Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 111 (2017) 826 – 835

Energy Procedia

8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

# Enabling energy smart cities through urban sharing ecosystems

Maurilio Zuccalà[a,*], Emiliano Sergio Verga[a]

[a]*CEFRIEL – Politecnico di Milano, Via Renato Fucini 2, 20133 Milan, Italy*

**Abstract**

In order to build real smart cities, heterogeneous data from different sources has to be properly collected, integrated and shared. In this paper, a real district scale example of urban sharing ecosystem based on coopetition is presented. This digital ecosystem enables data sharing that can be synergically applied to different sectors relevant to the urban context, e.g., energy and transportation, in order to create innovative solutions for energy monitoring, citizen engagement, and evaluation and monitoring at district and city level.



*Keywords:* Digital Ecosystem ; Urban Sharing Platform ; API Economy ; Interoperability ; Smart City ; Sharing Cities ; Internet of Things

## 1. Introduction

Recent advances in technology enable innovative digital scenarios that provide citizens and communities with cohesive and tailored solutions for their urban life. At the same time, technology is improving city management and monitoring from the standpoint of different urban stakeholders (e.g., city managers). In this direction, an innovative vision of a "clever and integrated" city has emerged under the name of "smart city". A smart city is a sustainable urban center where every aspect of urban life is supported by Information and Communication Technologies (ICT) and governed in an efficient way, through integrated actions addressing building stock, energy systems, mobility, climate change, water and air quality etc. In order to achieve this goal, integration of information from various and distributed sources needs to be performed, and huge amounts of data have to be produced, elaborated, shared and consumed.

* Corresponding author. Tel.: +39-0223954321 ; fax: +39-0223954521.
*E-mail address:* maurilio.zuccala@cefriel.com


doi:10.1016/j.egypro.2017.03.245

## 2. Key challenges for Smart Cities

An important contribution to building smart cities is emerging even from advances in sensor technology and proliferation of smart metering devices, which provide easier access to valuable information about energy consumption and demand. Currently, smart grids represent a remarkable example of this scenario where several devices from different vendors, running different protocols and policies, are integrated in order to reach a common goal: bring together energy delivery and smart services. This potential has already been recognized by governments and industries, e.g., in the Green Button initiative [1]. This initiative is an effort to provide utility consumers with easy and secure access to their energy usage data and the ability to share such data with third parties. Smart meter data is provided to consumers in a standardized format, which facilitates data sharing, integration and reuse.

In order to extend the boundaries of data sources – including not only the Internet of Energy devices of smart grids, but also every sort of device, which can be part of what we can call the Internet of Everything – "Web of Things Architectures", have been proposed [2]. In these architectures, a standard scalable Web protocols layer provides an abstraction mechanism to interact with heterogeneous connected "things". This way, the technical issue of having access to different data sources is addressed, but political and relationship constraints of having access to third-party data are still to be solved. Moreover, a comprehensive and valuable data integration needs to take into account also data owned by heterogeneous stakeholders that are not strictly related to the energy field, e.g., public transportation players.

In this paper a real district-scale example of effective energy smart city solutions based on data sharing and integration is presented, proposing an innovative holistic approach to governing heterogeneous data sources provided by various stakeholders – e.g., players of building, public lighting and transportation sectors.

## 3. "Sharing Cities" H2020 project

"Sharing Cities" [3] is a 5 year Horizon 2020 project. It aims to take a digital-first and data-driven approach to overcome key environmental challenges facing cities such as carbon emissions from buildings and transport, and air quality [4]. The overall holistic goal is to integrate these issues and interventions, using data from a wide range of sensors and sources, by means of an ICT platform to enable their management according to an uncoupled distributed architecture in line with the Application Programming Interface (API) Economy trend. In doing so, the project will deliver cost savings in terms of energy bills, and by tackling and optimising demand will reduce the need to invest in electricity infrastructure. Citizen engagement is at the heart of the project, involving the co-design of services by residents and a digital bond scheme to ensure their take-up. Through the integration of different measures, and thanks to an API-based ICT ecosystem, new smart services will be available and it will be possible for citizens to access information to change their behaviour virtuously in order to produce a measurable environmental impact.

By taking a collaborative approach across the three lighthouse core cities (London, Lisbon and Milan) to the development of products and services, and rolling these out across the three follower cities (Bordeaux, Burgas and Warsaw), the "Sharing Cities" project aims to create the level of certainty and demand that will drive the market, turning an initial European Union investment of 25 million Euros to draw in 500 million Euros of external investments.

### *3.1. Objectives and goals*

The "Sharing Cities" project has four key objectives [4].

- To achieve scale in the European smart cities market by proving that properly designed smart city solutions, based around common needs, can be integrated in complex urban environments. This will be done in a way that exhibits their true potential and allows for the significant scale-up and consequent increase in social, economic and environmental value.
- Adopt a digital-first approach which proves the extent to which ICT integration can improve and connect up existing infrastructure, as well as the design and running of new city infrastructure. This will also allow for the creation of a new set of next stage digital services which will help citizens and city managers make better and

beneficial choices around energy efficiency and mobility, which when scaled up will enhance the city's ability to hit key targets for mobility, housing, energy efficiency and resilience, and economic development.

- Accelerate the market to understand, develop and trial business, investment and governance models, essential for the true aggregation and replication (through collaboration) of smart city solutions in cities of different sizes and maturities. In doing this, the project intends to accelerate the pace by which transformative improvements are made, and enhance sustainability in communities.
- Share and collaborate for society: to respond to increasing demand for participation; to enhance mechanisms for citizens' engagement; to improve local governments capacity for policy making and service delivery through collaboration and co-design; resulting in outcomes that are better for citizens, businesses and visitors.

These objectives are further broken down into 10 "audacious" goals which are in line with Horizon 2020 Call requirements and other European initiatives such as the European Innovation Partnerships (EIP) Action Clusters [5], as summarized in Fig. 1. Then, each goal has specific deliverables to be achieved across the participating cities.

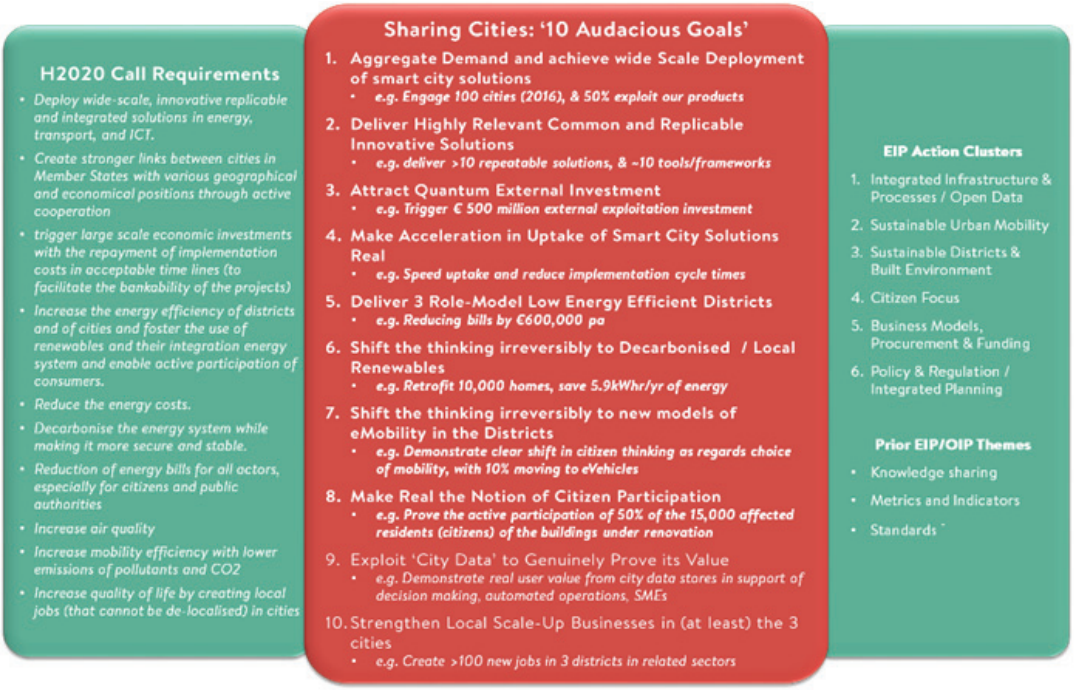


Fig. 1. The "10 Audacious Goals" of the "Sharing Cities" project (source: project technical annex).

These goals will be addressed by implementing a portfolio of digital-first and interconnected measures (Fig. 2) in each of the three smart city districts, all of which are part of cities with ambitious and well documented smart city implementation strategies and leadership commitment, and most of which are related to the energy sector.

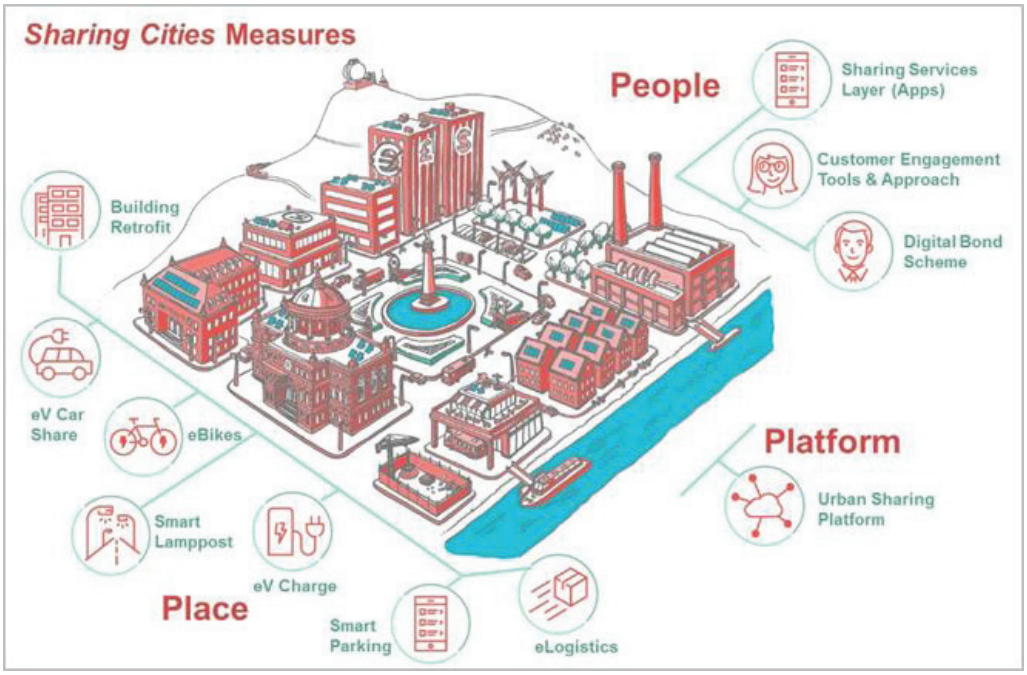


Fig. 2. "Sharing Cities" measures (source: project technical annex).

### *3.2. Demonstrators in Milan*

Each of the three core cities of the project selected a demonstration area of strategic importance. In this area, different smart interventions are put into action, ranging from Sustainable Energy Management Systems (SEMS) to building retrofit, e-mobility and e-logistics with related facilities, parking, lighting. The following Italian partners are directly involved in Milan's pilots: Comune di Milano (city lead), AMAT, ATM, Politecnico di Milano, Fondazione Politecnico di Milano, CEFRIEL, Poliedra, Legambiente, RSE, Kiunsys, NHP, Teicos, Future Energy, A2A, A2A Smart City, Unareti, Siemens.

#### *3.2.1. Demonstrator area*

Milan's demonstration area, "Porta Romana/Vettabbia" (Fig. 3), is undergoing complete redevelopment and its renewal will link the historical centre of the city to its agricultural belt by connecting two areas which are currently geographically, economically and socially separated.

Porta Romana is a brownfield and former railway yard of 216,000 square meters. The opportunity for this area is to host a functional mix of private and social housing, multi-modal integration around a new station and a large park of at least 74,000 square meters. The main road axis (via Ripamonti) will be redesigned as an "urban quality road", exploiting the tram line number 24 to sustain public transport linkage to other areas of the city. Crossed by the Vettabbia canal, the southern part of this area is characterized by the connection between urban and rural, e.g., the 12th-century complex of the Chiaravalle Abbey. This area also hosts remarkable integrated infrastructures, e.g., a heat recovery system for exhausted purified waste at the Nosedo wastewater treatment plant: among the first in Europe, it is highly replicable and scalable, and in 2014 was awarded as the best eco-friendly innovation by Legambiente national organisation.

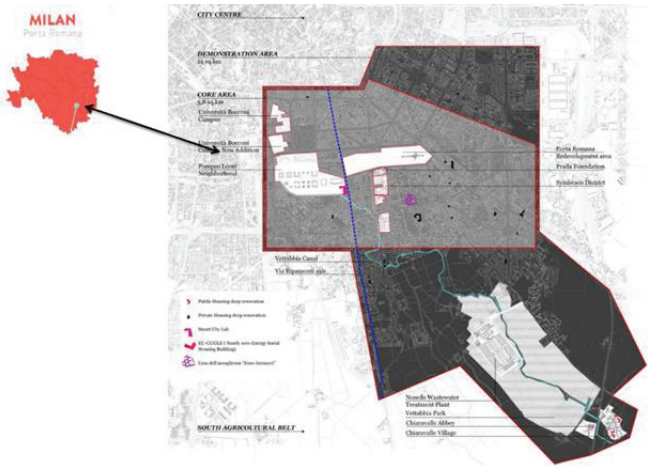


Fig. 3. Porta Romana/Vettabbia, Milan's demonstrator area in "Sharing Cities" (source: Comune di Milano).

*3.2.2. Planned interventions*

A number of measures will be implemented in Milan in the selected smart district.

**Building retrofit and local renewable energy production**

- In different multi-property buildings, owners will actively participate in understanding their energy behaviours, needs and performance of their home through energy audits and digital-first monitoring of energy consumption and thermal comfort conditions to inform the design of retrofit activities during the project. Significant application of photovoltaic / solar thermal integrated with electric vehicle (EV) charging is planned.
- Deep retrofit of a number private apartments, exploiting the existing extensive and pro-active resident/owner outreach network which informs and supports energy savings and wise retrofit choices.
- Deep retrofit of mixed ownership multi-story buildings, with specific focus on improving building occupant indoor environmental quality. This builds upon retrofitting intervention under the EU-GUGLE project [6] funded under the 7$^{th}$ Framework Programme for Research.

**Sustainable Energy Management Systems**

- Milan SEMS developed for Expo Milano 2015 Smart City will be adopted in the smart district, proving immediate scale-up of the solution for the city. The system will be enhanced to integrate specific district systems and needs.
- The system collects energy data from: electric distribution network; measures from primary substations and secondary substations; medium/low voltage transformer data; public lighting system; lighting consumption; electric mobility; measures for electric vehicle recharging; electric meters in retrofitted buildings; thermal meters in buildings; environmental data.
- The system will have three main use cases:
  - District Energy Management: provide municipality energy managers with detailed and near real-time information about energy flows in the district. Energy data will be aggregated and analysed via the urban sharing platform (see Sect. 4). Furthermore, SEMS calculates typical curves for consumption and provides forecast of generation/consumption based on both historical data and weather forecast information. These data shall be used to support decisions in terms of energy reduction investment and planning.
  - Integration at regional level: provide information of energy flows at regional level by publishing data to the urban sharing platform and in particular to the E015 digital ecosystem (see Sect. 4.1).
  - Building energy management: providing the Building Energy Manager with a cockpit for energy, energy efficiency and demand-response monitoring.

**Shared eMobility**

- Milan has significant experience in this area and has specific plans for electric vehicles usage. Significant funds are already committed in order to improve EV services in the smart district.

**Smart lampposts**

- Milan has recently completed a city-wide Light Emitting Diode (LED) replacement programme on public lampposts. This could provide valuable case study experience based on achieved efficiency savings. The public utility involved in the project will upgrade the new lighting in the demonstrator area with smart features, e.g., wireless communication infrastructure to support interoperable multi-sensors.

*3.2.3. Citizen engagement and participation*

In order to properly implement the interventions summarized above, proper citizen engagement processes and awareness programs will be put in place in the smart district area. One of the core Work Packages of the project will deliver people-centered services through the definition of approaches and tools to develop a deep understanding of society, and the means by which they are informed and actively participate in making their districts better places, with better outcomes. The main tasks of this Work Package are:

- Benchmark analysis of current landscape in each smart district, in terms of 'digital conditions', existing incentivizing mechanisms, existing engaging initiatives and hubs, etc.
- Co-design of urban services (e.g., retrofit, energy management, shared e-mobility), enabling a user-centered approach for understanding, assessing and shaping urban services. E.g., citizen engagement will contribute to intervention design defining topics such as location, type and number of mobility services like EV sharing stations in the smart district. In order to foster active citizen participation, the service co-design process will be located in physical facilities within each district, such as Milan's Smart City Lab.
- Development of a 'digital social market', i.e., a portfolio of (co-designed) urban services that will be implemented around the digital-first and integrated infrastructure themes, with a system of incentives under a broader district bond scheme. This will encourage behavior change, based on end-user energy savings, overall resource consumption and reduction, and better mobility solutions.
- Deployment of a 'service layer', i.e., a suite of integrated digital interfaces onto co-designed services, leveraging the "Sharing Cities" Urban Sharing Platform (see Sect. 4).
- Iteration and dissemination, to spread main project principles and results to an always wider audience.

*3.2.4. Expected results*

At the time of writing, the impact of the "Sharing Cities" smart interventions in the demonstrator area of the city of Milan can be summarized as follows.

- Retrofit of 7 mixed-owner buildings (300 private housing homes, 25,000 square meters).
- 150 electric bikes for bike sharing (14 stations).
- 62 electric cars for car sharing.
- 60 charging points for electric vehicles (20 of which provide rapid charge).
- 125 smart parking bays.
- 300 smart lampposts.
- 11 vehicles for e-logistics.
- Sustainable Energy Management: systems supporting real-time demand response, energy optimisation and micro-geographical information and visualisation.
- Development of a common open standard reference ICT architecture for federated information sharing and exploitation between and beyond the lighthouse cities, i.e., the Milan instance of the Urban Sharing Platform (see Sect. 4).

## 4. Digital ecosystem approach

One of the core Work Packages of the "Sharing Cities" project is dedicated to architecting and building an open Urban Sharing Platform (USP) that enables both the technical and functional aspects of the project interventions. An USP is an ecosystem of technical components, capabilities and processes which provides functions and services enabling a smart city. Its purpose is to aggregate information and control from a wide variety of actors as well as "things" (i.e., devices and sensors), store and process the data, enable cross-city federation between different platform instances, and finally present information to information consumers, e.g., the city and the citizens, which enables better use of city resources. The USP is being co-developed within the "Sharing Cities" project to:

- Provide a shared reference architecture at European level that extends the strengths and capabilities of each of the cities both "vertically" increasing each cities capability and "horizontally" shared between the core, followers and scale up cities.
- Enable information and functional sharing by providing an interoperable federated platform based on open and reliable standards, technologies and reference models (e.g., FIWARE [7], EIP Action Clusters [5]).
- Utilise Micro Services Architecture and API Economy best practices to align city needs with services and technology.
- Provide a federated governance structure to ensure alignment between the core cities and ensure that the USP is linked to evolving city management goals, which are in turn mainly linked to citizen engagement.

Each core city shares significant existing capability which informs the design of the USP and provides valuable skills, experience, blueprints and resources. In particular, Milan has invested in an internal Interoperability Platform and in the E015 digital ecosystem (see Sect. 4.1), that constitute the foundation of the ICT platform supporting urban smart digital interventions: an ecosystem of open, multi-stakeholder service environments enabling digital interoperability between different players to effectively support the smart city. In particular, smart interventions in mobility and logistics, building retrofitting, lighting, energy management etc. will take advantage of current expertise and solutions of Milan project partners, in particular to: support real-time data collection from field sensors and devices; provide components for data storage and business intelligence; provide API-based access to all data and functionalities managed by the USP, in line with the API Economy and Micro Services Architecture trends; support seamless integration of third-party open data and APIs; support people engagement enabling the development of dashboards and applications for the end-users (e.g., citizens, city managers) to exploit data collected and elaborated through the USP.

### *4.1. E015 digital ecosystem*

One of the pillars of Milan's USP is the E015 digital ecosystem [8,9]. E015 is an open API ecosystem operating in Italy since 2013. It was initially developed in order to exploit the Expo Milano 2015 as a major opportunity to introduce disruptive innovation in providing visitors and citizens with a novel and immersive experience, as well as in all aspects of urban daily life: infrastructures, transportation, cultural and social life, accommodation, services and facilities etc.

E015 enables a new, "coopetitive" approach to the design and implementation of advanced digital services. It provides members (e.g., companies, public authorities) with participation guidelines and a set of shared and consolidated standards, processes, policies and technologies to develop their digital products (i.e., APIs, end-user applications) and enable information systems interoperability. E015 fully exploits the notion of API Economy and Micro Services Architecture. Its interoperability model is based on open, consolidated standards. E015, with its constantly growing number of participants, is one of the legacies that Expo Milano 2015 left to the city and, more generally, to the Italian and European public and private economic system after the closure of the event.

#### *4.1.1. Background*

The E015 project was established in 2010 by major Italian associations of industries and companies (Confindustria, the Chamber of Commerce of Milan, Confcommercio, Assolombarda and Unione del Commercio).

The E015 reference model was conceived by CEFRIEL, since then in charge of the scientific coordination and evolution of the ecosystem. The E015 interoperability standards, technical guidelines and overall architecture were defined with the important contribution of a Scientific Technical Committee from academia. In 2011, Expo 2015 S.p.A. became a full partner of the initiative and the operator of the ecosystem technical infrastructure.

As the result of the convergent efforts of a number of different actors and partners operating in the Milan Urban Area, pilot initiatives to test E015 were started by six large companies, i.e., the major national and regional transportation players (SEA, ATM, Trenitalia, Trenord, Milano Serravalle – Milano Tangenziali, Infoblu – Autostrade per l'Italia).

In accordance with an iterative approach, this initiative led to the publication in the ecosystem of a number of real-time services focused on the Milan Urban Area mobility domain: traffic information and camera views on main streets, highways and bypasses; status and timetables of railway services, public transportation and flights in Malpensa and Linate airports; status and availability of car parking slots and bike sharing stations. Such APIs were then leveraged by different end-user applications made available as mobile apps, Web sites, information kiosks etc.

In 2013, the E015 Digital Ecosystem was publicly launched. Since then, hundreds of participants from both the public and the private sector (e.g., private companies from multiple business sectors, SMEs, public authorities, universities, innovative startups) signed the membership contract. Thanks to E015, 40 innovative applications (such as multimedia totems, Web sites, smartphone apps) were published during the Expo Milano 2015 and contributed to enrich the visitor experience of the event. Such applications used third-party APIs among the 100 available at that time through E015.

In October 2015, the Regional Government of Lombardy replaced Expo S.p.A. as the organization in charge of managing the E015 Digital Ecosystem in future years, and therefore E015 became one of the most important legacies of Expo Milano 2015. Today E015 is still very active, its community is constantly growing in terms of new participants, and more and more services and applications are being published in the ecosystem.

### *4.1.2. Reference model*

E015 is an open API ecosystem. Ecosystem participants can describe and publish their Web services (i.e., APIs), in terms of both functionalities and usage policies, in order to share their data assets through standard Web service interfaces. Other participants can then discover such services and leverage them, in agreement with the respective usage policies, for building new value-added services or new integrated applications for the end-users, thus contributing to the overall growth of the ecosystem. The interoperability model is based on open standards, thus enabling open innovation. Moreover, in the context of "Sharing Cities", E015 will implement a specific federation component that enables digital interoperability at international level between different instances of the USP, e.g., between the three core cities, as well as the follower cities or other adopters.

Fig. 4 provides a high-level view of the E015 architectural reference model.

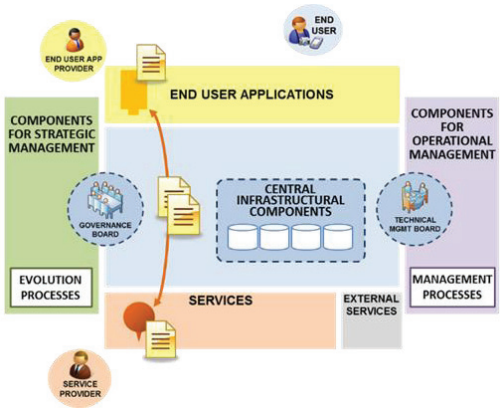


Fig. 4. E015 digital ecosystem architectural reference model, high-level view (source: E015 Technical Management Board).

Everyone can join the ecosystem: membership is free and can be activated online through the E015 Web portal [10]. By signing and uploading the contract, members commit themselves to comply with the E015 public guidelines and technical standards.

E015 in fact provides members with guidelines for participating in the ecosystem – i.e., the E015 "common language" – for developing their software products and for interoperating with other members.

Members can contribute to the ecosystem in different ways. I.e., basically they can:

- Publish E015 services, i.e., expose part of their own information assets and functionalities in the ecosystem through Web services, so that other members can ask for usage and integrate them into applications for the end-users.
- Build E015 end-user applications, i.e., develop Web sites, mobile apps, information kiosks etc. providing end-users with value-added contents and functionalities built by integrating the data and functionalities provided in real-time by the E015 services.
- Share E015 glossaries, i.e., provide standard ways to represent information in the ecosystem by means of taxonomies, ontologies, classification schemes etc. so that members can rely on a set of shared and consolidated data models for developing their software products and for interoperating with other participants.

Moreover, E015 relies on the following internal roles:

- Technical Management Board. The team in charge of managing the technical and procedural aspects of the ecosystem, such as: maintain and evolve technical and process guidelines; manage the ecosystem registries, the Web portal and the other "core" components; provide technical and procedural support to ecosystem participants; validate services and applications in order to assess their compliance with E015 technical standards and guidelines; monitor the availability of services and, in general, the health of the ecosystem.
- Governance Board. The team in charge of long-term governance and strategic evolution of the ecosystem. They take care of different tasks, such as: management of membership requests; management of communication and relationships; strategic planning and management of long-term evolution of the E015 Digital Ecosystem.

Such an overarching IT infrastructure represents a modular, open, scalable, replicable backbone sustaining Milan's (and Italy's) evolution process towards building a network of federated smart cities.

## 5. Building an energy-aware digital ecosystem for "Sharing Cities"

Applying the digital ecosystem model to the USP represents an effective approach to handle energy data integration from different sources. Actually, the E015 model – whose main building blocks are E015 services and E015 end-user applications – enables both data sharing and data consumption in an easy but regulated way, not focusing only on technical details. Technical Internet of Things solutions to collect data from smart sensors can fit into the model as (parts of) E015 services, in order to provide information assets and functionalities within the ecosystem through Web services. At the same time, IT components used to correlate information from different sources can be modeled as (parts of) E015 end-user applications.

In this scenario, solutions provided within the "Sharing Cities" project can benefit from E015 guidelines and "common language" as for integration of data collected and provided by smart interventions such as retrofitted buildings, electric distribution networks, lampposts, electric charge stations and parking infrastructures, electric bikes, and environmental and meteorological monitoring networks.

End-users engagement solutions envisaged in the project (described in Sect. 3.2.3), such as mobile apps for integrated energy and mobility monitoring, can take advantage of collected and processed data made available through the urban ecosystem via standard APIs, and become precious sources of information from citizens acting as "prosumers".

This urban big data collection enables an innovative usage of information, e.g., citizens will have the possibility to understand the quantitative impact of their own behaviors on urban environment; entrepreneurs and city managers will be helped in planning decisions and making investments; also overall evaluation and monitoring at city level

will be supported more effectively thanks to the data collected by the USP, thus enabling both local indicators calculation (e.g., real thermal comfort inside buildings) and high-level evaluation of smartness at district or city scale.

## 6. Conclusions

In this paper, recent advances in technology contributing to the creation of smart cities have been considered, especially regarding heterogeneous data collection and integration. In particular, this paper presented a city-scale solution, enabled by ICT, which is being built in Milan within the "Sharing Cities" Horizon 2020 project: a urban sharing ecosystem, synergically integrating the E015 digital ecosystem and state-of-the-art ICT technologies and trends to support and foster data sharing and consumption between different city stakeholders according to a coopetitive model. The proposed approach enables innovative solutions for citizen engagement and awareness, data management, service federation and interoperability, as well as scientific evaluation and monitoring of the smart city itself. Thanks to the "Sharing Cities" project, relevant improvements in energy indicators modelling are expected. Big data collection from different and heterogeneous sources will provide an opportunity to evaluate the smart city on different scales, such as local view or comprehensive exergetic level. Data integration is expected to catalyse further smart city realizations and improvements, thus helping organizations and entrepreneurs in creating a growing number of innovative energy services for the city and beyond.

## Acknowledgements

This paper is supported by European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 691895 SHAR-LLM ("Sharing Cities").

The authors would like to thank all the partners of the "Sharing Cities" project, in particular the Italian partners supporting the development of project interventions in Milan.

## References

[1] Grolinger K, L'Heureux A, Capretz MAM, Seewald L. Energy Forecasting for Event Venues: Big Data and Prediction Accuracy. Energy and Buildings. 2016;112:222-33. DOI: 10.1016/j.enbuild.2015.12.010

[2] Vernet D, Zaballos A, Martin de Pozuelo R, Caballero V. High Performance Web of Things Architecture for the Smart Grid Domain. International Journal of Distributed Sensor Networks. 2015;2015:1-13. DOI: 10.1155/2015/347413

[3] Sharing Cities [Internet]. Available from: http://www.sharingcities.eu/

[4] Sharing Cities H2020 project, Grant Agreement, Part B, 2015.

[5] Action Clusters - EIP Smart Cities and Communities Market Place [Internet]. Available from: https://eu-smartcities.eu/action-clusters

[6] Milano - EU-GUGLE [Internet]. Available from: http://eu-gugle.eu/pilot-cities/milano/

[7] FIWARE [Internet]. Available from: https://www.fiware.org/

[8] Bonardi M, Brioschi M, Fuggetta A, Verga ES, Zuccalà M. Fostering Collaboration Through API Economy: The E015 Digital Ecosystem. In: 3rd International Workshop on Software Engineering Research and Industrial Practice SER&IP'16, in conjunction with ICSE 2016. 2016 May 17; Austin, TX, USA. ACM; 2016; p. 32-8. DOI: 10.1145/2897022.2897026

[9] Zuccalà M, Celino I. Fostering Innovation Through Coopetition: The E015 Digital Ecosystem. In: 15th International Conference on Web Engineering ICWE'15. 2015 Jun 23-26; Rotterdam, The Netherlands. Springer LNCS; 2015. p. 625-8. DOI: 10.1007/978-3-319-19890-3_44

[10] E015 - Digital Ecosystem [Internet]. Available from: http://www.expo2015.org/archive/en/projects/e015.html