Sustainable and Social Energy on Smart Cities: Systematic Review

Regina Sousa, Diogo Lopes, António Silva, Dalila Durães(✉), Hugo Peixoto, José Machado, and Paulo Novais

ALGORITMI Research Center, School of Engineering, University of Minho, Gualtar Campus, 4710-057 Braga, Portugal
regina.sousa@algoritmi.uminho.pt, pg42823@alunos.uminho.pt, {antonio.silva,dalila.duraes}@algoritmi.uminho.pt, {jmac,pjon}@di.uminho.pt
https://algoritmi.uminho.pt

Abstract. Sustainability and social energy are two concepts associated with smart cities. They aim to combat and contain the alarming environmental and socio-economic repercussions that urbanization has been causing on our planet. Smart sustainable cities drive to improve the life quality of citizens while ensuring that they meet the needs of the current and future generations. Sustainability is essential for urban transformation to achieve more resource-efficient, resilient and smart cities. The main objective of sustainable cities is to guide decisions for interventions in the city. Monitoring systems are examples of measures that aspire to ensure greater sustainability and energy efficiency, such as the application of air quality meters or smart water and light meters. Throughout the analysis of the collected data, it's possible to develop alert systems and optimization models considering various metrics based on artificial intelligence. Therefore, allowing users to make better decisions to positively affect the course of actions in their cities and make it possible to apply sustainability and social energy measures. Thus, it is possible to reduce and improve the consumption of natural resources. Industry 5.0 is crucial in the evolution of smart cities. The complementarity role that this industry has been demonstrating is related to the technologies being developed, in which artificial intelligence plays an important role. This industry places its technology at the service of human beings, society and the environment.

Keywords: Sustainability · Social energy · Smart cities · Smart sustainable cities · Energy efficiency · Monitoring systems

1 Introduction

Cities have been transformed into hubs to meet the needs of modern civilizations. Due to this continuous transformation, a great impact on the use of natural

T. Guarda et al. (Eds.): ARTIIS 2022, CCIS 1676, pp. 72–84, 2022.
https://doi.org/10.1007/978-3-031-20316-9_6

resources has been caused by these cities as they seek to provide better conditions for their citizens. Data from the United Nations Department of Economic and Social Affairs, DESAP, predict that around 68% of the world's population will live in urban areas by 2050. This population growth brings countless new challenges for governments beyond the impact on natural resources, such as pollution, displacement problems due to traffic and congestion, high costs of living and security problems [5]. Related to sustainability and the fact that natural resources are not unlimited, there is a huge concern to make cities sustainable, connected and optimized thanks to the influence and evolution that technology has had [8].

The study and development of the concept of smart cities have been a topic of great interest for several years. The first steps were made by focusing on the study of some general aspects. Forced by the fact that cities are constantly evolving, over the years, the scientific community has started to implement different approaches and new technologies to develop more sustainable measures. They are seeking better solutions to improve the life quality of citizens in crowded areas like cities, to make them more efficient and optimize their resources [5]. Today there is a great diversity of methods focused on sustainability estimation. However, the complexity and multidimensionality of these concepts usually become barriers and difficulties [8].

As stated, cities, regardless of their size, are constantly developing in search of solutions that improve life quality and efficiency. These cities are called smart sustainable cities. With the use of information technologies (ICTs), they ensure that they meet the needs of present and future generations concerning economic, environmental and cultural aspects. Industry 5.0 plays an important role in the evolution of information and communication technologies. An increasing number of projects have been launched to create information management systems [5], with a vast potential to contribute to cities' needs, such as systems to improve the energy consumption of schools or houses. Energy efficiency is one of the most relevant issues for the scientific community and society since greater energy consumption will contribute to better global sustainability. It is important to note that buildings, on average, are responsible for 40% of the total energy consumed [2]. However, in all of these developments, it is important to take into account some aspects that are closely related to citizens and their respective environments as smart city models must be useful and evolve alongside their population. These developments must be efficient yet flexible and easy to implement with other existing smart city tools. ICTs play an important role in this, as they are a key element in the infrastructure that provides a city with intelligence and sustainable devices [5].

Environmental sustainability requires the minimization of the human impact activities in the area where they take place. With the population growth, the energy demand is higher as the population demands more comfort. Smart sustainable buildings play an essential role in the future generation of smart cities. The main goal of these buildings is to reduce the impact of energy consump-

tion [2]. Ensuring higher energy efficiencies will contribute to worldwide sustainability.

The area of sustainability is highly diversified and has been witnessing an enormous evolution, since sustainability range from environmental to socio-economic measures. Sustainable socio-economic development depends on, among other factors, the availability and accessibility of natural resources such as energy and water [9]. Water management and energy recovery systems, are examples of sustainable and efficient cost-effective solutions, as they can improve the resource use efficiency, where the waste of water and energy can be minimized, which allows the cities to become more efficient and sustainable. Implementation of sustainable and social energy measures and systems, incorporated with the citizen's help throughout intelligent systems, such as a web application, are key factors for the constant development of smart cities.

Bearing in mind that the goal of a systematic review is to look for the most recent scientific publications to give us an overview of the current state of the art. This helps because we obtain a better perspective on the state of the development of different approaches and technologies related to the theme of sustainability and social energy applied and developed in favour of a Smart City and what has been and is being done in this domain. That said, this research was conducted based on the principles of a systematic review. The following Research Questions have been proposed:

- **RQ1:** What strategies and tools have already been developed and used to implement and integrate sustainable and social energy measures in smart cities?
- **RQ2:** How can sustainability measures improve citizens' lives in a smart city, and how to make them active contributions?

This paper is structured as follows: Sect. 2 describes the methodology carried out to do the research and review process, taking into account its main steps, i.e., the selection of data sources, the search strategy, and the selection criteria and the respective results. Section 3 provides the results obtained throughout the relevant literature search and review described in the previous section. Next, Sect. 4 presents a discussion of the results obtained and the relevant articles and documents are presented. Finally, Sect. 5 summarises and compiles the set of conclusions, lessons learned and contributions obtained through the review. In addition, proposals for future work are presented.

2 Methodology

This review was conducted based on PRISMA[1] (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) statement and respective checklist [7]. This choice was mainly due to PRISMA being widely accepted by the scientific community. Therefore, the following steps were taken into consideration:

[1] http://www.prisma-statement.org.

1. Identification of the study's research questions and relevant keywords;
2. Creation of the research query;
3. Definition of the eligibility criteria to filter and reduce the articles sample;
4. Analysis of the resultant set of studies and papers;
5. Presentation and discussion of the results.

The preliminary research was conducted on 21 April 2022 and the used data source was SCOPUS[2], due to its size, quality assurance and wide coverage in terms of publication subjects.

To carry out the relevant literature and documentation research, some keywords were defined as a starting point. These keywords were applied in the following fields: title, abstract and keywords. To organize the search resources, the keywords were organized into two groups, which are combined in conjunction. Keywords in each group are combined with disjunctions. This choice fulfils the purpose of each group selecting all documents that include at least one of its keywords and then ensuring that only documents that contain at least one term from each of the groups are selected. The first group is related to the areas and technical subjects directly related to the research topic ("*Social Energy*", "*Sustainable Energy*", "*Smart Cities*", "*Smart Sustainable Cities*" and "*Energy Efficiency*"). The second group aims to filter by broader areas of the technological scope ("*Monitoring Systems*", "*Information Systems*", "*Data Management Systems*" and "*Decision Support Systems*"), in order to focus the results in the context of information systems and agents. Therefore, by applying the strategy described above, the following research query arose:

```
( TITLE-ABS-KEY ( social  AND energy )
OR  TITLE-ABS-KEY ( social  AND energy )
OR  TITLE-ABS-KEY ( sustainable  AND energy )
OR  TITLE-ABS-KEY ( smart  AND cities )
OR  TITLE-ABS-KEY ( smart  AND sustainable  AND cities )
OR  TITLE-ABS-KEY ( energy  AND efficiency )
AND
( TITLE-ABS-KEY ( monitoring  AND systems )
OR  TITLE-ABS-KEY ( indicators )
OR  TITLE-ABS-KEY ( information  AND systems )
OR  TITLE-ABS-KEY ( data  AND management  AND systems )
OR  TITLE-ABS-KEY ( decision  AND support  AND systems ) ))
```

To screen the articles and studies collected, some eligibility criteria (in the form of exclusion criteria) were defined. As such, all documents that matched any of the following criteria were excluded:

EC1 : Not accessible in *OPEN ACCESS* mode.
EC2 : Were not produced in the last 3 years or have not yet been fully published.
EC3 : Do not come from the field of *Computer Science* or *Engineering*.

[2] https://www.scopus.com.

EC4 : Are not an Article or a Review/Survey
EC5 : Article or a Review/Survey are not written in English.
EC6 : Article or a Review/Survey are not with the accordance with the area of investigation.
EC7 : Were not produced inside the European Union (due to similar policies regarding extraction, manipulation and exploitation of data for the production of knowledge, as well as data protection).
EC8 : Do not focus on the variables studied or are out of context.

3 Results

The initial database resulting from the previously described search returned more than 87 800 documents and the document selection process is summarized in the Fig. 1.

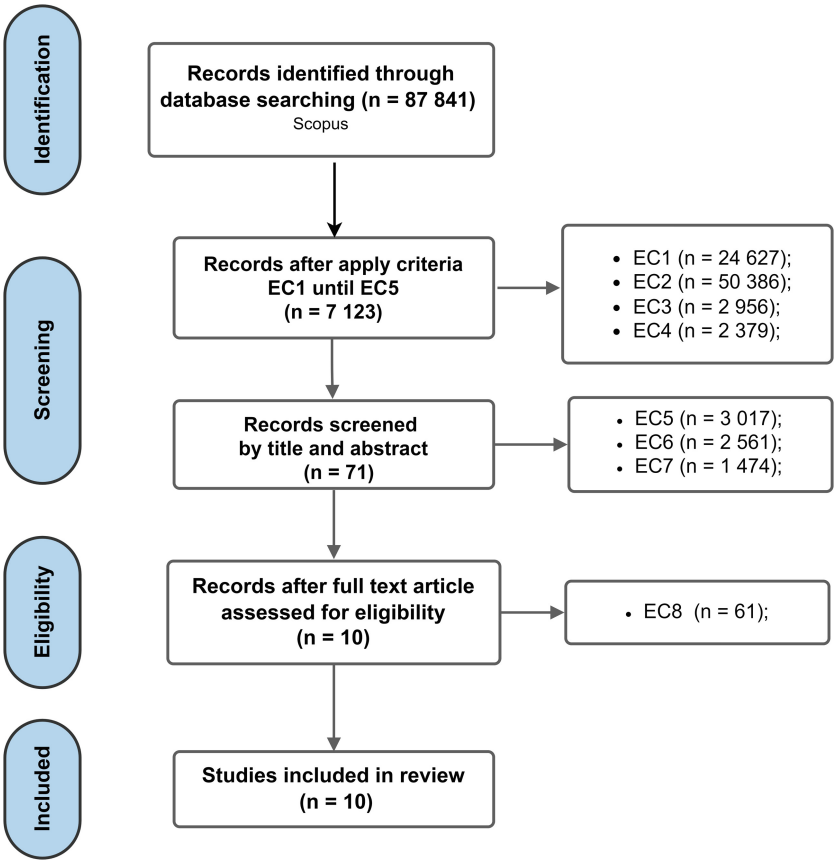

Fig. 1. Adaptation of the PRISMA Flowchart applied in this study.

The first two criteria (EC1 and EC2) were applied using the SCOPUS direct filtering system, resulting in a subset of documents that are freely accessible and written no more than three years ago. Of the obtained 12 828 studies, the third and fourth criteria (EC3 and EC4) were applied. The results were a subset of engineering and computer science documents written in English. In the 7 123 studies, the following three criteria (EC5 to EC7) were applied, again using the SCOPUS direct filtering system, resulting in articles or reviews that are in line and area of investigation and produced in countries inside the European Union. As a result, 71 studies were left for full reading, which resulted in a final set of 10 that were considered relevant and reviewed in detail. The other 61 documents were excluded due to not focusing on sustainability and social energy (EC8).

Considering the final set of suitable studies, Quijano et al. [8] developed a framework with the aim of covering multiple pillars of smart and sustainable cities. Related to the mySMARTLife project, this framework concerned the main pillars of smart and sustainable cities, such as environment and energy. This framework was validated in real case studies implemented in the cities of Nantes, Hamburg and Helsinki. The insights obtained from the evaluation performed, lead to measures to boost the scaleup of the sustainable solutions in the cities.

Hernández et al. [6] benefiting from the use of ICTs, started developing a monitor and control tool. This tool is yet to reach its final version. Making use of artificial intelligence for the automated decision-making process in buildings, they seek to produce optimal comfort measures for their occupants to achieve energy efficiency. The state-of-the-art building control systems are based on simple decision-making processes, which does not help to obtain the most suitable comfort measures and energy efficiency. This tool is being validated in a real case study implemented in a school in Turkey. Nevertheless, being currently under development, the marks obtained so far with their tool show promising results in applying artificial intelligence to buildings. Therefore, the integration of prediction techniques such as those found in the project BRESAER (BREakthrough Solutions for Adaptable Envelopes in building Refurbishment), a building energy management system (BEMS), has shown several advantages in making more efficient use of the energy.

Garcia-Retuerta et al. [5] also benefited from the use of ICTs, and as networks and services are more flexible and effective, they were able to develop a platform to improve the cities operations for the benefit of its citizens. The presented platform has as its main objective analyzing and creating dashboards, to be used in alert systems. Nowadays, cities have data acquisition types of equipment to collect data for their own systems. This information is used to optimise resource consumption. Addressing a gap found, this research team developed this platform with optimization models for the decision-making process, which have proven to be more effective when compared to the systems that don't make use of these models. Their platform is also the cornerstone of smart territory development. To estimate pedestrian traffic, the platform was validated in a real case study implemented in Melbourne (Australia). To sum up, it is important to state

that Deepint.net made the creation of an advanced crowd detection dashboard possible through advanced machine learning algorithms.

García-Fuentes et al. [4] implemented a multi-criteria decision methodology based on relevant district sustainability indicators, that allow individuals to make effective decision-making about energy efficiency improvements. This methodology can evaluate the district complexity in terms of the specific features associated (buildings, urban areas, energy systems) providing solutions to implement the best combination of energy efficiency according to buildings' typology, standards and regulations.

CRISTEA et al. [3] conclude that in the current state-of-the-art there is a lack of intelligent transportation platforms/systems. Therefore, began to study and develop a platform that assists in the mobility of citizens. This intelligent mobility assistant is a data platform developed for public authorities, businesses and casual users. The goal is to enhance citizens' level of comfort, safety and environmental awareness. The current state of the application leads to an innovative portable solution, easily deployable and configurable. The key feature of this platform is that it is able to integrate data provided by third-party systems. The prototyped device can be used to determine, store and provide useful notifications through the visualization and management tools that offer.

Ramos et al. [9] study renewable energy sources used in the water sector in order to improve the system's efficiency. Developed a water and energy nexus model, in a real case study, to improve the system's efficiency and sustainability. In terms of social impacts, this study has shown that renewable energy can contribute to better air quality and promote the idea of eco-friendly and more sustainable life in the local communities.

Benavente-Peceset al. [2] study the information and communication technologies, ICTs, their respective techniques, their key characteristics and their contribution in order to obtain higher energy efficiencies in smart buildings. It presents the most suitable and new emerging technologies and their applications in smart buildings. Energy efficiency and the technologies make it possible to increase this improvement in energy efficiency and energy savings. As stated, information and communications technologies play a relevant role. Until now, as a result of the study developed, smart devices such as thermostats, temperature sensors, and light intensity meters have been applied to buildings, demonstrating the ability to provide and obtain better consumption, improving energy savings.

Salom et al. [10] present an evaluation framework which defines key performance indicators to evaluate the energy sustainability of neighbourhoods which are distributed in five categories: energy and power performance, GHG emissions, indoor environmental quality, life cycle costs and social sustainability. The authors conclude that future work is still needed in regard to testing and validating the proposed assessment framework as well as further research regarding the selected performance indicators.

Akande et al. [1] report on an evaluation and raking of 28 European capital cities based on their current state of transition towards fully smart and sustainable cities. The authors were able to conclude that Berlin and the other Nordic

capitals lead the ranking. On the other hand, Sofia and Bucharest obtained the lowest scores and therefore concluded that they are not yet on the path to becoming smarter and more sustainable cities. The authors also stated that there is a positive correlation with the cities' GDP per inhabitant, which is an indicator of wealth and its progress in the transition.

Finally, Sánchez et al. [11] proposes a control and monitoring system for irrigation systems based on a new irrigation algorithm that uses rainfall probability data to regulate the irrigation of the installation. This algorithm has the particularity of being complemented by the verification of sending and receiving information in the LoRa network. In this way, it is possible to reduce the loss of information packets.

4 Discussion

This section explores and discusses the findings of the review against the research questions. The Subsect. 4.1 presents different strategies, tools and developments that have already been developed and used to implement and integrate mechanisms and measures of sustainability in smart cities. Next, Subsect. 4.2, is related to how sustainable and social energy measures can improve citizens' lives in a smart city, and how it's possible to make them active contributors.

4.1 Strategies and Tools that Have Already Been Developed and Used to Implement in Smart Cities

The work developed by the scientific community, in terms of strategies and tools, to implement and integrate sustainable and social energy measures in smart cities, is extremely relevant as it serves as a foundation for future developments and experiences. Table 1 presents the articles identified and analysed, those that

Table 1. Strategies and tools implemented for sustainable and social energy measures in smart cities.

Authors(s)/Article	Strategies/Tools
Quijano et al. [8]	Propose an evaluation framework developed with the aim of covering multiple pillars of smart and sustainable cities.
Hernández et al. [6]	Present a monitor and controlling tool to optimize the comfort of the people inside buildings in order to improve its energy efficiency.
Garcia-Retuerta et al. [5]	Introduce a platform that captures, integrates, analyses, and creates dashboards, alert systems, and optimisation models, to make services more flexible, effective, and sustainable.
García-Fuentes et al. [4]	Multi-criteria decision methodology based on relevant district sustainability indicators.
CRISTEA et al. [3]	A smart assistant platform for smart mobility to enhance the level of comfort, safety and environmental awareness of the transportation users

are considered to be the most relevant for the application of sustainability and social energy.

The solution presented by Quijano et al. [8] is a framework that contains more than 150 actions, such as environment and energy, aiming to help in the smart and sustainable transformation of cities. Related to the mySMARTLife project, their framework was validated in real case studies implemented in the cities of Nantes, Hamburg and Helsinki. On energy and the environment, this solution seeks sustainable ways to ensure energy efficiency, implying a reduction in energy consumption, through measures such as smart lighting. The insights obtained, lead to measures to boost the scaleup of the sustainable solutions in the cities.

Following the same principle, the approach proposed by Hernández et al. [6] emerges as a solution for the energy efficiency problem. However, the tool base is a little different. Benefiting from the use of ICTs, started developing a monitor and control tool that uses artificial intelligence for the automated decision-making process to achieve energy efficiency in buildings. Making use of artificial intelligence for the automated decision-making process in buildings has proven to produce optimal comfort measures for their occupants to achieve energy efficiency. In Turkey, as part of the H2020 BREASER project, this tool was validated in a real case study implemented in a school. Through the implementation of fuzzy logic techniques, this system has allowed the best possible management of the energy resources of a school.

The big problem for cities lies in the way in which data can be processed and analysed. With the possibility of complementing the previous approaches, the work presented by Garcia-Retuerta et al. [5] addresses the problem by presenting the deepint.net platform. This platform includes several data analysis algorithms developed through artificial intelligence techniques and aims to collect, integrate, analyse, and create dashboards, alert systems and optimization models. This use case is a clear example of the applicability of an efficient system, implemented through a platform that offers multiple possibilities for managing the collected data and thus making it possible to apply various sustainability measures since we can monitor and manage resource consumption, such as water and electricity in buildings or cities.

To have better platforms for creating and analysing dashboards, and generating alerts, it is necessary to have a good decision system. A comprehensive approach is a key factor for an effective decision-making system aiming for, i.e., energy efficiency improvement. Therefore, the multi-criteria decision system presented by García-Fuentes et al. [4] addresses interventions on a wider scale. The necessity of developing new methodologies to address projects for improving the energy efficiency in buildings has become one of the main concerns in recent years. This proposed approach is based on a set of indicators, ranging from the diagnosis to the final assessment.

To maintain sustainability in urban areas, maintaining population mobility sustainably and securely is another very important factor. The platform presented by CRISTEA et al. [3] consists of a smart assistant platform for smart

mobility inside smart cities. Based on a prototype of a portable device, this tool was developed to assist public authorities, business and casual users, in various transportation/mobility scenarios. So, it manages to guarantee greater sustainability in a large city and guarantee a better quality of life for its citizens.

All approaches evidence slightly different strategies but they are all related to the implementation of sustainable and social energy measures in smart cities. In all of them, it's proven that through their application citizens' life quality in crowded areas was improved. These tools also helped in the optimization of resources and costs associated with them.

4.2 Improvement of Citizens' Sustainability and Strategies to Make Citizens Active Contributors

In smart cities, citizens can not only interact and engage with the services provided to make their lives easier and more sustainable in urban centres but also can be active contributors through some of these services. Concerning the strategies to make citizens active contributors, those considered most relevant are presented in Table 2.

Table 2. Strategies and tools implemented to make citizens' active contributors in smart cities.

Authors(s)/Article	Strategies/Tools
Ramos et al. [9]	Presents a water and energy nexus model, in a real case study, to improve the system's efficiency and sustainability
Benavente-Peces [2]	Describes the most suitable and the new emerging technologies and their applications in smart buildings

The work presented by Benavente-Peces [2] concerning the study of information and communication technologies, ICTs, their respective techniques and their contribution in order to obtain higher energy efficiencies in smart buildings also can make citizens contribute to more sustainable measures. The study presented focuses on the evolution of information and communication technologies and the respective role that they have been playing in the development of smart cities, namely in the fact that they can improve the energy performance of buildings by making them into smart sustainable buildings. Energy efficiency is one of the most relevant issues for the entire scientific community and society in general since greater energy efficiencies will contribute to better global sustainability. One way to ensure greater global sustainability in terms of energy consumed by buildings, since these are responsible for about 40% of the total energy consumed, they use renewable energy emerges. This is where the common citizen can come in. Throughout the presented study, various forms of renewable energy are studied, such as solar panels and wind generators, all of which show

positive results and undoubtedly contribute to better energy efficiency in buildings. That said, citizens can contribute to the cause of sustainability by using renewable energies.

Another case where the citizens were active contributors was in the water and energy nexus model developed by Ramos et al. [9]. With the help of the population of Mozambique, and once the water system supply of Nampula showed promising potential for energy recovery, a case study was conducted there. With the help of the population and with the application of a pump-as-turbine (PAT), thanks to the development of ICTs, was possible to reduce the system costs and lower the environmental impacts while making it more sustainable and increasing the system's efficiency.

Both approaches evidence improvements in sustainability in cities, through the contribution of their citizens'. In both cases, the authors concluded that is fundamental to make citizens active contributors to obtain better results in the application of sustainable and social energy measures.

5 Conclusion

A Smart City is an environment that uses technology to make networks and services more flexible, effective and sustainable, thus bringing greater benefit to its citizens. Therefore, these cities represent a solution that aims to combat and contain the alarming environmental and socio-economic repercussions. So, to improve the quality of life in these urban centres and preserve natural resources, the involvement of citizens in the mechanisms of transition to smarter cities is indispensable and essential for the implementation of sustainable and social energy measures.

In this paper, a systematic review was conducted to analyse all the relevant literature and documentation related to the fields of sustainability and social energy measures and applications in a smart city. The review was based on the PRISMA model using the SCOPUS database as the source. In total 87 800 studies were identified. After the application of the PRISMA methodology, a set of 71 documents were selected, however, only 10 of those were considered relevant and found within the intended scope and are relevant to answering the previously defined research questions.

From the proposed research questions, the state of the art was assessed regarding the role and purpose of sustainability and social energy in smart cities. The collected studies suggest that sustainability and social energy measures applied to urban centres or cities can combat and contain the alarming environmental and socio-economic repercussions that urbanization has been causing on our planet. Furthermore, using ICT and other means that aim to improve the quality of life and efficiency, are helpful to the development of sustainable measures such as sensors on lampposts to measure air quality, monitoring systems associated with smart water and light meters, to optimize the consumption of this resources, are some examples of developments being carried out and adopted by the scientific, in this case, to reduce the consumption of these natural resources, while ensuring that they meet the main needs of the current and

future generations. Energy efficiency is also one of the most relevant issues to ensure a better sustainable world. Knowing that buildings are responsible for a high percentage of the energy consumed in the world, smart buildings have been playing a very important role to make cities more sustainable. Through sensors, technologies and communication standards, techniques and algorithms of artificial intelligence, these buildings seek to reduce the impact of energy consumption. Finally, in most of the analysed case studies, all authors agreed that socio-economic sustainability is a key factor to maintain sustainable and social energy measures in smart cities.

This work was developed as part of a research project whose goal is to study the application of sustainable and social energy measures in smart cities' infrastructure and framework. As such, and given all the compiled information, future work includes the study and development of a platform to integrate all these concepts into a viable and helpful information system that can bring value to the smart city paradigm and the citizens' lives where it is applied.

Acknowledgements. This work has been supported by FCT-Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020 and the project "Integrated and Innovative Solutions for the well-being of people in complex urban centers" within the Project Scope NORTE-01-0145-FEDER-000086.

References

1. Akande, A., Cabral, P., Gomes, P., Casteleyn, S.: The lisbon ranking for smart sustainable cities in europe. Sustain. Cities Soc. **44**, 475–487 (2019). https://doi.org/10.1016/J.SCS.2018.10.009
2. Benavente-Peces, C.: On the energy efficiency in the next generation of smart buildings-supporting technologies and techniques. Energies **12**, 4399 (2019). https://doi.org/10.3390/en12224399
3. CRISTEA, D.S., et al.: An IoT environmental and motion assistance system for the smart mobility context. Stud. Inf. Control **29**, 433-443 (2020). https://doi.org/10.24846/v29i4y202005
4. García-Fuentes, M.A., García-Pajares, R., Sanz, C., Meiss, A.: Novel design support methodology based on a multi-criteria decision analysis approach for energy efficient district retrofitting projects. Energies **11**, 2368 (2018). https://doi.org/10.3390/en11092368
5. Garcia-Retuerta, D., Chamoso, P., Hernández, G., Guzmán, A.S.R., Yigitcanlar, T., Corchado, J.M.: An efficient management platform for developing smart cities: Solution for real-time and future crowd detection. Electronics **10**, 765 (2021). https://doi.org/10.3390/electronics10070765
6. Hernández, J.L., Sanz, R., Corredera, A., Palomar, R., Lacave, I.: A fuzzy-based building energy management system for energy efficiency. Buildings **8**, 14 (2018). https://doi.org/10.3390/buildings8020014
7. Page, M.J., et al.: The prisma 2020 statement: an updated guideline for reporting systematic reviews. BMJ **372**, (2021). https://doi.org/10.1136/bmj.n71
8. Quijano, A., et al.: Towards sustainable and smart cities: Replicable and KPI-driven evaluation framework. Buildings **12**, 233 (2022). https://doi.org/10.3390/buildings12020233

9. Ramos, H.M., Morillo, J.G., Diaz, J.A.R., Carravetta, A., McNabola, A.: Sustainable water-energy nexus towards developing countries' water sector efficiency. Energies **14**, 3525 (2021). https://doi.org/10.3390/en14123525
10. Salom, J., et al.: An evaluation framework for sustainable plus energy neighbourhoods: Moving beyond the traditional building energy assessment. Energies **14**, 4314 (2021). https://doi.org/10.3390/EN14144314
11. Sánchez-Sutil, F., Cano-Ortega, A.: Smart control and energy efficiency in irrigation systems using LoRaWAN. Sensors **21**, 7041 (2021). https://doi.org/10.3390/S21217041