# Improving energy efficiency in South West Europe transport stations

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**Abstract** *Stop $CO_2$ Project aims at creating an evaluation tool to assess the energy efficiency of transport stations. It will help determine both consumption and appropriate potential solutions for a more sustainable building management. The strategy is to include transport facilities such as bus/coach stations as a key issue in the local policies on sustainability and environmental protection, not only as a link in the mobility chain but also as a main aspect for the whole energy efficiency of urban areas. The project will draw a framework of recommendations for the relevant institutional bodies and for the decision and policy makers.*

## 1. INTRODUCTION

Most European towns/cities and urban areas have at least a bus/coach or railway station in the city centre. These facilities and their surroundings usually have an extremely high density of vehicles which, combined to an inadequate connection with the urban transport networks in terms of energy efficiency and the lack of planning and energy management policies in these facilities (often linked to a matter of competences and ownership), creates a negative impact on the urban environment, far from the EU objectives. On the contrary, the transport facilities should be a key factor to influence people towards a transition to a sustainable way of living, in which the collective transport should play a basic role.

## 2. STATE OF THE ART

According to a first data assessment covering 244 stations in cities of 50,000 inhabitants (165 in Spain, 52 in Portugal and 27 in South West France), bus and train stations are usually old public buildings, with high energy consumption and high costs: an average of 55 years in Spain, 81 in Portugal and 145 in France.

Interesting energy indicators were developed with the collected data, such as energy consumption per traveller (Spain has the highest indicator) and consumption per implementation area (France has the highest value). The study also showed that the renewable energy was very weak (7% for Spanish stations, only 1 in Portugal and 0 in France) and that 33% of the Spanish stations were certified (EPBD) against 7% in France and 2% in Portugal.

All the station managers were identified and contacted to collect energetic, consumption and environmental information for the project. They are key actors representing the final users, therefore benefiting from the project.

## 3. EVALUATION TOOL AND STATIONS SUSTAINABILITY NETWORK

The main objective is to improve the station energy management using an evaluation tool to create a station network for energetic sustainability. The required data include building area, thermal insulation, lighting system, heating, use of renewable energy and mobility criteria. As a final result, the systems output gives a global rating from one to five stars and a score for each management block. Station managers can do the assessment alone or with our help through a video.

Figure 1: Stop $CO_2$ sustainable stations network

With a large number of evaluations, the SUDOE area will have a network of stations evaluated with the same criteria. This ranking will help managers know and correct their deficiencies and reduce management costs. Today, 65 stations have been evaluated.

## 4. RESEARCH & INNOVATION APPLIED TO ENERGY EFFICIENCY MANAGEMENT IN TRANSPORT STATIONS

The main result is an innovative methodology based on the research and knowledge sharing for the improvement of the station energy management. The results are the definition of BIM model requirements and information transfer protocols with the Level of Development (LOD). Through the analysis of case studies developed in this project, we defined LOD requirements for energy analysis in existing buildings (Transport Stations) and evaluated the interoperability between the BIM authoring software and energy-analysis software. We also specified various requirements for each type of energy study. Low LODs (LOD 100) are restricted to non-detailed energy studies. Higher LODs (200 and 300) are required to represent the building and equipment as required for energy studies beyond the conceptual design stage. This methodology gives an accurate decision-making process to identify the best solutions for energy retrofitting projects, including the entire process from data acquisition, energy modelling, software interoperability and building energy analysis. With this methodology, the benefits of assessing the building energy performance on a virtual environment may be gathered in the earliest project stages.

## 5. PILOT PROJECTS FOR IMPROVING ENERGY EFFICIENCY IN TRANSPORT STATIONS.

The 6 stations studied in the project were 3D scanned to get the exact geometry of the buildings. Then BIM models were created to use this geometry in designing software for energy or lighting simulations but also to connect with maintenance tools.

### 5.1 Arcachon train station (France): management and operational control with BIM technology

Built in 1910, Arcachon SNCF railway station is a good example of the regional public transport stations of that time. A pilot project was carried out to use of the BIM methodology. The objectives were to improve and facilitate planning and studies related to design, to capitalize essential information for the maintenance of buildings, and to have detailed numerical models for operational management. All of these objectives should contribute to improving the energy and environmental performance of operations. Based on the digital architectural model developed by the design team, it has been associated with a hypervisor that creates a link between the digital model in IFC format and a results control system (centralised management). This allowed the definition of indicators related to alerts and reporting. Here’s the process followed:

1. Research on existing hypervision solutions on the market (advantages, limits, etc.);
2. Communication and sharing with the operator (SNCF Gares and Connections) of the objectives and expected indicators for the proposed solution.
3. Exchanges with the operator regarding existing systems (Building Monitoring) and the data required to define indicators and control operations (equipment maintenance, construction data, etc.), as well as the human resources necessary for the correct use of the hypervisor.
4. Interoperability with the proposed solution for hypervisor start-up.
5. Pilot Project Implementation.

### 5.3 Cartagena bus station (Spain): renewable energies and monitoring

Cartagena's bus station is situated Avenida Trovero Marín, in the Spanish city of Cartagena (region of Murcia), close to other public transports such as the railway station of Via estrecha and the railway station of ADIF. The bus station, inaugurated in 1995, covers a built area of 3 891 $m^2$, on a plot of 11 441 $m^2$, distributed on a ground floor where are installed 37 platforms and 5 floors. The energy studies identified as main energy consumption, the lighting of the hall, (not air-conditioned). The following actions were undertaken:

1. Different alternatives were analysed with energy management methodology and digital modelling tools, with the aim of improving the energy efficiency of the building and reduce their $CO_2$ emissions.
2. One of the solutions evaluated and finally implemented was the installation of photovoltaic solar panels in order to generate electricity for the self-consumption of the bus station.
3. Another implemented solution was the installation of a control platform for energy consumption of the building and other variables, such as building occupancy, indoor temperatures and meteorological variables. This system, which will be integrated with the city's Smart City platform, simply displays the information collected, through the different control screens.

### 5.4 Torrelavega bus station (Spain): lighting systems and naturel light

The Torrelavega bus station showed various energy failures, due to its structural conditions and the construction characteristics of its equipment. Thus, the first energy evaluation, using the Sudoe Stop $CO_2$ self-assessment tool, resulted in a low energy rating of the building, with only 2 out of 5 stars, energy failures to be resolved.
As a case study under the Sudoe Stop $CO_2$ project, the BIM methodology was used to mitigate the problems detected. A digital model of the building in 3D was therefore built and shared with experts in thermal and energy studies who proposed alternatives to reduce the energy costs of the bus station. The solutions included replacing the lighting system, as well as passive actions such as using natural light or improving air circulation. The process was completed with the refurbishment of the lighting system, which reduced consumption by up to 50% and achieved a 3-star ranking in the network of Sudoe Stop $CO_2$ sustainable public transport stations.
The digital mock-up has been enriched with new elements so that it can be used as a tool for building maintenance and management, as well as to collect and recount data from the monitoring systems installed in the bus station.

### 5.5 Campo 24 de Agosto bus station (Portugal): improved user comfort without energy costs

The bus station "Campo 24 de Agosto" is located in Porto, Portugal. The bus station was completely renovated in 2016 and reopened to the public in May 2017. This bus station occupies the basement of an office building, covering an area of 4805 $m^2$. The bus station is open every day of the week, from 04:00 to 01:00 in the morning.
The recent renovation of the building has enabled the installation of energy efficiency solutions, such as LED technology for the lighting system. The Sudoe Stop $CO_2$ studies have identified the energy standards of the station's main fuel burners, associated with lighting and vending machines.

1. The application of the "Methodology of energy management of public transport stations by

means of numerical modelling tools" (BIM) elaborated in the project makes it possible to identify the most adequate energy solutions for the bus station, as well as evaluate the behaviour of the building.

2. The consumption of vending machines can be reduced and optimized simply by switching off the devices during the closure of the bus station, without this affecting the quality or condition of the products sold. It is therefore recommended to install programmable automatic shutdown systems, to ensure that the devices operate according to the real needs of users.
3. The studies carried out in this bus station in order to evaluate the thermal comfort of the users show that they have an important ability to adapt to thermal variations. However, the provision of quality public transport services and the development of infrastructures capable of meeting user expectations deserve special attention. It is therefore recommended to improve the thermal comfort of users through the creation of isolated independent areas acting as waiting rooms.

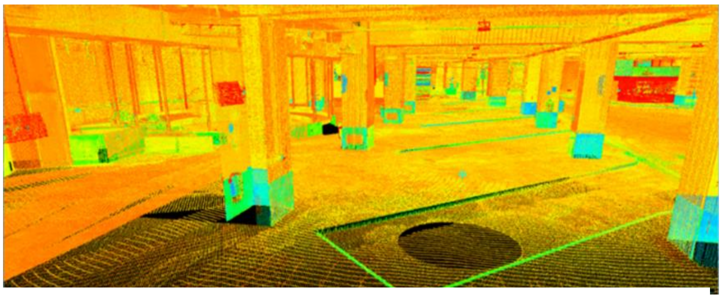

Figure 2 : Pilot project in "campo 24 de Agosto" bus station

## 5 ITINERANT PUBLIC AWARENESS CAMPAIGNS

### 5.1 Itinerant public awareness campaigns in Spain, France and Portugal

An itinerant exhibition was organised to raise awareness on the need of improving energy efficiency and $CO_2$ emissions in the city centres. Under the motto “Discover a sustainable station”, exhibitions travelled across South West Europe displaying the results of Sudoe Stop $CO_2$ to thousands of travellers every day, ensuring visibility and impact on the citizens. The exhibition has been presented in Lisboa, Bordeaux St Jean, Porto Sao Bento, Santander, Cartagena, Santa Pola, Porto Campo 24 de Agosto, Zaragoza, and Torrelavega.

## 12. CONCLUSIONS

So far, more than 60 stations are assessed with Stop $CO_2$ evaluation tool. This great success is a key indicator regarding the willing of station managers to improve environmental efficiency of their infrastructure. 5 pilot stations were deeply studied in the project, using 3d scanning, BIM modelisation and numerical simulation to implement improvement works. In some cases, lightning systems were changed for LEDs with astronomical clock. New energy centralised management systems were also widely used. Renewable energy such as Photovoltaic solar systems were implemented in some stations when planning permission was possible regarding the historical architectural style. More than saving $CO_2$ emissions, the methodology developed in the project allows to better understand the building behaviour and help station manager to develop new skills in energy management.