

# Application of a KPI-Driven Protocol for Sustainability Assessment <sup>†</sup>

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**Abstract:** Traditionally, the energy efficiency in buildings has been evaluated through well-established protocols that highly depend on Key Performance Indicators (KPI). However, nowadays, the trend has moved from buildings to districts and cities where not only energy efficiency is pivotal, but also the sustainability under the scope of smart city. There exist several widely recognized environmental assessment methodologies such as BREEAM or LEED that aim to assess the sustainability of buildings based on a rating system represented by a set of indicators, namely credits. Nevertheless, the application of these standards is complex and costly. Hence, this paper presents an alternative holistic sustainability protocol, developed under the European project CITYFiED, driven by a comprehensive set of indicators to assess the sustainability of urban areas in terms of energy efficiency, environmental, economic and social impact, together with the effect of the information and communication technologies.

**Keywords:** sustainability; KPI; assessment; CITYFiED; BREEAM; LEED

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## 1. Introduction

The reality of climate change presents particular challenges for cities. In 2016, an estimated 54.5 per cent of the world's population lived in urban areas [1]. Projections show that the proportion will increase to 60% by 2030, in contrast with the situation in 1950, when less than 30% of the world population lived in cities [2]. In particular, buildings represent the largest energy-consuming sector in the EU, and offer one of the largest cost-effective opportunities for savings and sustainability improvement. Overall, buildings are responsible for about 40% of the energy consumed in Europe and 36% of CO<sub>2</sub> emissions [2].

The sustainability concept involves a complete new model of socio-cultural relationships between citizens and their environment. Its development requires a wide transformation of the way in which human activity is conceived and organized in urban environments, in the institutional, economic, social or technical sphere. The European Commission, under the Action Plan for Energy Efficiency, identified Energy Efficiency in buildings as a key priority, having been recently reinforced by publishing in November 2016 plans to update the Energy Performance of Buildings Directive and the Energy Efficiency Directive that aim to reduce energy consumption in buildings.

In this context, the demonstrative Smart City FP7 project CITYFiED [3] (Future Innovative and replicable Efficient Districts and cities) aims to deliver a replicable, systemic and integrated strategy to transform European cities into Smart Cities, focusing on reducing the energy demand and GHG emissions and increasing the use of renewable energy sources [3]. Nevertheless, the final impact should be evaluated and, for this reason, CITYFiED proposes a novel holistic protocol to evaluate the

sustainability. That solution reduces the complexity of protocols like BREEAM [4,5] or LEED [6,7], widens the scope of the current sustainable standards and integrates new features. Basically, the protocol is thought as the glue between the following six pillars: Energy, ICT tools, Quality control of interventions, Economic evaluation, Social acceptance and Life Cycle Analysis (LCA). The proposed approach offers a new sustainability assessment procedure, based on evaluating KPIs, which provide an objective view about the facilities' performance.

### 2. KPI-Driven Evaluation Protocol

As stated before, within CITYFiED project a novel holistic protocol has been defined in order to assess the sustainability level of a district. The objective was to reduce the complexity of some standards such as BREEAM and/or LEED and integrate new pillars [8] in the evaluation according to the new trends, i.e., ICTs and LCA, which were not initially included by the aforementioned standards. Thus, Figure 1 [9–11] illustrates the protocol including the identified pillars: Energy, ICTs, Quality control of interventions, Economic evaluation, Social acceptance and LCA. Moreover, all the evaluation is based on objective parameters, i.e., KPIs [11].

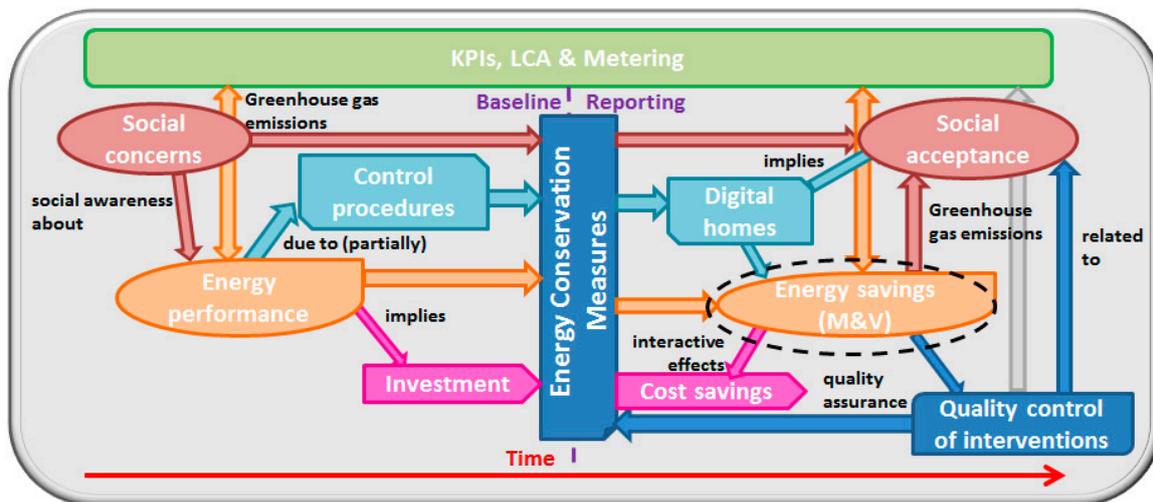


Figure 1. Proposed sustainability evaluation protocol.

Starting from the left hand side, it is shown that the energy concerns begin with social awareness, both at citizens' level and at organizational level (public authorities, sustainability plans, etc.). The low performance due to existing facilities or wrong control strategies has as a consequence emissions of greenhouse gas (GHG), and the improvement of such performance and the inclusion of new technologies implies an initial investment. Collecting all these aspects through metering determines the retrofiting strategy as well as the best ECM for the specific building or district.

On the right hand side, the post-intervention status is evaluated. The main aspect is the energy performance in terms of energy savings, which is partially achieved by the investment in new ICT technologies (digital homes), and the ECMs. To ensure the expected energy savings, ECM has to be implemented in the correct way following Quality Control of Interventions rules. These energy savings drive to cost savings at consumption and also at generation level. And thanks to the energy efficiency, less invoice costs and new technologies, together with the involvement of citizens, the social acceptance of these solutions is increased from both the citizens' point of view (reduction of the bill) and the organizational perspective (less energy consumption and maintenance costs).

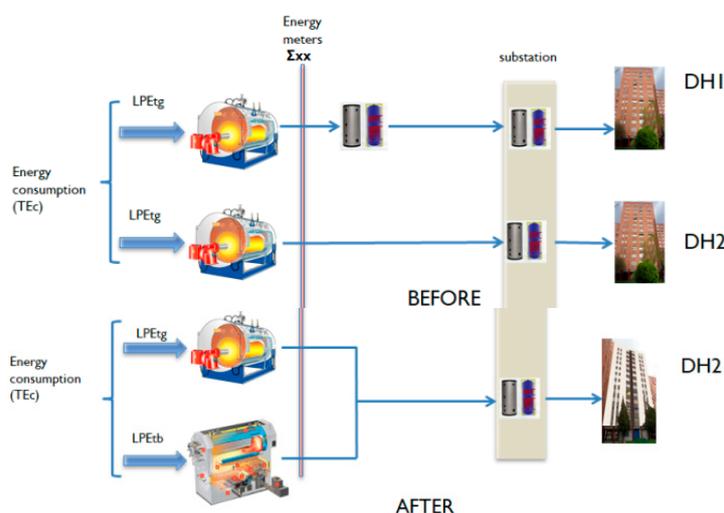
### 3. Application in Laguna de Duero

Laguna de Duero (Valladolid) is the Spanish demonstrator of CITYFiED and is experiencing a big challenge in terms of sustainability. From this initial status, the following specific ECMs are being carried out:

- Retrofitting of the façade in order to increase the insulation level.
- Improve the district heating by integrating a mix of energy supplies: biomass boilers for the main demand and a support boiler based on gas for peaks.
- Cogeneration plant so as to increase the self-consumption.
- Monitoring of the interventions and integrate ICT solutions.
- Web visualization of consumption to increase social awareness.

### 3.1. Energy

As explained before, the main topic of the sustainable assessment is the energy performance. In this case, IPMVP (International Performance Measurement and Verification Protocol) [13] has been selected, which is a world-wide use protocol for energy efficiency. Figure 2 represents the situation before (left) and after (right). The initial status contained two district heating based on two gas boilers, while new situation is one single district heating based on one biomass boiler and a second (gas) boiler for support. Bearing this in mind, some indicators are required to evaluate the energy savings. The main one is the primary energy consumption (TEC in Figure 2) per square meter, from where the real energy savings will be obtained. In this case, the performance of the boilers is also taken into consideration.



**Figure 2.** KPIs for energy efficiency and schemas of measurement.

### 3.2. Environment: Quality Control of Interventions

Their objectives are in the first place to guarantee the proper development and implementation of the strategies - related to the quality in the materials which conducts to more energy efficiency - and secondly to ensure a sustainable process, i.e., guaranteeing low waste or noise during the implementation, obtaining final measures for the quality performance of the renovation, etc. They are adapted from different sources as BREEAM [4], LEED [6], DGNB [14] or ISO standards among others, describing the necessary documents, the test to be performed, references or degree of compliance.

### 3.3. Social Acceptance

One important issue that is usually not taken into account in some renovation projects is the social acceptance. However, the involvement of residents and citizens from the very beginning is crucial for the success of this kind of energy efficiency retrofit projects. That is one of the most relevant contributions of CITYFiED's assessment procedure with respect to the existing standards. In the Torrelago case [11], a survey procedure in combination with objective results is applied and four dimensions that will allow the assessment of the global satisfaction degree and social acceptance of the project have been defined:

- Social: evaluates the citizen engagement by analysing the participation degree.
- Indoor environment: used especially in relation to the comfort of building occupants.  
Economic: assesses the affordability of the retrofit project to the residents.
- Technical: evaluates the acceptance degree of the technical solution.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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