mean that it is not possible to have a centralised system of any type, whether all air or through fan coils.

The solution is, as always, for architects, engineering consultants and fitters to work together so that, in the various stages of the project, a proper compromise can be achieved between the need to reduce costs and to provide the desired level of comfort.

However, when all these details have been discussed, three important decisions must be made which, if not adhered to, would give rise to delays in development and even poor operation in the future facility:

- Choice of air conditioning system: all air, all water, air-water or even a refrigerant distribution system if none of the above can be adopted because of architectural or building use constraints.
- Selection of the type of cold and hot water production equipment.
- Selection of its location, allowing sufficient rights of passage for pipes and air conduits, for air distribution in each area or the introduction of external air.

The first decision will give the conditions of flow to be used for the building's air conditioning, that is, what quantities of air or water, and at what temperature should they circulate?

The building must then be divided into areas where the water distribution system and the control system must be capable of ensuring comfort throughout the year.

With knowledge of the zone layout of the building, the cold and heat loads must be confirmed to ascertain the volume of water that will have to reach each area and at what stage this volume should arrive.

This leads to selection of fan coil type area terminals. The water distribution system and the terminals contribute to the loss of pressure in the water circuit, which must be resolved with the pressure available from the pump system.

In summary, the first steps of the design of a facility greatly determine the subsequent financial impact.

Improvement of energy efficiency in the refrigeration cycle

Lines of action in relation to refrigeration technology are encompassed within the present trend to increase Energy Efficiency Air Conditioning Systems.

This trend is closely associated with two technical, social and regulatory phenomena of each country, which are the concern for protection of the environment and the achievement of sustainable development.

This phenomenon is based on two fundamental issues: removal of the risks of destruction of the ozone layer and reduction of greenhouse gas emissions:

- The first aspect is set out in the Community and National Regulations and its main origin is in Regulation (EC) No. 2037/2000 (successor to the Montreal Protocol), associated with the elimination of gases capable of destroying the ozone layer.
- The second issue, of utmost significance these days, is associated with the commitments acquired under the Kyoto Protocol. The significant reduction of emissions will be connected to a manifest decrease in energy consumption, and this will only be viable with the development of technologies of maximum energy efficiency.

There are two lines of action underway in the field of technological developments aimed at optimising the refrigeration cycle:

The so-called optimisation mechanisms:

- Use of new technologies and new materials in the design and construction of compressors and heat exchangers.
- Implementation of the heat pump.
- Application of electronic expansion valves and economisers.
- Development of expansion turbines in centrifugal coolers.

- Co-generation in facilities that use systems based on the absorption cycle.
- Optimisation of systems for the control and management of units and facilities.

The so-called savings mechanisms:

Recovery of heat for the production of hot water in air condenser units.

- Free cooling (free cooling by external air) on the air side.
- Recovery in relation to air extraction.
- Free cooling on the water side.

We show some of these mechanisms below.

Energy saving from technological progress in **new equipment**.

In general, the energy efficiency of all air conditioning equipment has been increased. The efforts made to increase the efficiency of air conditioning units have been productive in the following ways:

- Through improved materials, with increased heat transfer coefficients, especially in water-refrigerant exchangers.
- Through more simple and efficient compressors, such as the scroll compressor with only three moving parts or inverter technology.
- Thorough MCHX technology air batteries (micro-channels).

Use of more effective energy-saving control systems

Management System

Implementation of a smart, comprehensive system that meets the following needs:

- **Air Conditioning:** The system must make it possible to see, control and act on the reference temperatures established for each stay, according to pre-established timetables for use of the rooms. These systems will, at the same time, enable optimisation of the resources used, making use of free cooling of air conditioning units [and] frequency shifters in variable flow systems and, thus, reduce the thermal cost in both summer and winter. It is recommended that reference temperatures be established that are consistent with the use of the rooms and the season of the year. It is also necessary to use adjustable thermostats and to ensure that they are not within the reach of the public.

- **Lighting:** The flow of light produced by the lights should be adjusted according to the lighting requirements of the room and the contribution made by natural light present at any stage.

- **Filtration:** It is most advisable that the system should be able to adjust the filtration level according to the level of occupancy of the facility, whether occupied by spectators or only by users.
  Provided that the water quality so allows, it is advisable to filter as slowly as possible if this means an economic saving in terms of electrical power used by the pumps.

<u>Equipment upgrades</u>:

- Replacement of present motors for more efficient motors.
- Implement frequency shifters for motors that operate in different load systems.
- Replace halogen bulbs with LED bulbs, which have five times lower consumption.
- Replace linear fluorescents with LED tubes, which consume half.
- Use presence sensors in areas of low occupation: passageways, toilets, rooms for stretching, etc.
- Use photocells to manage external lighting and also the lighting in very well-lit areas of passage, along with presence sensors.

<u>Electricity quality protection equipment</u>:

Electricity is a consumer good and, as such, it should maintain a particular quality because, otherwise, it will affect all the equipment that directly or indirectly depends on it.

The distribution systems and the electrical facilities themselves can present numerous inefficiencies in their operation and this will give rise to energy losses that translate into economic waste.

The view is that the main problems that have a negative effect on the quality of the electricity in our facilities arise from:

- The electrical supply (poor supply quality).
- Voltage dips.
- Interruptions (unintentional or unplanned) in the supply.
- Overvoltage.
- Voltage imbalances.
- Ripples.
- Voltage fluctuations.
- Derived from the installation itself.
- Reactive energy and power factor.
- Load imbalance.

The effects on the facilities, derived from both poor quality of supply and from disturbances created therein, can be specified as follows:

- Errors in computers and computer equipment: re-booting, freezing, disc or data errors.
- Damage to or malfunction of control systems: loss of control of process, hardware device failures, damage to remote devices.
- Poor functioning of protection equipment: switch and fuse tripping.
- In interconnection components: appearance of electrical arcs or burned connections.
- Overheating of transformers, contribution to the appearance of ferroresonance.
- Overheating of rotary equipment.
- Decrease in the useful life of equipment. Reduced electrical efficiency of the system.
- Interference in communication systems.
- Poor behaviour of electrical charges, failure of condensers to correct power factor.
- Errors in measuring energy consumption.
- Excess currents through the neutral.
- High neutral to earth voltage levels.

The addition of equipment that acts as a bidirectional stabilising filter (**E*ƒ*E Equipment**) along with the installation and thus acts as a component to protect the quality of the electrical supply and restrict disturbances created in the tri-phase installation itself permits in all cases:

- Absorption of micro-cuts (dips) of up to 4-5 milliseconds.
- Limitation of current peaks.
- Reduction of decompensation between phases.
- Partial absorption of voltage highs and lows.
- Reduction of ripple-effect distortion.
- Reduction of Active/Reactive decompensation.
- Limitation or reduction of necessary power.

On the basis of the overall parameters set out above:

Ripple tuning Power reduction Load stabilisation Reactive reduction	→	Loss elimination
By eliminating losses	→	Consumption reduction
By reducing consumption	→	FINANCIAL SAVING

Insulation:

The insulation of a building, walls, doors, ceiling and floor, is fundamental for the reduction of cold or heat loss. And savings of up to 40% of the cost of heating or cooling can be saved.

Exterior walls should be protected with insulating materials. In view of the significant influx of the spectators to certain sports facilities, it is necessary to connect the outside and the lobby with a double access door in order to reduce any leaks that occur when people come in and out. It is also advisable to add an air curtain to avoid creating draughts.

Doors for passing between different areas must be kept closed and so automatic mechanisms must be fitted to avoid leaks of air at desired temperatures.

In systems heated by hot water, where steel pipes are used, it is obligatory to insulate the distribution sections, that is, any sections used to distribute hot water to the final point of consumption. In this way, losses can be reduced by 70%. Thermal and lighting gains caused by the entrance of solar radiation into the building must be taken into account as free natural contributions to the heating systems, and so adequate measures should be available to take maximum advantage of them and also to control the effects thereof, whether or not desired, on the creation of interior comfort.

Correct installation management:

Below we will give a series of practical recommendations for saving on heating:

- It is necessary to take into account the fact that, for each degree above 21º C, 7% more energy in heating will be unnecessarily wasted. In the sports areas of rooms and halls where a physical activity of some intensity is carried out, 14º C is sufficient. Dressing rooms must be kept at a minimum of 20º C.
- In the administrative offices that may be present in sports centres, a check should be made as to whether it is heated at more than 21º C because the maximum recommended heating level is this temperature.

- It is advisable to reduce the heating level in those areas where a high ambient temperature is not needed. Radiators situated in passages and on stairways should be taken out of service. It should be remembered that heat needs are lower in areas where physical exercise is carried out.

- Divide the heating system into groups in hot air systems. In this way, according to the heat needs, one or another group may be activated, so that the entire system is not put into operation. This phased switching on can be carried out manually or electronically. With this system, savings of 10% can be achieved compared with the same equipment without this function.

- Installation of a heat pump which consumes three times less energy than an electric radiator which can also be used as a refrigeration system (in the case of reversible operation pumps). This system is appropriate for facilities of moderate size.

- For large surface areas, it is necessary to adjust thermostats and radiator controls in order to obtain the desired temperature and to seal them with anti-manipulation covers. Thermostat controls should not be misused as switches.

- The adjustments for internal thermostats are 4º C and for external thermostats 0º C to 1º C. These should be labelled as anti-ice thermostats. If thermostats are adjusted too high, money will be lost through excess heating and, if they are too low, the system will run the risk of freezing.

- It is advisable to regularly check that the timers state the correct time and day and that the adjustment time corresponds to the occupation time. It should also be checked that the heating and ventilation are switched off when the building is empty. Pre-heating periods should be adjusted to the weather conditions and it should be remembered that stored heat in radiators in the rest of the building can be sufficient to allow the heating to be turned off before the opening hours are over in particular areas of the sports centre.

- It is recommended that controls with an optimisation module be fitted when the surface area to be heated is more than 1,000 m^2. Climate optimisers adjust activation of heating systems to compensate for changes in outside temperature, saving money by preventing overheating when the weather conditions are good and switching the heating on earlier when there is a high level of nocturnal cooling.

- It is necessary to check whether there are any parts of the building that normally have the heating on too high. The installation of additional thermostats or sensors in specific areas may be needed. Similarly, bleeding valves should be fitted to ensure flows in all pipes so there are no areas with a lower-than-required flow.

It should be checked that no heat surfaces are obstructed because, if they are, this will reduce their effectiveness, resulting in low emission, much longer heating times and increased energy consumption. It is also important to locate the radiators correctly.

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