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Sharing cities: from vision to reality. A People, place and platform approach to implement Milan's smart city strategy

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ABSTRACT

Transforming Milan into a smart city is a strategic objective and political priority of the Municipality, which has taken up a variety of projects and experiments with the aim to transform the main suburbs of the city into smart areas. This paper presents Milan's demonstration of a smart district supported by the European Union (EU) funded project *Sharing Cities*, aimed at creating a "smart" district with "near-zero" emissions in three different "lighthouse" cities, London, Lisbon, and Milan. The paper describes the first outcomes of this project in Milan, based on a *People, place and platform approach*, aimed at involving the different stakeholders and applying solutions to foster innovation processes instrumental to the implementation of a smart city urban agenda.

Keywords:

Smart district;
Strategy;
Pilot;
Engagement;
Scale-up;

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1. Introduction

In the current global context, cities face common pressing challenges such as air pollution, climate change, and socio-economic sustainability associated to increasing urban population [1], and have often identified the journey into smartness as a privileged strategy to address such critical issues [2].

A variety of definitions of smart city abounds in academic, business and government debates [3]. On one hand, smartness is associated to pervasive and ubiquitous digital infrastructure; on the other hand, to social innovation and creativity enacted by smart people [4]. Currently, the concept of Smart city is increasingly linked to the presence of digital infrastructure, smart citizens and physical infrastructure enabling efficient, functional services [5].

In this context, over the recent years the Municipality of Milan has decided to promote the economic transformation necessary to tackle the pressing societal challenges firstly by adopting a set of strategic policy frameworks on sustainable mobility, sustainable energy and smart agenda with a vision to become more sustainable, resilient, smart, and circular.

Specifically, the Sustainable Energy Action Plan (PAES), adopted by the Municipality in 2014, promotes several actions to achieve national and community targets for reducing greenhouses gas emission and support urban decarbonization [6]. Energy transition is encouraged through measures regarding energy efficiency of buildings, optimization of public lighting and conversion of the fossil system to a carbon neutral one by using renewable energy sources.

With the adoption of the Smart City Guidelines, the Municipality affirmed its overarching strategic objective and political priority to transform Milan into a smart city. After a consultation process, in 2014 the Municipality approved the document, based on a vision of smart city that does not only cultivate its technological component,

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Acknowledgement of value

The paper offers local stakeholders the opportunity to know Milan's demonstration of a smart district as it describes the first outcomes of the EU project Sharing Cities. The project allowed the Municipality to test a smart district pilot in the Porta Romana/Corvetto/Vettabbia area through deep retrofit interventions, to improve comfort and energy management of both private and public buildings, and the implementation of e-logistics, digital social market, smart-parking technologies and smart lampposts. I have closely followed the Sharing Cities project since its early stages as I retain that an eclectic action of knowledge and applications shared with the most involved stakeholders can give a substantial push towards the replication and scaling of the initiative. Citizens shall be aware of their pivotal role as enablers of this transformation from humble to more resilient, socially and environmentally sustainable cities.

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but must combine economic development and social cohesion, innovation, training, research and participation [7].

Since its adoption, Milan decided to test smart solutions coherent with its Smart City strategy focusing on limited parts of the city, for testing innovative solutions with the aim of scaling up to the rest of the city. At the national level, similar experimentations are being carried out, such as the Smart Home network experimentation in the Centocelle district of Rome [8].

In 2018 the City of Milan also approved the Sustainable Urban Mobility Plan (PUMS), aimed at meeting the mobility needs of the population while ensuring the reduction of atmospheric and noise pollution levels and of energy consumption by enhancing public transport and shared mobility services [9].

This paper presents Milan's demonstration of a smart district supported by the EU funded H2020-SCC1 project *Sharing Cities* (www.sharingcities.eu), aimed at creating a "smart" district with "near-zero" emissions in three different "lighthouse" cities, London, Lisbon, and Milan (Figure 1), to respond to the main urban environmental challenges and improve the daily life of its inhabitants. In

Figure 1: Map of Milan with Sharing Cities area

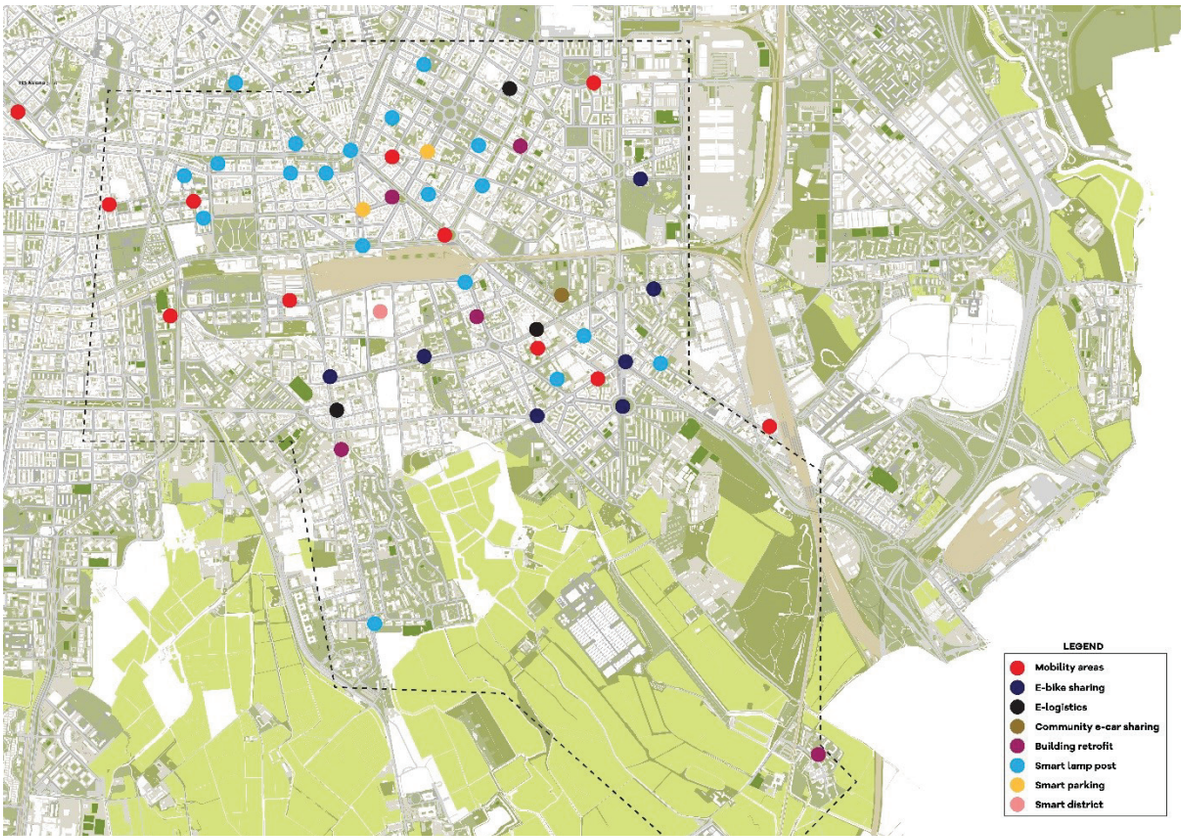

Figure 2: Map of Sharing Cities district

Milan, the project has allowed the Municipality to test a smart district pilot in the Porta Romana/Corvetto/Vettabbia district (Figure 2), based on its smart city strategies, with a view to scaling up and replicability.

This research is aimed at investigating the effectiveness of new technologies in improving urban mobility, increasing the energy efficiency of buildings and reducing carbon emissions along with the effectiveness of the *People, place and platform approach* to smart city. This paper presents the methodology adopted and the interventions carried out in the Sharing Cities project, followed by the preliminary results and conclusion.

2. Methodology

Sharing Cities adopted an original holistic "*People, place and platform approach"* taking account three dimensions: *people* (user-centric smart city services co-designed with citizens), *place (*infrastructure solutions for: low-energy districts, e-mobility, retrofitting of buildings, installation of sustainable energy management systems and smart lampposts) and *platform* (urban sharing platform based on open data) as illustrated in Figure 3. The approach was developed by partners within the Sharing Cities project and applied to all the three partner cities.

The project is structured in six main pillars: 1) Deep Building Retrofit, 2) Shared e-Mobility (with five subdomains: charging points, e-car sharing, e-bike sharing, e-logistics, and smart parking), 3) Smart Lampposts, 4) Sustainable Energy Management Service (SEMS), 5) Urban Sharing Platform (USP) and 6) Digital Social Market (DSM).

2.1. Sharing Cities: the six pillars

1) Deep Building Retrofit

The first pillar, which concerns the *place* dimension, is the deep retrofitting work for respectively 24,000 m^2 of private and 4,500 m^2 of public residential buildings, trying out an approach based on owners' engagement through co-design processes, monitoring system, and deep retrofit interventions. The latter consisted in renewing the buildings by integrating them with low carbon energy sources (solar PV, water source heat pump) and energy

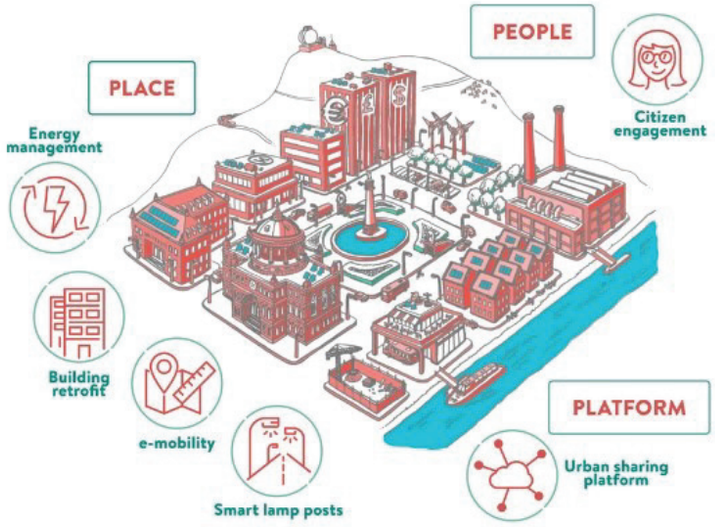

Figure 3: Sharing Cities three domains (people-place-platform) (www.sharingcities.eu)

Figure 4: Private residential building pre and post retrofitting funded by Sharing Cities

management systems which serve for monitoring and managing the energy consumption. Such interventions are aimed at an average 60% reduction in energy consumption and at an increased comfort inside dwellings.

Owners co-designed the retrofit interventions, as part of the co-design methodology defined by project partners in charge for citizens' engagement.

All of the five eligible private buildings, accounting for 262 flats and 24,000 m^2, have already undergone the process of retrofitting (Figure 4) as well as the implementation of the monitoring system, which allows fuel and electricity consumption to be recorded every 15 minutes through smart meters, and temperature, humidity and CO_2 level to be analysed by wireless sensors. Data collected by smart meters is recorded by the utility company (A2A) and transferred to the Sustainable Energy System System (SEMS), while data gathered by other sensors is recorded through LoRaWAN technologies and directed to the Energy System. LoRaWAN is a Low Power, Wide Area networking protocol designed to wirelessly connect battery operated devices to the internet, targeting Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services.

Since 95% of Italian public housing requires energy efficiency measures, the Municipality of Milan selected also one of its public residential buildings, accounting for 66 flats and 4,500 m^2, to test their feasibility. The deep retrofit process was focused on improving building occupants' indoor environmental quality through intervention specifications for energy retrofit and an innovative monitoring system. More specifically, the building was integrated with photovoltaic panels, solar thermal collectors, windows frames, mechanical ventilation and thermal insulation, along with an energy management system.

Energy efficiency measures included the arrangement of the thermal coating, through the application of the insulating material on the external facades of the

buildings, in order to reduce heat exchanges between inside and outside. The performance of the system chosen for the thermal insulation coatings allowed to reduce the thermal dispersions and therefore to contain the energy consumption. The operation will terminate with the replacement of the windows and the boiler with a centralized system. On the windows of the external facades, shading systems will be installed, so as to allow the control of natural light, improving the visual comfort inside the apartments and their isolation. Retrofit works on public building will be closed within the end of 2019.

2) Shared e-Mobility: creation of intermodality hubs

The shared e-mobility measure supports the shift from high to low carbon mobility, by implementing a number of shared e-Mobility "infrastructures and services". These include: e-vehicles charge; e-car share; e-bikes: smart parking and e-logistics.

Specifically, e-vehicles charge was addressed by implementing 60 charging points in 10 Mobility Areas with the aim of fostering electric personal and shared mobility and intermodality. Mobility Areas for public e-car sharing offer free-floating car-sharing operators a parking and charging place and charging points for private users.

E-car share was promoted by installing 72 e-vehicles, two of which for building car sharing with 50 registered users. 10 e-cars for community car-sharing (Figure 5) were deployed in Symbiosis, a new business district included in Sharing Cities area and ambition.

E-bikes service was promoted by providing 150 new e-bikes for bike sharing with child seats and 14 new stations (Figure 6) with the aim of supporting the shift from cars to active mobility. Furthermore, operator-based relocation systems were studied for ameliorating level of service.

Smart parking was addressed by providing 175 parking lots with smart parking sensors (for logistics, disabled people, no-parking areas), 100 of which are set to be installed in the 10 Mobility Areas to avoid illegal parking of private cars on lots dedicated to electric vehicles. The implementation of smart parking technologies, including the evaluation of sensor type implementation, tested and provided for operational experiences to incentivise e-mobility.

As part of the project, e-logistics measures were implemented in order to counter the increase in conventional (particularly diesel) freight delivery vans, spurred by the growth of on-line commerce. The electric logistics interventions aim to be the business cases for new ways of urban emission free logistics: 9 e-vans and two e-cargo-bikes (and 11 charging points) were set-up in the project area, guaranteeing zero-emission logistics for a mass-market retailer. These e-vehicles replaced 10 vans used by the company responsible for providing logistics home delivery services for Carrefour, a large-scale distribution company, with several shops in Sharing Cities area.

Figure 5: Building Car Sharing funded by the Sharing Cities project
Photo by Sara Soldano (www.sarasoldano.it)

Figure 6: E-bikes sharing station funded by the Sharing Cities project
Photo by Sara Soldano (www.sarasoldano.it)

3) Smart Lampposts: from Humble to LED to Smart Lampposts

The Smart Lampposts measure consisted in the installation of 28 sensors on 20 lampposts and the coverage of project area with LoRaWAN network. The 20 new Smart Lampposts are poles integrated with smart technologies, such as WiFi antennas, enabling environmental and traffic flows controlling. The smart approach consists in considering how to develop business models that incentivize the implementation of smart technologies (WiFi, air quality, parking, EV charging, etc.) alongside lighting, using the already existing assets: i.e. to boost the shift from "humble" lamppost to "smart lampposts". The aim was to test added value services related to smart lighting, in order to demonstrate that the passage from humble to smart lampposts is feasible and convenient, so that other Institutions are encouraged to shift directly, skipping the LED lampposts step.

4) Sustainable Energy Management System

Sharing Cities envisaged the development of the Sustainable Energy Management System (SEMS), an advanced system for energy management and balance. The ambition of such tool is to provide for integrated, efficient, and interoperable energy management across urban infrastructures. More specifically, it optimises the relation between energy demand and supply, so as to reduce citizen's energy use and bills; within the e-mobility area, i.e. charging stations, it balances energy peaks so as to avoid network failures. Finally, such tool plays the role of data-bridge drawing data from the retrofitted buildings and making them available for the USP. The SEMS is a proprietary software of Siemens, one of the project partners, and it will be used directly by the Municipality of Milan for monitoring and assessing the performances of retrofitted public social housing.

5) Urban Sharing Platform

With respect to the Platform domain, Sharing Cities envisages the creation of an Urban Sharing Platform (USP), an ICT platform able to gather data from several heterogeneous data sources and provide functions and services that help in enabling a smart city. Its aim is to aggregate data and control functions from a wide variety of devices and sensors (e.g. electric vehicles and bikes, smart lampposts and energy efficient buildings), store, process, correlate the data and present information to the city and citizens so as to enable a better use of the city resources. The project has allowed the implementation of a data monitoring service layer realized with the view to demonstrate the potential of interoperability and data integration processes. The USP, developed by the Informatics Service Directorate of the Municipality of Milan, will be one of the main asset for the City of Milan for data collection and integration, and further deployments will occur beyond Sharing Cities for enlarging included data set and enhancing the available tools. Though USP can be freely adopted by other Municipalities (as happened for the Municipality of Venice), each Lighthouse city works in the deployment of their USP in order to customize it according to their requirements.

6) Digital Social Market

Lastly, with respect to the people domain, the citizen-focused activities include the implementation of a Digital

Social Market (DSM), an ecosystem of relations between different actors that promotes citizens engagement and peer-to-peer exchange of good practices. The DSM in Milan has a community of users and rewarders, SharingMi, hosted by an app, greenApes, that rewards citizens' positive behaviours**.** The application allows accessing a community of people who share ideas and concrete actions for a more sustainable lifestyle [11]. Virtuous behaviours are rewarded through prizes and discounts offered by the local businesses participating in the project. The Public Administration, that promotes the DSM, plays a role by setting challenges in particular sustainability fields (e.g. "Plastic free" challenge has encouraged users in sharing good practices in plastic saving).

3. Results

Ex-ante evaluation, performed for estimating the effectiveness of project actions, and preliminary collected data estimate that project actions have contributed to energy consumption reduction, CO_2 savings, increased data monitoring and collection and citizens' engagement.

Building retrofit performances ex-ante evaluation is based on BEST table methodology, set up by European Commission, envisaging an energy diagnosis for estimating thermal energy consumption and a parametric estimation of electric energy consumption of the building. Energy needs, combined with dimensions of each intervention (such as façade insulation, mechanical ventilation, photovoltaic panels, etc.), technical characteristics and climate zone for each retrofit intervention allow the calculation of CO_2 and energy savings. Mobility performances ex-ante evaluation was set up by Sharing Cities technical partners through the design of cognitive map mode [12], able to identify causal networks to estimate the effects of each mobility measures implemented on the base of preliminary and parametric estimation of services use (such as travelled distances, energy performances, modal shift, etc.).

Since performances monitoring is at an early stage, only the modelled estimations and first data collected on mobility and energy are presented.

Energy efficiency measures on buildings are estimated to result in a 50–70% reduction of energy consumption compared to pre-implementation levels, improving also comfort inside dwellings. More specifically, available data show that the energy consumption has been lowered by 55% in one of the private residential building retrofitted and by 60% in the public residential building. The consumption of energy was halved in all of the retrofitted buildings and the CO_2 produced was lowered by 23,500 Kg. Retrofitting measures have also resulted in an increased comfort inside dwellings, by means of the stabilization of internal temperature at 24–25 C, and humidity level at 30%-70%, compared to a much greater pre-implementation temperature and humidity variance.

As argued in [10], available results suggest the participatory process proved crucial to the implementation of the deep retrofit interventions as it created consensus and increased the probability, speeding up the process of reaching the majority in the vote of the building assemblies, necessary to approve the interventions.

Sharing Cities acted in a consolidated urban area, optimizing, renovating, and putting in synergy different elements of an existing and living district in line with the Smart Retrofitted District approach, which consists of working on existing districts and is based on improving and renewing what is already in place. In such case, a top-down approach is not effective as residents need to be informed about the externalities of building retrofitting in terms of quality of life, economic benefits and the effects on the environment. Indeed, a fundamental aspect of this approach is the bottom-up, participative practices, aimed at building collaborative communities aware of the value of natural and social assets.

Shared mobility measures are expected to result in 646.21 tons CO_2 savings from the implementation time till the end of the project (Table 3). More specifically, e-car sharing contributes to save 202.37 tons of CO_2,

Table 1: Sharing Cities private buildings retrofitted

Name	Year of construction	Number of floors	Number of apartments	Total conditioned area (m^2)
Via Passeroni 6	1963	4/6	50	6260
Via Tito Livio 7	1960	7	25	2049
Via Verro 78 B/C	1979	5	36	3857
Via Fiamma 15/1	1967	7	15	3314
Via Benaco 26	1960	6	141	8830

Table 2: Comparison between energy consumption before and after deep retrofitting

[kWh/m² y]	Initial Energy consumption	Post-retrofit energy consumption
Via Tito Livio, 7	143.2	58
Via Fiamma, 15/1	103.4	64.34
Via Verro, 78 B/C	91.5	37
Via Passeroni, 6	178	105.57
Via Benaco, 26	146.47	56.71

followed by e-logistics (28.80), e-Bike sharing (376.17) and eV charging stations (38.88).

Data monitoring system is being developed with the view to be instrumental to the development of new Municipal strategies. As the integration of data collected through the sensors into the Urban Sharing Platform is currently being finalised, while a survey is envisaged to assess the results, in terms of behavioural change, of the DSM, ex post evaluation and full critical discussion will be available only from 2020, after the completion of the monitoring & evaluation phase.

4. Conclusion

Sharing Cities has allowed the Municipality of Milan to test smart solutions coherent with its Smart City strategy focusing on a limited part of the city, with the aim of replicating and scaling up to the rest of the city.

Adopting a People, place and platform approach has allowed acting on the different dimensions of the concept of smartness and leveraging on each of them to maximize the policy effectiveness. A pivotal role is recognised to the citizen engagement, crucial to enable the behavioural change necessary to transform the cities into more resilient and socially and environmentally sustainable places.

Sharing Cities has allowed to apply smart city features in the city of Milan, which is committed to take forward the journey also intervening through other policies and projects. By an example, the EU funded EUGUGLE project focuses on buildings energy efficiency demonstrating the availability of building renovation models [12] that have near-zero energy consumption in view of large-scale deployment. The European H2020 project CLEVER (Cities Co-designing Locally tailored Ecological solutions for Value added, socially inclusivE

Table 3: Sharing Cities expected results of mobility measures

Mobility mode	Tons CO_2
eV car sharing	202.37
eLogistics	28.80
eBike sharing	376.17
eV Charging stations	38.88
Total	646.21

Regeneration in Cities) contributes to defining the regeneration of urban spaces concentrating on the role nature-based solutions, i.e. solutions borrowed and supported by nature, that lead to environmental, social, cultural and economic benefits, thus contributing to achieving sustainability and energy and economic efficiency. Finally, the EU Horizon 2020 project Syncronicity allows a large-scale experimentation with IoT services within specific areas of the cities, in support of citizens to solve significant problems within three application domains: adaptive traffic management, multimodal transportation, community based policy making.

These are few examples of several put in place by Milan to address the current pressing urban challenges testing innovative solutions for creating a smart, sustainable, and resilient city. In particular, Sharing Cities has allowed the Municipality also to test the "human centred smart cities" approach, which emphasises the centrality of the citizens rather than that of technology, by leveraging on the methodological dimension of co-design processes and behavioural change.

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References

[1] United Nations, Department of Economic and Social Affairs, Population Division, The World's Cities in 2018—Data Booklet (ST/ESA/ SER.A/417)., https://www.un.org/en/events/citiesday/assets/pdf/the_worlds_cities_in_2018_data_booklet.pdf, 2018.

[2] P. Newman, The environmental impact of cities, Environment and Urbanization, 18(2), pp.275–295. http://doi.org/10.1177/0956247806069599,2006.

[3] V. Albino, U. Berardi and R. M. Dangelico, Smart Cities: Definitions, Dimensions, Performance, and Initiatives, Journal of Urban Technology, 22:1, 3-21, 2015 https://doi.org/10.1080/10630732.2014.942092

[4] R. Kitchin, The real-time city? Big data and smart urbanism, GeoJournal (2014) 79:1–14, http://doi.org/10.1007/s10708-013-9516-8

[5] A. Caragliu and P. Nijkamp, The impact of regional absorptive capacity on spatial knowledge spillovers: the Cohen and Levinthal model revisited, Applied Economics, 44:11, 1363–1374 http://doi.org/10.1080/00036846.2010.539549

[6] Comune di Milano, Piano di Azione per l'Energia Sostenibile (PAES), https://www.comune.milano.it/aree-tematiche/ambiente/energia/paes-piano-di-azione-per-l-energia-sostenibile, 2014.

[7] Comune di Milano, Linee guida Milano Smart City, https://economiaelavoro.comune.milano.it/sites/default/files/2019-02/milano%20smart%20city%20-%20linee%20guida.pdf,2014.

[8] S. Romano, Experimental demonstration of a smart homes network in Rome, Int J Sustain Energy Plan Manag 2019;24. http://doi.org/10.5278/ijsepm.3335

[9] Comune di Milano, Piano Urbano della Mobilità Sostenibile (PUMS), https://www.comune.milano.it/aree-tematiche/mobilita/pianificazione-mobilita/piano-urbano-della-mobilita,2018.

[10] C. Meloni, F. Cappellaro, R. Chiarini and C. Snels, Energy sustainability and social empowerment: the case of Centocelle smart community co-creation, Int J Sustain Energy Plan Manag 2019;24. http://doi.org/10.5278/ijsepm.3339

[11] SharingMI, <www.sharingmi.it>, 2019.

[12] A. Luèa, A. Colornia and R. Nocerino, Cognitive mapping and multi-criteria analysis for decision aiding:an application to the design of an electric vehicle sharing service, Transport Research Arena 2014, Paris https://pdfs.semanticscholar.org/0bc1/57ab7843b308f869614e984ea47c4af13c28.pdf

[13] Østergaard PA and Maestosi PC, Tools, technologies and systems integration for the Smart and Sustainable Cities to come. Int J Sustain Energy Plan Manag 2019;24. http://doi.org/10.5278/ijsepm.3450

[14] Sharing Cities, "Building smart cities together - common solutions for shared challenges," <www.sharingcities.eu>, 2019.