Having regard to Article 41, paragraph 34 of the Statute of the City of Zagreb (Official Journal of the City of Zagreb No 23/16, 2/18 and 23/18), the City Council of the City of Zagreb at its 20th session held on 26 February 2019 adopted the following document

ZAGREB SMART CITY FRAMEWORK STRATEGY

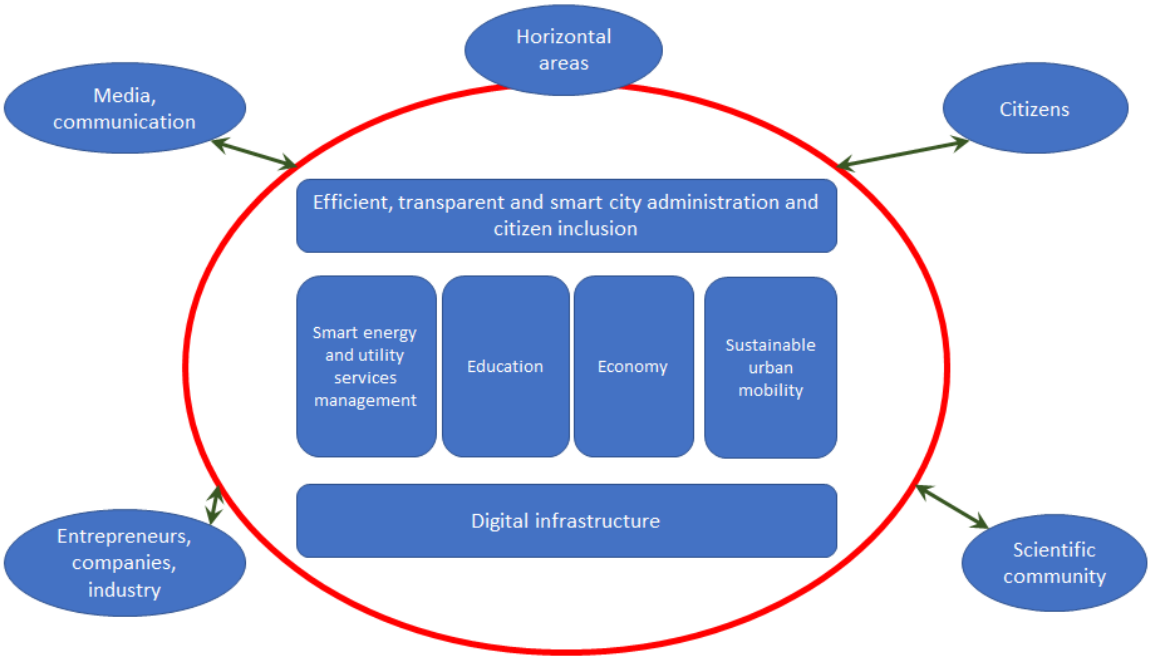
VISION UP TO 2030

Summary

Based on an overview of the current situation, the Zagreb Smart City Framework Strategy, sets the goals and determines strategic areas of future development of the City of Zagreb as a smart city. Priority measures and activities for the achievement of the goals are defined for each strategic area. In accordance with recommendations and guidelines from the existing strategic documents on the development of smart cities on both international and national levels, and primarily from the European Union's European Innovation Partnership on Smart Cities and Communities initiative (EIP-SCC), this Framework Strategy focuses on the following strategic areas:

1. Digital infrastructure;
2. Efficient, transparent and smart city administration;
3. Smart energy and utility services management;
4. Education;
5. Economy;
6. Sustainable urban mobility.

The first two strategic areas represent the foundation, i.e. the requirements necessary for the development and upgrade of smart solutions, applications and technologies in other areas. Only through active participation of every key group, i.e. stakeholder (citizens, entrepreneurs and companies, i.e. the industry, the scientific community and the media), and mutual communication, can the goals be achieved and the possibilities offered by smart solutions and technologies fully utilised. The Framework Strategy also takes into consideration horizontal areas such as financial mechanisms for funding the implementation of measures and mitigation of negative effects of climate change and adaptation to such effects (Picture 1).

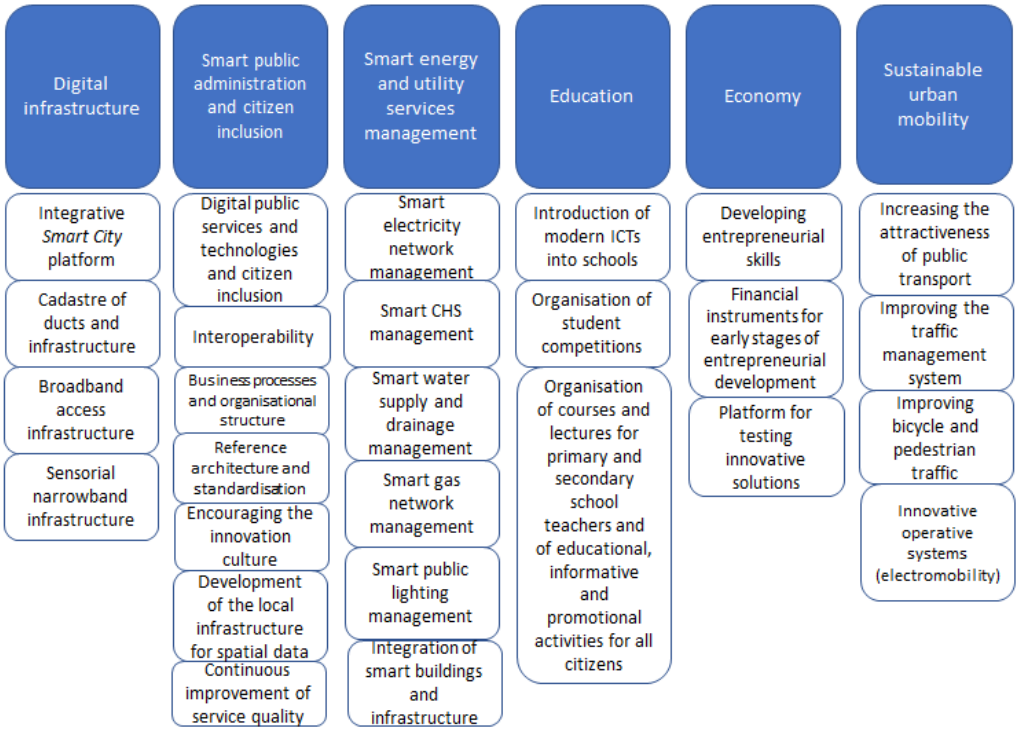


Picture 1 Diagram of strategic areas and key stakeholders of the Zagreb Smart City Framework Strategy

Main objectives set out by this Framework Strategy:

- Improving the quality of life and living standard
- Strengthening the competitiveness of the economy based on knowledge and innovation;
- Further development and improvement of digital infrastructure availability;
- Maximum use of information and communication technologies' potential in order to generate progress;
- Enhancing sustainable use of natural resources and efficient adaptation to the impact of climate change.

The most important and comprehensive part of the Framework Strategy in terms of text are the very measures, i.e. activities that must be undertaken to achieve the vision and objectives envisaged for every strategic area. A total of 27 priority measures grouped according to strategic areas have been defined (Picture 2). Chapter 5 of the Framework Strategy contains a detailed description of every measure.



Picture 2 Diagram of the Framework Strategy priority measures, grouped according to strategic areas

The Framework Strategy is the starting point which provides the guidelines or the framework for future development of the City of Zagreb in an open, flexible and sufficiently clear manner for it to support specific at-the-field project solutions. For the purposes of measures and project implementation, it is necessary to draft a separate action plan or other implementation document containing the necessary information on specific technological solutions and ranges (scope of implementation) for each strategic area. Such detailed data will serve as basis to provide an estimate of the amounts and sources of financial assets necessary for the realization for each year of implementation, which in turn needs to be coordinated with the City of Zagreb budget. The City of Zagreb has set up the Department for the Realisation and Coordination of the Zagreb Smart City Projects with the task of coordinating and monitoring the implementation of all measures and activities outlined in the Framework Strategy.

The Framework Strategy is primarily aimed at ICT implementation and digitalisation, as well as promoting the development of the smart city concept, which makes it a document complementary to other City of Zagreb strategic and implementation documents , such as the *City of Zagreb Development Strategy for the Period up to 2020*, the *Development Strategy of the Zagreb Urban Agglomeration*, the *City of Zagreb Sustainable Energy and Climate Action Plan* (SECAP) and the *Master Plan for the City of Zagreb and the Zagreb and Krapina-Zagorje Counties Transport System*. As such, the Framework Strategy represents a link between the specialised sectoral plans and programmes, some of which already exist, while others are yet to be drafted, such as, for example: the *City of Zagreb Sustainable Energy and Climate Action Plan* (SECAP).1. Introduction: smart City of Zagreb - pathway to the future

What exactly is a *smart city*?

Smart cities are cities tailored to the needs of people, i.e. developed urban areas which facilitate efficient use of natural resources and of the existing city infrastructure, allow for sustainable economic growth, support strengthening of research capacities, development and innovations, ensure high quality of life and provide all inhabitants with access to public digital services. Furthermore, all public services' functions, such as lighting, traffic or energy supply, are integrated in smart cities, resulting in increased efficiency, lower energy costs, faster communication between such subsystems and a significant decrease in greenhouse gas emissions.

The greatest potential in creating solutions capable of answering these challenges, lies in a continuous development and use of new innovative and technological achievements as well as accelerated development of information and communication technologies (hereinafter referred to as ICT), This allows for direct and continuous communication between citizens and the city administration, city institutions and service providers in real time, along with constantly raising the citizens' awareness concerning the city development and infrastructure planning processes. A rapid development of modern technologies, innovative applications and their usage in everyday life have generated the smart city idea, which is becoming a reality in the world's leading cities.

Zagreb Smart City

The increase and ageing of the City of Zagreb population, the increase in the need for mobility, the increased pressure on city resources such as energy and water consumption, the increased demand for employment and the increased life costs all impose the need for solutions that address the citizens' new needs and make the City's sustainable development possible. The increase in population is becoming a growing burden for the existing city infrastructure, whose capacities and service life are limited, as well as setting new challenges for the fundamental functioning of the City. Demands on urban planning, traffic infrastructure, public transport, water and energy supply, environment protection, sustainable waste management, delivery of goods and demands related to the adaptation to climate changes are becoming more complex. That is why the development of smart solutions for the City of Zagreb is becoming a necessity, which does not entail simple copying other cities' solutions, but rather researching those solutions that fit the City of Zagreb and its citizens.

The main purpose of smart cities is to provide optimal quality of life for every citizen, while, at the same time, operating at the highest level of resource preservation, which is something the City of Zagreb strives for. The above-mentioned can only be attained by innovative urban management, that is, development of useful solutions based on real data and information on the city life, with the help of communication technologies in a way that they:

- Connect different sources of information, resulting therefore in synergy;
- Achieve a significant level of efficiency and resource preservation through integrated approaches; and
- Include both citizens and investors in the city's development in order to make it more attractive, sustainable, resistant to many challenges and dedicated to increasing the quality of life.

Therefore, Zagreb Smart City implies a place of high quality of life and a competitive economy, which can only be achieved by continuously developing new innovative solutions in every area of relevance to the City development, with the key roles being played by advanced, integrated, digital and communication technologies.

Framework Strategy – drafting method and goals

This Framework Strategy has been drafted by the Working Group for Development and Implementation of Zagreb Smart City Projects, which was set up in October 2016 by a Conclusion of the Mayor of the City of Zagreb. Members of the Working Group are representatives of all relevant city administrative bodies, institutes, institutions and companies. External associates were also involved in the drafting of the Framework Strategy, as authors of the parts of the text addressing specific areas. As the first step in the drafting of the Framework strategy, in February of 2017 the Working group produced a Project Task which contains basic guidelines and instructions for the drafting and also defines the following basic sectors which require determining specific measures i.e. activities that will be carried out:

- Quality of life;
- Economy;
- Management and informing;
- Environment protection and combating climate change.

The working version of the Framework Strategy was drafted in early January 2018 and it included comments from all relevant city offices, institutes, institutions and companies, as well as those from other key stakeholders that are not owned by or under the competence of the City of Zagreb (primarily HEP d.d.) . After taking those comments into consideration and adjusting the working version, a final version of the framework strategy was drafted.

The Framework Strategy defines the direction of development of all sectors bringing it in direct connection with advanced, integrated, digital and communication technologies. Modelled after the strategies of advanced European cities, this Framework Strategy aims at directing the City of Zagreb towards the implementation of innovative methods of resources and new technologies usage, a better coordination of city administrative bodies and active involvement of citizens in the city development, in order to achieve optimal quality of life, develop economy and decrease greenhouse gas emissions, as well as adjust to climate changes. Since specific goals, related to energy efficiency, sustainable transport, economic development etc. overlap, a comprehensive approach to possible solutions is necessary in order to achieve better efficiency with minimal costs and ensure a constructive exchange of knowledge and experience within the scope of drafting and implementation of the Framework Strategy.

In line with the above-mentioned, the Framework Strategy has foreseen to make possible in the long term:

- cohesion and cooperation of all city systems and key stakeholders' systems for the development and service providing (public administration, private sector, civil sector, academic community and the citizens, as well as the environment in general and society as a whole) aimed at encouraging innovations, economic activity and long-term sustainability and

environment protection in the City of Zagreb area (the *Quintuple Helix* model based on the interconnectivity of the mentioned stakeholder types, the environment and the society);

- Analysis of actual needs of the key stakeholders, especially of citizens, through their active cooperation in the city's activities, aimed at improving the quality of life and the stakeholders' satisfaction;
- Collection and analysis of data related to city services, activities in the city and feedback based on the data collected, aimed at proactive and reactive response.

In drafting the Framework Strategy, special attention was paid to its compliance with the *City of Zagreb Development Strategy for the Period up to 2020*, which is the fundamental planning document for the development of the City of Zagreb. The Development Strategy provides guidelines for development in general, whereas this Framework Strategy is aimed primarily at the development, implementation and utilisation of smart solutions and provides specific guidelines regarding priority measures and activities. Compliance with strategic documents, drafted as part of the European Commission's *European Innovation Partnership on Smart Cities and Communities* initiative, was also taken into consideration, as well as that with the Europe 2020 strategy, that is, general compliance with documents mentioned in the following chapter. These documents consist in large part of guidelines for applying for the *Horizon 2020 - Smart Cities and Communities* programme calls for grants for the implementation of parts of activities outlined in the Framework Strategy. A detailed overview of individual measures is supplemented to the existing sectoral strategic documents or outlines the drafting of the missing ones. The operationalisation and specific activities will be outlined in comprehensive action plans and will be specifically foreseen in the budget and budget projections of the City of Zagreb, budgetary users and the companies owned by the City of Zagreb, which is something that will determine the dynamics of implementation. Compliance with the EU's 2021-2027 Multiannual Financial Framework will also be taken into consideration. Future financial perspectives represent a special priority because innovations and digital society development are the key elements for the implementation of the 2021-2027 Digital Europe Programme in the public sector, as well as of other policies and programmes of the new 2021-2027 financial perspective.

2. Strategic frameworks at the international and national level

The European Union encourages the development of smart cities through its Europe 2020 strategy[1] and European Innovation Partnership on Smart Cities and Communities (EIP-SCC)[2]. It especially encourages innovation in the fields of energy, transport and information and communication technologies aimed at increasing the quality of urban life by investing in research and development of new technologies and integrated smart city solutions. In relation to this initiative, a strategic and implementation framework for smart cities has been drafted, contained in two documents: *Strategic Implementation Plan (SIP)*[3] *and Operational Implementation Plan (OIP)*[4]. These documents contain a series of guidelines and recommendations taken into account in the drafting of this framework strategy.

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[1] EUROPE 2020: A European strategy for smart, sustainable and inclusive growth, European Commission 2010, available at http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

[2] The European Innovation Partnership on Smart Cities and Communities, available at: http://ec.europa.eu/eip/smartcities/

[3] European Innovation Partnership on Smart Cities and Communities – Strategic Implementation Plan (SIP), available at: http://ec.europa.eu/eip/smartcities/files/sip_final_en.pdf

[4] European Innovation Partnership on Smart Cities and Communities – Operational Implementation Plan (OIP), available at http://ec.europa.eu/eip/smartcities/files/operational-implementation-plan-oip-v2_en.pdf

Considering the common topic, in the preparation of the Zagreb Smart City Framework Strategy, the existing strategic documents described below were taken into account.

- ***The Urban Agenda for the EU: Pact of Amsterdam***[5], agreed upon at the Informal Meeting of EU Ministers Responsible for Urban Matters on 30 May 2016, as the base for drafting up the Urban Agenda for the EU. The Pact of Amsterdam explains the motivation, reasons and importance of drafting and adopting this kind of document for European urban areas, as the principal dynamos of the future overall development of the EU.

Considering the population concentration (over 70% of European population lives in urban areas), better employment opportunities and a higher level of education, as well as problems such as high concentration of unemployment and poverty, urban areas have a key role in the realisation of strategic goals of the European Union, with the city administration being the stakeholder with the most significant role and impact. The city administration needs to be focused on improving the following three main areas:

- Legislation (adoption of European legislation in an efficient and comprehensive manner, with as low costs and bureaucracy involved as possible);
- better financing (use of EU funds and other innovative models of financing); and
- Exchange of knowledge based on open access to data and city infrastructure generating continuous data (e.g. real-time location of trams and public transport buses, readings from air quality monitoring stations etc.).

Moreover, it is necessary to improve the cooperation between the city administration, city districts and city councils, citizen associations, business and scientific institutions. Cooperation with the regions (counties) surrounding a specific urban area is important. Sustainable development underlines the sectors of economy, environment protection and society and culture, with the following selected priorities for the cities in the EU area: air quality, urban poverty, housing, circular economy, employment on a local level, adjustment to climate changes, energy transition, sustainable land and natural solutions use, urban mobility, digital transition, innovative and responsible public procurement and assets management.

- ***Establishing an INfrastructure for SPatial Information in the European Community (INSPIRE) Directive (2007/2/EC)***[6] is a directive of the European Parliament and the Council of the European Union adopted on 14 March 2007 referring to spatial data, supporting the formulation of environmental policies and providing a future framework for the National Infrastructure for Spatial Information in the EU Member States.

The INSPIRE Directive provides obligatory general guidelines for all activities of the EU Member States related to the National Infrastructure for Spatial Information (NISI), whereas the more detailed technical provisions are defined via implementing rules and technical specifications. The Directive is based on the improvement and coordination of the existing infrastructures for spatial information that would include all data directly or indirectly related to environment protection. The Directive dictates the storage of spatial information, its availability under conditions which do not unduly restrict their extensive use, as well as the

[5] Urban Agenda for the EU: Pact of Amsterdam, available at http://ec.europa.eu/regional_policy/sources/policy/themes/urban-development/agenda/pact-of-amsterdam.pdf

[6] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), available at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007L0002

conditions of its usage, easy finding of spatial information, evaluation of suitability for the purpose and the optimal maintenance of spatial information. It also enables a consistent combining of spatial information from different sources across the EU and sharing of spatial information between different users and applications, as well as insight into spatial information of all public authorities, regardless of the level of the public authority that collected the information. The basic components of the INSPIRE directive are the metadata database, interoperability, sharing of spatial data and services, network services (discovery, view, download, transform and services allowing spatial data to be invoked), coordination and measures of monitoring and reporting. The INSPIRE Directive encompasses 34 spatial information-related topics required for a successful creation of the National Infrastructure for Spatial Information relating to environment protection and owned by public authorities or other institutions. The INSPIRE Directive was introduced into Croatian legislation by the National Infrastructure for Spatial Information Act (Official Gazette no 56/13, 52/18), adopted on 26 April 2013 and amended on 6 June 2018. Further implementation will be carried out in accordance with the INSPIRE development plan, which falls under the jurisdiction of the Croatian Geodetic Administration (National Infrastructure for Spatial Information Service).

- ***A Digital Agenda for Europe***,[7] initiated in May 2010, set out the objective to enable citizens and economic operators to optimally utilise digital technology, as well as the objective to stimulate the European economy by providing sustainable economic and social benefits of a unique digital market.

A Digital Agenda for Europe stresses the fact that more and more daily tasks are done over the Internet, which demands better digital skills from all citizens in order to be completely included in the society. The digital economy grows seven times faster than other sectors of the economy, which is mainly made possible by the development of broadband Internet. Nowadays, the development of high speed networks generates the same effect once generated by the energy system and traffic network development. The European Commission encourages the expansion of a fast broadband network by adopting new cost reduction rules, publishing the recommendation for the Next Generation Access Networks, reviewed guidelines for state aids for broadband networks, proposing the fulfilment of the single market for telecom services and adopting the Connected Continent legislative package. The single market for telecom services will bring about a proportionate development of the telecom sector in the EU area, higher productivity in other economic sectors as a result of a more efficient cross-border connectivity, favourable cross-border prices, higher innovation potential and larger offer of products and services. The main elements of the #Connected Continent package include borderless Internet, stronger consumer rights and the already accomplished embargo on charging additional roaming fees in the EU Member States. Accomplishing the goals of the Digital Agenda would lead the way for innovative services in smart cities, such as usage of smart systems with the purpose of increasing energy efficiency and achieving energy savings, e-health and e-administration systems, smart traffic management systems etc. The purpose of the Digital Agenda is not only enabling Internet access, but also providing assistance in navigating around the digital world. Computers, mobile phones and digital technologies are integral parts of our everyday lives and can be used in solving many challenges we face, from road safety and healthier ageing to better public services and sustainable environment. According to the Digital Agenda, a smart city is a place where traditional networks and services have become more efficient through the implementation of

[7] A Digital Agenda for Europe, COM(2010) 245 final, available at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52010DC0245R(01)

digital and telecom technologies for the well-being of the citizens and economic operators in such a city.

- ***Connectivity for a European Gigabit Society***[8]

Drafted as part of the Digital Single Market initiative, the document follows in the steps of A Digital Agenda for Europe and defines the EU goals for 2025, primarily in the area of:

- European Electronic Communications Code;
- Joint broadband goals of the EU for 2025;
- 5G action plan;
- WiFI4EU initiative;

- ***Europe 2020: A European Strategy for Smart, Sustainable and Inclusive Growth***[9] is a 10-year-long EU strategy for growth and employment initiated in 2010 in order to create conditions for a smart, sustainable and inclusive growth. Five headline EU-wide targets until the end of 2020 in the fields of employment, research and innovations, climate changes and energy, education and fight against poverty were agreed upon.

Europe 2020 sets out a vision of Europe's social market economy for the 21st century and puts forward three mutually reinforcing priorities: smart growth – developing an economy based on knowledge and innovation; sustainable growth – promoting a more resource efficient, greener and more competitive economy; and inclusive growth – fostering a high-employment economy delivering social and territorial cohesion. The EU needs to define where it wants to be by 2020. To this end, the Commission proposes the following EU headline targets: 75 % of the population aged 20-64 should be employed; 3% of the EU's GDP should be invested in R&D; the "20/20/20" climate/energy targets should be met (including up to 30% increase of emissions reduction if the conditions are right); the share of early school leavers should be under 10% and at least 40% of the younger generation should have a tertiary degree; 20 million less people should be at risk of poverty. The Commission proposes for EU goals to be translated into national targets and trajectories. The Commission is putting forward seven flagship initiatives to catalyse progress, one of which is A Digital Agenda for Europe.

- ***Tallinn Declaration on eGovernment***[10]

The Tallinn Declaration on eGovernment was signed in October 2017 and builds on the previous initiatives of EU institutions, the 2009 Malmö Declaration, the eGovernment Action Plan 2016-2020 and the European Interoperability Framework. The overall vision remains to strive to be open, efficient and inclusive, providing borderless, interoperable, personalised, user-friendly, end-to-end digital public services to all citizens and businesses – at all levels of public administration.

[8]Connectivity for a European Gigabit Society, available at https://ec.europa.eu/digital-single-market/en/policies/improving-connectivity-and-access
[9]Europe 2020: A European Strategy for Smart, Sustainable and Inclusive Growth, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF
[10]Tallinn Declaration on eGovernment, available at: https://www.eu2017.ee/sites/default/files/2017-10/Tallinn_eGov_declaration.pdf

- ***Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system*** **White Paper**

The White Paper represents the basis for the implementation of structural reforms meant to establish a competitive and efficient transport system that will enable mobility throughout the EU. The objective of these reforms is to create a Single European Transport Area as one of the requirements for fuelling growth and employment, as well as competitiveness of EU companies. Additional goals are to dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050.

The national strategic documents are the following:

- ***Croatian Smart Specialisation Strategy 2016-2020 and the Action Plan for the Implementation of the Croatian Smart Specialisation Strategy 2016-2017***[11] set as their main goals encouraging economic growth, increasing the business sector investments in research and development, responding to current social challenges facing Europe and the world and opening new workplaces, especially the highly qualified ones. Special stress is put on the efficient cooperation between the business and the scientific research sector in those areas where the Republic of Croatia offers the most potential for a smart, inclusive and sustainable growth based on the nation's advantages and potential for progress and excellence.
- ***Transport Development Strategy of the Republic of Croatia 2017-2030***[12], adopted by the Government of the Republic of Croatia in August 2017[13]. This strategy serves as a framework for the development of the transport sector and consists of 16 general objectives, 37 specific objectives and 118 measures for 6 transport sectors: railway, road, air, inland waterways, maritime and public urban, suburban and regional transport. Furthermore, the Strategy is one of the fundamental documents for the use of EU funds for the transport sector.
- ***National Programme for the Development and Deployment of Intelligent Transport Systems in Road Transport for the 2014-2018 Period***[14], the basic objective of which is to show the state-of-play and the plan of future activities of development and deployment of intelligent transport systems (ITS) in the Republic of Croatia. The adoption of the National Programme is in accordance with the obligations arising from Directive 2010/40/EU of the European Parliament and the Council, which were implemented in the national legislation via the Roads Act (Official Gazette no 81/11, 22/13, 54/13, 148/19, 92/14). The National Programme provides a clear overview of the general importance of ITS utilisation and the state of ITS in the EU and the Republic of Croatia.

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[11] *Strategija pametne specijalizacije Republike Hrvatske za razdoblje od 2016. do 2020. godine i Akcijski plan za provedbu Strategije pametne specijalizacije Republike Hrvatske za razdoblje od 2016. do 2017. godine* (Official Gazette no 32/16), available at http://narodne-novine.nn.hr/clanci/sluzbeni/2016_04_32_853.html (Croatian)

[12] *Strategija prometnog razvoja Republike Hrvatske za razdoblje od 2017. do 2030. godine*, Ministry of Maritime Affairs, Transport and Infrastructure of the Republic of Croatia. Available at: http://www.mppi.hr/UserDocsImages/MMPI%20Strategija%20prometnog%20razvoja%20RH%202017.-2030.-final.pdf (Croatian)

[13] *Odluka o donošenju Strategije pametnog razvoja Republike Hrvatske za razdoblje od 2017. do 2030. godine* (OG 84/17)

[14] *Nacionalni program za razvoj i uvođenje inteligentnih transportnih sustava u cestovnom prometu od 2014. do 2018. godine* (OG 82/14), available at: https://narodnenovine.nn.hr/clanci/sluzbeni/2014_07_82_1580.html(Croatian)

- ***E-Croatia 2020 Strategy***[15] was adopted in 2017 and represents the framework for further development of informatisation and e-services in the public sector. The main objective of this strategy is the integration of the information systems of public administration bodies from all sectors in such a way that the citizens are granted access to a large number of complex e-services and that their interaction with the public administration becomes less overwhelming. The Strategy sets objectives for the development of a central interoperability system, along with the digitalisation and intersectoral integration of simplified business processes on central, regional and local levels. The Shared Services Centre will enable infrastructure, technical platforms and e-services in the national "cloud" and a further development of the e-Citizens and e-Business platforms, as well as ensure a single point of interaction between the public administration and the citizens and economic operators, in accordance with the *only once* principle.

At the City of Zagreb level, the strategic documents are the following:

- ***City of Zagreb Development Strategy for the Period up to 2020***, adopted by the City Assembly of the City of Zagreb on 28 September 2017,[16] is the fundamental planning document for the regional development policy for the City of Zagreb area. The City of Zagreb Development Strategy follows the Zagreb Smart City horizontal principle, a concept developed through the formulation of all six strategic goals. The horizontal principles chapter provides a list of measures promoting the smart city concept and the dedicated Measure 6.4.5. Zagreb Smart City, which expressly anticipates the drafting of a strategic document for the transformation of the City of Zagreb into a smart city, has also been formulated in the document.
- ***Zagreb Urban Agglomeration Development Strategy for the Period up to 2020***[17], adopted by the City Assembly of the City of Zagreb on 21 December 2017. The Zagreb urban agglomeration consists of the City of Zagreb and 29 cities and municipalities with 1,086,528 inhabitants that gravitate towards the City of Zagreb. The strategy defines the goals and priorities, whose implementation will result in better quality of life, infrastructure and citizen education, as well as in the development of a competitive and sustainable economy and improvement of environmental management.
- ***City of Zagreb Sustainable Energy Action Plan***[18] adopted by the City Assembly of the City of Zagreb on 20 April 2010, following the signed Covenant of Mayors[19], ratified by the City Assembly of the City of Zagreb on 30 October 2008, which binds the signatory mayors to implement the 20/20/20 programme and the numerous energy efficiency measures which should contribute to the fulfilment of the four elementary goals of the 2007 European energy policy by 2020: a 20 % decrease in greenhouse gas emission, a 20% increase in energy efficiency, a 20% increase in the share of renewable energy resources and a 10% increase in the share of biofuel in transport. In accordance with the

[15] *Strategija e-Hrvatska 2020, 2017*, Ministry of Public Administration of the Republic of Croatia, available at: https://uprava.gov.hr/strategija-e-hrvatska-2020/14630 (Croatian)
[16] City of Zagreb Development Strategy for the Period up to 2020, 2017, the City of Zagreb: City Office for the Strategic Planning and Development of the City, available at: www.zagreb.hr/UserDocsImages/arhiva/strategijsko_planiranje/RSGZ.doc (Croatian)
[17] Strategija razvoja Urbane aglomeracije Zagreba za razdoblje do 2020. godine, prosinac 2017, City of Zagreb, available at: http://www.zagreb.hr/UserDocsImages/arhiva/strategijsko_planiranje/Strategija%20razvoja%20Urbane%20aglomeracije%20Zagreb%20za%20razdoblje%20do%202020..pdf (Croatian)
[18] *Akcijski plan energetski održivog razvitka Grada Zagreba*, March 2010, City of Zagreb, available at: http://www.eko.zagreb.hr/UserDocsImages/akcijski_plan_2013.pdf (Croatian)
[19] http://eko.zagreb.hr/default.aspx?id=142

obligations arising from the Covenant of Mayors, the City of Zagreb plans to adopt a Sustainable Energy and Climate Action Plan, which sets the goals and anticipates specific measures for the period up to 2030, by April 2019. The document should be coordinated with this framework strategy.

- ***City of Zagreb Energy Efficiency Action Plan for the 2017-2019 Period,*** adopted by the City Assembly of the City of Zagreb at the session held on 20 December 2016.

In addition to the aforementioned strategic documents at the City of Zagreb level, the drafting of phase one of the Master Plan for the City of Zagreb, Zagreb and Krapina-Zagorje counties, which contains the analysis of the current condition of transport systems in those areas, is being finalised. Drafting of phase two, which will consist of goals, priorities, measures and the action plan for implementation, is planned to take place during 2019. The promoter of this project is the company Integrirani promet zagrebačkog područja d.o.o.

3. Analysis of the situation and opportunities

A state of play overview

The City of Zagreb possesses significant potential for the realisation of all smart city aspects. The existing city infrastructure, environment and share of green spaces in the overall city area, zones for recreation, water supply, waste and waste water management, transport and the level of ICT integration in all sectors provide a very good basis for further progress of development and implementation of smart solutions.

The University of Zagreb is the leading university in the Republic of Croatia in terms of academic activities and research, and, considering that it was founded in 1669, it is among the oldest European universities. An array of faculties of the University is already developing and implementing smart solutions in all fields of life (e.g. the Faculty of Electrical Engineering and Computing, the Faculty of Mechanical Engineering and Naval Architecture and other). Numerous projects, completed ones and in progress, have yielded significant results.

In that respect, there exist significant possibilities of improving the already existing cooperation, synergy and joint development and work on smart solutions, applications and devices between the University of Zagreb and City of Zagreb, as well as city companies. The APIS IT company is another significant City of Zagreb potential. The said company is of strategic interest for the Republic of Croatia and is also co-owned by the City of Zagreb. Therefoer, in the implementation of the framework strategy, it is possible to use the already existing experiences, competences and resources in the development of the critical IT infrastructure.

Zagreb is the economic, cultural and political centre of the Republic of Croatia, as well as an international commerce and business centre and a crossroads of the Central and Eastern Europe. A significant number of companies that are seated or have branches in Zagreb work on the development and implementation of smart solutions, applications and devices, with a stress on ICT (e.g. HT (Croatian Telecom), IBM, Microsoft, Odašiljači i veze (Transmitters and Communications), as well as a large number of small and medium-sized companies), some of which have already been implemented in Zagreb and other Croatian cities. A strong cooperation between private and public sectors is a necessary prerequisite for Zagreb to fully become a smart city, which has especially been recognized and stressed in this framework strategy.

Zagreb has a high quality of life. The numerous city parks and the large share of green spaces in the City area, the Sava River and the maintained Jarun and Bundek lakes, the Medvednica Nature Park, a large number of cultural institutions, healthcare institutions and institutions for elderly care and care of the infirm, as well as the exceptional security reflected in the small and continuously decreasing number of criminal and minor offences, contribute to that fact.

In order for the full potential of a smart city to be realised, another necessary prerequisite is also the involvement of citizens in decision-making regarding the matters vital for their city. In terms of administration, Zagreb consists of city districts and local councils, in which citizens, via their directly elected representatives, participate in the decision-making process regarding the activities that affect their everyday life and work in their local communities. In order to additionally include all citizens, the City of Zagreb City Administration has set in motion a number of initiatives and projects utilising ICT, which represent results of the already implemented smart solutions (e.g. MojZagreb (MyZagreb) – the central point of access to every e-service that the City offers its citizens; the Zagreb – Inovativni grad (Zagreb - Innovative City) pilot project and other).

Specific examples of the implemented projects and those in progress can be found below.

Information and Communication Technology (ICT) and infrastructure and the utilisation of smart solutions

Within the scope of this framework strategy preparation, the involved city offices, institutes and institutions gathered information on the existing smart solutions and ICT and infrastructure situation in the City of Zagreb. They also collected the information from many branches/companies of Zagrebački holding and from several most significant private companies which develop smart solutions and applications. An overview of the most important projects and activities implemented by now is given below. It clearly shows significant progress in the implementation of smart solutions in practically every sector analysed in this framework strategy.

Quality of life – smart education, social welfare and citizen participation

The **education** sector in the City of Zagreb follows real life situations and needs related to the education of children and youths, which is why many programmes and projects are aimed at satisfying the needs of the citizens are being initiated. The City of Zagreb sponsors, funds and co-organises numerous activities aimed at increasing the standard of work in the education field. To that end, the City of Zagreb has initiated the formulation of many documents (strategies, programmes, plans) which encourage and implement an education system suited to the needs of the City's economy, as well as create the requirements for a better integration of the education and economy sector. The following documents of importance in the field of education of the City of Zagreb have been drafted and adopted in the recent period:

1. The *Digital network of elementary schools in Zagreb* project was a result of cooperation between the City Office for the Strategic Planning and Development of the City and the City Office for Education, with the backing of the City Office for the Local Self-Administration. The project was aimed at generating a map of all the City's elementary schools in their respective city districts, with detailed information regarding the status and needs.

2. The *City of Zagreb Human Resources Development Strategy* analyses the existing status of education and provides a set of measures aimed at achieving the education level suited to the needs of the economy of the City of Zagreb.
3. The *Feasibility Study with a Cost-Benefit Analysis for the Vocational Centre for Crafts and Entrepreneurship Project* was driven by the idea of developing innovative and competitive economy in fields of crafts, micro-, small- and middle-sized enterprises and vocational education in the Zagreb and neighbouring counties, provoked by the years of decrease in the number of craft trades, income from and employment in the craft trades and lack of interest in enrolling in vocational schools.
4. The *Agreement on the Participation of the City of Zagreb in the e-Schools Project* is aimed at raising the level of digital competence of schools through developing digital capabilities of teaching and non-teaching staff, developing digital content, equipping schools with ICT equipment, implementing required infrastructure alterations related to Internet access and through developing services for transparent operating of schools and quality management of the teaching process.

Below are listed the examples of the implemented smart solutions in the education sector:

1. The e-Matica (e-Registry) system of the educational institutions of the City of Zagreb, comprising the following systems:
   a) Electronic systems for downloading the required data from the Ministry of the Interior, the Ministry of Public Administration and the Ministry of Science and Education;
   b) The electronic system for enrolment and transfer of children in kindergartens and keeping records of children, educational programmes, kindergarten/school teachers, buildings and equipment;
   c) The electronic school book procurement system.

The e-Matica system of the City of Zagreb's educational institutions was intended and implemented as an integral on-line system fulfilling the needs of all educational institutions in the City of Zagreb and those of the competent City Office for Education. The authorised employees of those institutions and the City Office for Education access the system via their user name and password, which enables them to view and/or use only the data they have the authorisation for. The authorised employees of the City Office for Education can, in real time, view the data of any institution that enters and/or uses the data from the e-Matica system of the City of Zagreb. At the same time, the e-Matica system keeps a historical record of every alteration made by whichever authorised employee and monitors the educational cycle of every child in the City of Zagreb by employing the required checks (e.g. a child cannot enrol in an institution via the e-Matica, without having been previously signed out of the previously attended school in the same application or if it does not permanently reside in the City of Zagreb; a school cannot order more of the authorised school books than it has students of a certain level which requires the use of said books etc.). In order to enable all the necessary checks, the e-Matica system pulls data from other institutions (e.g. the Ministry of the Interior's database provides the data on permanent and temporary residences of the children, the Ministry of Public Administration's database provides the data from the Register of Births, the Ministry of Science and Education's database provides the data on the valid/current school books etc.). The data is processed and utilised according to the prescribed needs of the institutions and the City Office for Education, while the necessary processing is shown in the predefined reviews and reports (separately for each institution and separately (accumulatively) for the needs of the City Office for Education). The Personal Data Protection Agency gave its assent for setting up the application system. The City of

Zagreb E-Matica system is based on a joint database and also allows for the possible production of new application systems using data from the database or partially using the existing data, while the other necessary data is entered by the institutions for which the new application system is being made. . The e-Matica system provides data for the needs of other systems operating within the scope of the city administration (e.g. APIS-IT). Keeping records of users and control of expenditure of the city budget funds is made possible by the transparent and purposeful checks.

2. The system for payments for kindergarten placement in the City of Zagreb, as well as that for subsidising pupil and student transport, comprising the following systems:
   a) The electronic system for downloading Tax Administration data (EDIP);
   b) The electronic system for the categorisation of pupils and students for the purposes of determining the amount of subsidies and for the categorisation of parents for the purposes of determining the amounts for the payments for kindergarten placement in the City of Zagreb.

   The purpose of the system for payments and subsidising is to make the determination of the payment/subsidy amount possible on the basis of the data on the income of pupils/students and members of their shared households. On the basis of the funding/subsidising criteria, determined by the City Assembly, the system gathers the required data and categorises the beneficiaries into groups according to the level of the approved amounts of the funds/subsidies. In order to calculate the amounts of payments/subsidies, the system gathers the data from the e-Matica system of the City of Zagreb (data on children/enrollees and the members of their shared households) and the data from the Tax Administration on the income amounts of the beneficiaries of the funds and the members of their shared households (the pertinent forms of income). Then it calculates and categorises the data and delivers the information on the payment category of the enrollee or their parent/caretaker to every educational institution of the City, which cares for infants and pre-school children, as well as to the City Office for Education. Based on that data, the institutions and the City Office for Education prepare the documentation for the payment of placement / subsidising of pupils and students. The application system is able to deliver data to the involved city administration bodies (e.g. the City Office for Financing).

3. The system displaying locations and basic data of the educational institutions, publicly available at the City of Zagreb Geoportal

   In order to quickly locate an educational institution in the City of Zagreb area and access its basic data, each institution's coordinates are included in the on-line spatial data application (the City of Zagreb Geoportal). The citizens of Zagreb can (via their Internet browser) view the spatial position of every educational institution in the City of Zagreb on a digital map of the City, as well as access the basic data of each institution. Geoportal pulls data from the e-Matica application.

The following solutions have been implemented in the City of Zagreb within the scope of activities aimed at **social welfare and inclusion**:

1. The *Socijalni programi* (Social Programmes) application is a register of data on all rights and services that an individual user can receive in the City of Zagreb area. The application was launched in March 2017 and is currently in the process data transfer from the previous database. In addition to social programmes, demographic

programmes that include financial aid for stay-at-home parents and equipment (the Bebe information system) are also being carried out. An upgrade of the existing Bebe system, as well as establishment of new functionalities in financial aid for stay-at-home parents are being carried out, and will result in a unified single system that will serve as a basis for future stimulative demographic measures.

2. The *DOGMA* application enables users to search a single database of retirement homes and focus their search on a specific home (a register of users and registrations in retirement homes). The search consists of several categories that encompass various fields of work (social work, healthcare etc.). The application was initiated by the former City Office for Health, Labour and Social Welfare, in cooperation with the City Service for Informatics and Communications. In 2009, it was launched as a pilot project in the Centar and St. Joseph retirement homes and by the end of 2011 it was implemented in all 11 homes, with the implementation and maintenance being entirely funded by the City of Zagreb.
3. *WELFARE CARDS* – a welfare cards system for soup kitchen users was introduced in 2007. Nowadays, the cards are used in soup kitchens, aid in kind and for receiving dairy products for children under the age of one.
4. *AUDIO DESCRIPTION FOR THE BLIND* – the project of audio description of sporting events aimed at blind and visually impaired people was launched in 2017. Expert commentators described events on the sports field via wireless technology to the blind and visually impaired, to whom special headphones had been handed out at stadium entrances in order for them to fully experience the events.
5. *GPS NAVIGATION FOR THE BLIND* - in cooperation with the Zagreb Association for the Blind, a training initiative for the blind on how to use a GPS smartphone application was started in 2015.

In the April-May period of 2017, the City of Zagreb carried out the ***Zagreb – Innovative City*** pilot project, aimed at instituting an innovation management system in the city administration, Zagrebački holding d.o.o. and all city companies. The project was also aimed at improving communication with the citizens and granting their involvement in all of the city administrative bodies and companies, with the ultimate goal of increasing their efficiency. The project was based on a crowdsourcing model (the Facebook platform), which provides three methods of enabling innovation: citizen feedback regarding certain matters and projects, publishing calls for ideas and researching citizen opinion. In that way, ideas and suggestions are received, discussions are led and the received ideas and suggestions are evaluated, which ultimately results in completed projects. This and similar platforms offer the citizens a chance to actively suggest new projects and ideas for innovative solutions aimed at advancing city services, as well as a chance to comment, evaluate and monitor every idea's implementation status.

Economy

The last two years have brought an increase in the number of active, competitive, highly innovative young and new entrepreneurs in the Zagreb-area, which is a result of synergy-based increase in the number of programmes and measures aimed at encouraging small- and middle-sized enterprises. ***The Zagreb Innovation Centre (ZICER), an institution for entrepreneurial support and innovative entrepreneurship***, has been continuously expanding the infrastructural capacities for supporting the progress of high-tech companies. ZICER supports the entrepreneurial ecosystem by mentoring, educating and offering infrastructural

and financial support. It operates through several specialised programmes aimed at specific groups, with ***Blue Office - the Entrepreneurial Centre of the City of Zagreb***, a programme offering counselling, free workshops and seminars to all the citizens, being among the most important.

However, in addition to the lack of specialised testing laboratories and development of new technologies, there is also the lack of the accompanying pre-seed and seed funding, primarily in the context of startup companies that have very limited access to funding. To remedy this, the City of Zagreb and ZICER have launched a pre-acceleration programme in the scope of which startups receive no-equity funding, mentoring and infrastructural support, as part of the ***StartUp Factory Zagreb*** programme. Also, the 7300 m2 on the first floor of the Zagreb fair pavillion 12 house the ***High-Tech incubator*** with 118 modular units (offices), an entrepreneurial accelerator and 6 modern tech centres for development and testing of products and services which are at the disposal of entrepreneurs and startup companies.

Plans have been made for the creation of digital educational content available via an open web-service on the ZICER website, aimed at strengthening the competencies of the citizens and informing them about current and relevant matters.

A special measure aimed at providing support to innovators who develop and promote innovations for entrepreneurial use is being carried out within the scope of the *Programme for Encouragement of Crafts and Small- and Middle-Sized Enterprises in the City of Zagreb*.

An array of private initiatives such as *HUB385, Impact Hub, Founder Institute* and others are also present in the City of Zagreb area.

Smart City Administration – Management and Informing

The Zagreb City Administration consists of offices, services and institutes performing administrative, expert and other activities of the City's self-government purview, as well as the State administration activities, entrusted in accordance with the law, the Statute of the City of Zagreb and other regulations. The City Administration is primarily oriented towards professional, reliable, transparent and efficient conduct, based on the best national, European and international practices and advanced service provision quality standards.

ICTs are available in all operational segments, but their use is limited by a series of organisational issues that need to be solved, that is, adapted in order to change the awareness about the usage of new and advanced technologies. The Service for the Information and Communication System of the City keeps up, to the extent possible, with the current IT standards and technologies. Certain technological solutions cannot be implemented because of the limited funds.

In 2012, the Service for Analysis and Improvement of Business Processes of the Office of the Mayor started improving the organisation of City operations on the basis of business process and management of change by conducting several projects aimed at quick adaptation to new business conditions and implementation of European administrative standards, as well as at introducing continuous advancements of business models, processes and services as everyday activity.

An example of an existing smart solution is the City's Geoportal, an access point for the Zagreb infrastructure for spatial data that contains the spatial data on City administrative bodies, companies and institutions. The mZIPP mobile application serves as a database used by city administrative bodies, companies and institutions. It enables users to quickly and easily view spatial data on their current or selected location. This mobile geoportal also offers the possibility of viewing the locations of City institutions filtered according to subject matter (e.g. City Administration, Healthcare, Culture etc.) in a selected city area, which enables users to quickly access the basic data (category, contact, content etc.) on the units they are interested in. The Geoportal is the access point for the Zagreb Infrastructure for Spatial Data and was created in accordance with the Ordinance on creation, content and method of maintenance of the Zagreb infrastructure for spatial data and the Annual development plan for the informational system of physical planning of the City of Zagreb for 2011.

Sustainable urban mobility – Transport

The transport systems of the City of Zagreb, the Zagreb County and Krapina-Zagorje County have not been viewed as a whole in the existing development documents, which resulted in an uneven development of the transport infrastructure and an unintegrated management of the transport process. This has especially been true in the public transport area, which causes a large share of transport to be conducted by personal vehicles. Such a situation led to traffic congestion, road safety risks, noise and higher concentration of exhaust gas, as well as lower quality of life and competitiveness of economy.

The ***Integrated Passenger Transport in the City of Zagreb, Zagreb County and Krapina-Zagorje County Area*** project is being carried out with the purpose of establishing an integrated transport service in the public urban and suburban transport with a single tariff charging system, which will significantly improve the public passenger transport service. By implementing the integrated passenger transport system, the public transport will become more popular, which will result in a higher share of passengers utilising it, achieving thereby the goal of increasing population mobility in the wider Zagreb area, urban as well as suburban. The ultimate goal of the project is not only to achieve the mentioned higher share of public transport passengers and the increased population mobility, but also to generate acceptable effects in terms of energy, economy and the environment, in addition to achieving an organisational and infrastructural system integration with a special stress on the public transport. The ***Automatic Traffic Management System of the City of Zagreb*** project is also being carried out with the purpose of developing and upgrading the existing traffic management signal system and implementing a modern automated traffic management system (Intelligent Transport System, ITS), which includes: modernisation of signal devices and equipment, installation of a traffic guiding system and a video surveillance system, prioritisation of urban public passenger transport on intersections with traffic lights, equipping the control centre with modern ITS equipment and connecting devices with the control centre and installation of a garage and parking guiding system.

By completing phase one of the Master Plan for the City of Zagreb and the Zagreb and Krapina-Zagorje Counties Transport System, the possibilities will be defined for the improvement of the transport system of that area with the purpose of achieving a viable system in terms of energy consumption and environmental impact, wherein special stress will be put on advancing the public transport, improving traffic connectivity and increasing

population mobility in a way that generates acceptable effects in terms of energy, economy and the environment, in addition to achieving an organisational and infrastructural system integration, as well as increasing traffic safety.

The public transport offer in the "tri-county" area is divided into railroad, bus and tram subsystems. Single companies operate in the railroad and tram subsystem – HŽ Putnički prijevoz and ZET, respectively. The Zagrebački električni tramvaj d.o.o. – ZET company conducts passenger transport in the City of Zagreb and part of the Zagreb County area. Passenger transport is conducted by buses, trams and a funicular, as well as by specially customised vehicles. ZET is currently offering 143 regular bus lines, with a total of 408 buses (of five different manufacturers). Out of the 272 trams (four manufacturers), 142 (51%) are the new, low-floor Končar trams.

ZET utilises an advanced ICT ticket charging solution which uses open interfaces and standardised data formats. A new transport service charge system that uses contactless smart cards and prompts user login and logout when entering and exiting the vehicle, which also applies to stopovers, was implemented in 2009.

HŽ Putnički prijevoz is the only stakeholder in the area that provides organised railroad passenger transport. The regional and local railroad lines cater to the transportation needs of the population of the tri-county area. The HŽ Putnički prijevoz tariff system is based on the distance coefficient – the larger the distance between the travel starting and ending point, the higher the price. However, the system also offers a wide range of discounts. An entirely new technical solution for the charging system is being implemented.

During the drafting of the concept design, the new passenger transport charging system (ISPRO) was partially implemented on 6 September 2016. ISPRO is an integrated transport service charging solution which supports various types and modalities of tickets and sales channels. The system is based on the standard software components and enables data exchange with other systems and subsystems via standardised data formats.

The contemporary Zagreb road network consists of 2,500 km of roads – 72% of which are unclassified – that are maintained by the Zagrebačke ceste branch of Zagrebački holding d.o.o. The number of intersections with traffic lights in Zagreb is linearly increasing, whereas the number of vehicles is fluctuating, from an extensive increase between 1995 and 2008, to a sudden decrease and recovery in the past three years. In June 2016, the City had 447 signal devices in its possession, 426 of which were traffic lights, 14 were blinkers, 7 were customisable light signals and 2 were traffic counters. Around 50% of traffic lights operate in some type of a traffic-dependent mode, while 60% of traffic lights are integrated with some synchronised corridor system. The average age of the devices exceeds 12 years.

360 devices are based on IT technology, 318 of which are in compliance with the current Croatian (ISO) standards. 66 devices are based on contact (relay) technology. 55% of sensors monitor vehicles (48% based on the induction loop technology; 7% based on video technology) and 45% of sensors have to do with pedestrian call buttons.

Zagrebačke ceste utilise four more ITS services. Surveillance of some traffic lights (17%, for now) is being conducted via GSM and Internet service. The Winter Service fleet management enables efficient functioning and monitoring of vehicles. The meteorological system, with its 16 meteo stations, supports the operations of the Winter Service. An

interactive map of road construction sites with short descriptions and estimated deadlines can be found on the Zagrebačke ceste website.

The existing municipal services and traffic monitoring sector utilises a video system covering 163 locations with 516 cameras – the installation facing the western inlet of the Vukovarska-Heinzelova intersection is shown. A traffic counting system utilising video analysis cameras has been implemented at 38 locations. A vehicle counting system, which is able to group the vehicles into types and calculate the travel time (individual, average, total) for a selected section was implemented on the Ulica kneza Branimira – Dubrava – Zagrebačka cesta and the Zagrebačka cesta – Bistrička ulica stretches. Zagrebačke ceste is also utilising that feature for both road vehicles and trams, as is exemplified in the traffic counting system overseeing the western inlet of the Maksimirska – Bukovačka intersection. A service enabling access to images of the critical intersections, aimed at the public, for traffic information purposes, was implemented within the scope of the project of video surveillance of the City.

The Zagrebparking branch oversees the parking facilities. More than 35 thousand parking spaces are covered with the m-parking service, making the City of Zagreb one of the leading cities in the world in that aspect. Several public parking garages, 7 of which are owned by Zagrebparking, with 2,407 parking spaces can be found in the City.

The statistics of the Zagreb Fire Department, which have been systematically recorded since 2012, indicate an average of eight interventions per day. Especially active is the Centre Fire Station with its prevention and responsibility activities, as well as through interventions in which it assists other fire stations.
In 84% of cases, response time is 10 minutes or shorter.

Traffic safety statistics position Zagreb within the scope of the EU objectives since the number of deaths per 100,000 inhabitants is less than three.

Environment protection and combating climate change

The two main sectors for energy consumption management and management of consequential negative effects on the environment, which were outlined in the City of Zagreb's Sustainable Energy Action Plan, are building management and transport. For many years now, the City of Zagreb has been subsidising the procurement and installation of renewable energy source systems for its citizens, via public tenders, which has resulted in over 250 systems that generate estimated energy savings of approximately 1.5 GWh annually.

The consumption of energy sources and water for approximately 930 buildings owned by the City of Zagreb is monitored via the ***Energy Information System*** (EIS), which provides the data for status analyses and the basis for the specific measures aimed at improving energy efficiency by conducting energy efficiency renovations of buildings. The EIS also serves the purpose of generating buildings' energy status models (registry of certificates and suggested measures for renovation, methods of utilisation and procurement of energy, status of renewable energy sources etc.) in a specific period, which enables efficient planning and estimations and optimisation of measures and investments. The energy consumption for nearly a hundred buildings is monitored via IoT (Internet of Things) systems, which provide

the buildings' actual energy consumption and production data, through interfaces open to different producers. The implementation of measures is planned to continue since the potential for improvement is large. 87 buildings intended for public use and part of the public lighting system are being renovated as part of the ***ZagEE – Zagreb Energy Efficient City*** project, which was initiated in 2013 and co-funded by the European Commission, as part of the Intelligent Energy Europe programme. The renovations are estimated to result in energy savings of almost 34 GWh annually.

District heating

HEP-Toplinarstvo d.o.o. conducts the activities of production, distribution and supply of heat energy and the activity of buying the heat energy for the end-users in the Zagreb, Osijek, Sisak, Velika Gorica, Samobor and Zaprešić areas, in addition to being the largest producer of heat energy in Zagreb.

HEP-Toplinarstvo d.o.o. is carrying out an array of projects aimed at establishing the Advanced System for Centralised Remote Substation Readings. Over 600 heat energy meters are integrated with the remote readings system via GPRS technology. A test system for the centralised remote substations readings which enables a periodical collection of readings data and an automated synchronisation with the charging system and the system for meter replacement has been devised. The existing test system's functionalities can be expanded with features for management of heat substation parameters and service quality improvement via remote monitoring of heat energy consumption, system pressure and temperature or via pump function optimisation and integration with heat cost allocators. The above-mentioned represents a foundation on which the complete digitalisation of the main part of business operations can be conducted, as well as a basis for numerous savings.

HEP-Toplinarstvo d.o.o. is in the final stages of the preparation of the Zagreb hot water supply network revitalisation project, which plans a revitalization of 78.7 km of pipes over 30 years old, that frequently leak and require frequent repairs. Co-funding by the European Structural and Investment Funds will allow for the old pipes to be replaced with new, technologically more advanced ones, which is the fundamental prerequisite for the informatisation of the central heating system.

Smart electricity networks

Several projects aimed at advanced management of the electrical energy system, enabling of savings and improvement of service quality are being carried out in order to accommodate the needs of the processes of production, transmission, distribution and supply of electric energy.

- **HEP-Proizvodnja** (Production): a remote reading system, which will complete the centralised system for monitoring and production of electric energy, is being implemented. The system has already been implemented in the production areas North and South, and is being implemented in the West. The central system will encompass both the thermal (TE-TO) and cogeneration (EL-TO) power stations in Zagreb.
- **HOPS (Croatian Transmission System Operator):** all the meters are read remotely during transmission and are encompassed by the central system. A strict safety policy does not allow direct data exchange with other stakeholders (producers, distributers etc.) but their meters can be accessed via separate communication channels and under

strictly controlled conditions.

- **HEP-ODS (Distribution System Operator):** within the scope of distribution, regular procurement of advanced meters that provide readings for tens of thousands business users and a smaller number of households is conducted. Feasibility studies for mass installation have been carried out, with positive results. Software for remote readings has been purchased, technology has been selected and the tenders for the procurement of the advanced meters are being carried out.
- **HEP-Opskrba** (Supply): market liberalisation has attracted other suppliers (RWE, Geni etc.) that are eager to access advanced measuring devices, which is currently being realised in the meters area.

The City of Zagreb can alleviate such demand by participating as buyer and strategic partner in the drafting of development strategies and plans for projects carried out by Elektra Zagreb, HEP-ODS, HEP-Proizvodnja, TE-TO, EL-TO, HEP-ESCO and others. The City of Zagreb can involve various stakeholders in these projects, such as Zagrebački holding d.o.o, REGEA, ZICER, the University, institutes and even the private sector, in order to jointly develop smart solutions for the citizens, industry and entrepreneurial sector, public sector, transport, lighting, building management and the utilities sector.

Zagrebački holding and ZET – smart solutions

An array of Zagrebački holding d.o.o. and Zagrebački holding group of branches and companies have been carrying out numerous projects and activities aimed at smart solutions and devices implementation in the last several years.

The ***Čistoća*** branch started the implementation of an energy efficiency system in 2011 by monitoring water, electric energy and heat energy consumption. The consumption monitoring indicated that, by implementing meters that can be remotely read and with timely interventions, 2,400 m^3 of water is saved every month. Devices that enable remote monitoring of boiler rooms and the gas station connected to the branch, that is, fuel consumption, and fleet management of the vehicles intended for activities of utility services were also implemented. ICT and smart solutions utilisation plans for the Čistoća branch in the next ten years include:

- Remote monitoring of remaining container capacity;
- Mapping waste collection routes on the basis of remaining container capacity and traffic density data;
- Smart charging of waste collection based on the amount of waste;
- Utilisation of electric vehicles;
- Utilisation of the collected waste as energy source, as part of sustainable waste management (bio-waste, mass timber, waste timber etc.).

Main objectives for 2030 include implementation of a circular economy and priority ranking based waste management system, utilisation of innovative and advanced technologies, a 20% reduction of total amount of waste, a 65% success rate of recycling and a 35% reduction of CO_2 emissions generated by the waste management and transport systems. Another challenging objective has to do with the system of public buildings management based on circular economy and utilisation of technologies with the purpose of achieving better usage, spatial and cost efficiency of public buildings throughout their service life. This system is aligned with the waste management and recycling systems, especially with regards to disposing of the buildings at

the end of their service life.

The ***Zagrebparking*** branch has been systematically striving for optimisation of business processes by investing in modern technologies that assist with the branch's principal operations, as well as in development of the projects based on the utilisation of ICT. The more prominent solutions include:

- Investing in the public garage automatisation system ;
- Opening new sales channels (e.g. web-shop, application, new retail points of sale);
- Project of cooperation with the traffic and utilities overseeing service;
- Parking machines (e-kiosks).

The implementation of the public garage automatisation system will enable a centralised management of the garages, via a single dispatch unit, as well as new services (single card for all the garages, selling other related services – possibility of cooperation with other branches and companies aimed at developing and selling new services, primarily through ZET). Web-shop and retail points of sale (e.g. iNovine) make the purchase of the service easier and the service itself more accessible for the end-users. The concept of the project of cooperation with the utilities overseeing service was designed in a way that enables utilisation of technology of both branches involved in the process of determining a violation. Therefore, the main idea is system integration, which results in increasing the efficiency of all involved services.

The new parking machines will be connected to the central server application, which should enable real-time monitoring and control. Thanks to real-time data, preventive action will be possible in case an alarm is activated. The new system, that is, the machines, will enable purchasing of several parking items, such as hourly/multihourly tickets and commercial parking tickets (KPK), as well as extension of privileged parking tickets (PPK) and daily parking ticket (DPK) payment orders via integrated keyboards. The new system will also be scalable, with the possibility of being used for providing and charging additional services in the future, such as: electric vehicles charging, purchase of tickets of different sorts (public transport, theatre, museum etc.); and for marketing as an additional source of revenue.

Vodoopskrba i odvodnja d.o.o. has carried out several projects aimed at remote reading of water consumption and cost reduction, from the centralised Water Leakage Management system, which monitors the water flow in over 60 of the main pipelines, through the monitoring systems for the consumption of business users and residential buildings, implemented at approximately 60 locations in the City, to the control water meters in several residential buildings in Slava Raškaj Street and Božidar Magovac Street. Remote readings cover more than 50% of water consumption in the Knežija city district, with other locations undergoing implementation. An advanced, secure, wide-reach and low consumption IoT wireless network based on modern RPMA technology was implemented to satisfy the needs of remote reading of meter data. The estimated duration of the implementation of the system for the remote reading of water meters in the entire City of Zagreb area, for which grants from EU funds are expected to be utilised, is 7 to 10 years. The smart solution of the system for the remote reading of water meters consists of the following elements:

- Smart water meters (readings);
- System for collection of data on performed readings and transmission of data to the server;
- Application for data processing and management;
- Application for automated invoicing.

Such a solution provides several advantages compared to the existing one, such as better customer relations (complaints), water supply system management (active approach) and early indication and prevention of water leakage. The water supply remote readings system is integrated with the charging system, whereas the integration with other systems is being planned. Pilot projects have proved the benefits of the advanced IEEE 802.15.4 network on a local level for covering difficultly accessible areas (manholes etc.). Also tested were the M-bus, Wireless M-bus and LoRa technologies.

Zagrebački holding also strives to provide a quality and reliable public service in accordance with the corporate sustainability principles, taking special notice of the social, economic and environmental impact on its business operations. Having the community in which it operates in mind, Zagrebački holding undertakes environment protection measures in all segments of its operations and invests significant resources into risk reduction and improvement of technological processes, which offer better solutions and smaller negative impact on the environment. In addition to caring about the environment by utilising environment-friendly technology, as well as through efficient usage of natural resources and through energy production from landfill gas, the projects aimed at improving the communication with end-users of services, conducted through the Customer Centre, should also be mentioned, as well as should the establishment and upgrading of the Call Centre. *The Zagrebački holding Call Centre* is the focal point of digital communication with the users of theZagrebački holding services and the citizens of Zagreb. It was established in 2015 by integrating the phone communication with a single platform which is available 24 hours a day. The Call Centre has been integrated with operative services of the branches and dependent companies since its beginnings. In that way, the pertinent public transport, traffic and utilities infrastructure, energy activities and information on other services was consolidated.

Continuous work is also being done on advancing e-services with the ultimate goal of establishing a single e-Platform that would become the focal point of communication with users via several digital communication channels. In 2017, Zagrebački holding launched a new service website for citizens (sada.zgh.hr) which contains all the current information on the Zagrebački holding services , available in real-time. The service website is also equipped with tools for direct communication with the Call Centre agents and online communication, which makes this website an additional platform for communication with the users of the services of Zagrebački holding, which is implementing more and more 24-hour channels for communication with citizens. Users can ask questions via WhatsApp, Viber, chat and Messenger and follow service information on all social networks. The digital platform also enables file exchange, so, in addition to asking questions and receiving answers, the communication channel also serves for document exchange. Therefore, citizens are no longer required to physically come to one of the branches in order to generate a request or check its status, save for those cases where personal identification and verification are legally required. Links to the Gradska groblja (search engine for deceased persons) and Zagrebparking (parking ticket purchasing portal) branches' websites have also been added. The mobile application also encompasses the Moj ZG info content, under which Zagrebački holding posts service information and breaking notifications in real-time, for which users are notified on their mobile devices. Social network sites related to Zagrebački holding are continuously updated with daily news, utility and maintenance services information and Zagrebački holding developments. In accordance with the new communication standards, the recognisable pictograms are used in informing the users in order for them to develop a consistent visual link with Zagrebački holding.

Zagrebački holding is actively engaged in upgrading the functionalities of the *Moj Zagreb* application, which is the City's online service that allows the citizens to report irregularities regarding utility services to which the City and Zagrebački holding promptly react jointly. The applications' functionalities were upgraded in 2017, when links were added to the online services of Zagrebački holding for gas meter status submission via login into the *mojRačun* service of Gradska plinara Zagreb – Opskrba d.o.o, and into the Moj ViO service of Vodoopskrba i odvodnja d.o.o, as well as into the utility services information system of Zagrebački holding on the e-Citizens portal. The users of utility services have had the possibility to check their consumption, calculations and outstanding obligations online through three independent systems - the MOJ VIO online application of Vodoopskrba i odvodnja d.o.o, the MOJ RAČUN online and mobile applications of Gradska plinara Zagreb – Opskrba d.o.o and the system for the delivery of a single Zagrebački holding payment slip into the *mPretinac* (mInbox) of the e-Citizens portal. The Zagrebački Holding Mobile Office should also be mentioned. The specialised vehicle makes services more accessible for the users since they can utilise all the services in one spot. A schedule, available at the Zagrebački holding website, is set up in advance for the Mobile Office's destinations in various city districts.

Zagrebački holding also has at its disposal the ISGE system for energy management, which is a computer application used for monitoring and analysing energy consumption in the Zagrebački holding buildings. General, structural and energy data on the direct energy and/or water consumption for each building is entered into the app, which can be upgraded with a system for remote monitoring of the energy sources consumption.

Gradska plinara Zagreb d.o.o. conducts the regulated energy activity of natural gas distribution in the areas of the cities of Zagreb, Zaprešić and Velika Gorica and the municipalities of Brdovec, Pušća, Marija Gorica and Dubravica, as the operator of the gas distribution system with approximately 280,000 meter locations, approximately 38,500 of which are equipped with some type of walk-by or system for remote reading of gas consumption data. In accordance with the Croatian Energy Regulatory Agency (HERA) decision, the GPZ has provided its large-scale customers (those that use over 10GWh of gas annually), as well as other customers that find it necessary, with meters for monitoring gas consumption on an hourly basis. 130 such meter locations have been equipped with meters for hourly monitoring of gas consumption on the basis of GPRS technology, which enables the GPZ to monitor, on an hourly basis, from 12% of the total gas consumption in its distribution area in the winter to 42% in the summer period. Plans have been made to raise the number of meter locations equipped with such a system to approximately 250 of the large-scale customers, which would enable the GPZ to monitor over 50% of the total gas consumption on an hourly basis.

The GPZ is continuously upgrading other customers' meters in order to be able to remotely read consumption data. Approximately 35,000 devices have been equipped with a radio module (mostly based on the OMS Wireless M-bus technology, in accordance with the HRN EN 13757-4 normative document) that enables drive-by or walk-by readings, effectively eliminating the need for the customer to enable attendants access to the meter in the condo-converted area of the property owner.

The GPZ has also carried out several pilot projects aimed at installing and testing smart meters:

- *Jarun Pilot Project* – the possibility of reading gas consumption data for those customers whose meters are equipped with radio modules was realised by installing stationary receivers for radio module readings. Locations include the Sky Office Tower and the Zagrepčanka skyscraper, with a planned location in the Lanište neighbourhood. Activities performed:
  - Installation of receivers with the supporting equipment for proper functioning on selected locations;
  - Establishment of a network connection with computer servers which will run the application for monitoring the hourly readings of gas meters in the area in question;
  - Establishment of computer servers with applications which will provide access to the hourly readings data for the GPZ.

  By testing only the two mentioned locations with polarised antennae, the partner responsible for such testing has, according to its most recent report, determined signal reception, that is, reception of the information regarding the hourly consumption from 60% of the meter locations equipped with radio modules (communication protocol, OMS, PRIOS, wM-bus).

- *The Dubrava – LoRa Pilot Project* was launched in October 2016 with the purpose of testing the information on the functionality of the LoRa radiocommunication technology, which has been extensively expanding in the last several years. By analysing the results of gas meter readings based on the LoRa module, the conclusion was reached that the LoRa technology could be utilised in the GPZ distribution area, with the recommendation of comparing the results with other technologies in use in Zagreb or new technologies in the making.
- The testing of microthermal gas meters is being carried out, whereas the testing of next generation ultrasonic and diaphragm gas meters that fall under the smart meter category is being prepared. Regardless of the metering technology, all of the types, in addition to the metering device, contain in their casings a stop valve and a GPRS module through which the operator receives hourly consumption data for the previous day (24 pieces of information), once daily. The modules also enable shutting off the service from the operator's headquarters without having to physically arrive at the location of the gas meter. Due to the increase of the offer of smart meters, which are based on GPRS technology and the price of which is competitive in comparison with the "regular" meters, in the gas meter market, European gas distribution system operators have been abandoning the walk-by and drive-by gas consumption readings and have been turning to telecom providers for the transmission of the gas consumption data, that is, they have been abandoning the idea of development of their own infrastructure of base stations for such data transmission.
- HERA has started preparing a single programme of measures for the implementation of advanced meters for end-users in the autumn of 2017, on the basis of Article 38 of the Energy Act, which can be construed as intent to comply with Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, which, in Article 3, among other things, dictates the optimisation of gas consumption through implementation of intelligent metering systems or advanced networks, which is why further GPZ activities will be coordinated with the regulatory body.

Zagrebački električni tramvaj – ZET d.o.o. (not a part of Zagrebački holding, but operating as a separate company since December 2017) implemented a system for traffic surveillance

and management and for informing passengers in 2007. The existing system is being replaced with a new one, which is based on a quality, uninterrupted real-time communication between the Traffic Centre (system's central units) and vehicles in traffic. The new system will increase the information availability in vehicles, at stations and via several web applications and mobile applications for the end-users of the transport service. The Traffic Centre will, at all times, have at its disposal information on all the active vehicles, such as basic info on the vehicle and the driver, the current location of the vehicle, all of the parameters having to do with the timetable (position along the line route, info on arriving early / late etc.) and the possibility of a two-way voice (video) and textual communication with certain vehicles (drivers), as well as groups of vehicles (e.g. all the vehicles operating on a single line or all tram vehicles).

The new system will provide the prerequisites for transmitting voice, textual or video notifications to the passengers in vehicles and at stations, as well as via several mobile apps. The vehicles will receive the necessary information in real-time, regardless of their location. The collected vehicle data will be processed in central units to allow the review of the performance of planned activities for all of the available and required timetable parameters, statistical and other indicators, which are adjusted or changed, and serve the purpose of conducting different analyses and reports and are sent back to the vehicles after being processed. In addition to voice and textual communication, Traffic Centre operators will have at their disposal an array of programme features that will enable them to affect the traffic conditions. This especially has to do with the diverse programme features that enable notifications and warnings about certain discrepancies that affect the timetable to be sent to the drivers, e.g. departure times discrepancies, early or late departures or info on discrepancies regarding a specific location along the route. It will also be possible to warn drivers about speed limits on every part of the line route. A possibility of managing connections, that is, stopovers with other vehicles or means of transport, also exists.

The main elements of the new system for traffic surveillance and management are the following:

- Info-display in vehicles intended for informing the passengers during the ride about: the line route along which the vehicle is moving and the current vehicle location on the route, the next stop (with remaining distance info and the remaining time in minutes), info on stopovers (lines that pass the next station or on possible other means of transport that connect with the current one, e.g. switching from a tram line to a connected bus line) and info on a passenger's required exit station;
- Info-displays on the stations/terminals, which will display visual and audio content to passengers regarding the time until arrival/departure of individual lines, capacity of the arriving vehicles, features of the arriving vehicle (low-floor, customised for people with disabilities, etc.), info on traffic conditions and other information and advertising content;
- Plans have been made for station machines, which will enable purchasing individual tickets, topping off stored-value cards, transaction monitoring and other functionalities via constant connection with the central system, to be installed at certain stations (with the total number of those machines breaching 2,600);
- A modularly designed smartphone application for citizens with a wide array of functionalities, such as: user account access via the mojzet.hr portal, control of funds and transfer of funds to the account, coupon purchase, real-time timetable info and info on emergency and extraordinary situations, route planning etc;
- Internet access for passengers via WiFi in all vehicles.

4. Zagreb Smart City Vision for the period up to 2030 – goals and strategic areas

A smart City of Zagreb should strive to achieve the following three goals:

1. Sustainable development;
2. Better quality of life for the citizens;
3. Improved efficiency of the City as a system (to be achieved by increasing the efficiency of the existing and the future infrastructure, which is accomplished by integrating its various components, services and users).

Sustainability, efficiency and high quality of life are to be achieved through six dimensions (fields of action), that is, specific aspects of the city. These dimensions are permeated by smart initiatives, through which the goals of smart city strategies are accomplished. A smart initiative or a smart project becomes *even smarter* as the number of fields of action increases, six of which are of key importance: smart management, economy, mobility, environment, life and people. This classification, consisting of *six pillars* on which a smart city stands, appears most frequently in expert literature, while some works introduce other fields, as well (e.g. smart healthcare, education, energy, safety, existing infrastructure and buildings). These fields can, however, be encompassed within the above-mentioned key fields, i.e. dimensions. Technology is not a field of action *per se*, but rather, it makes projects more efficient. Although ICT infrastructure and utilisation of ICT are quite important factors, they merely provide prerequisites for accomplishing the goals. A smart city strategy is worthless without real commitment and readiness for cooperation between institutions, the private sector and the citizens[20].

Fields of action within each dimension could be defined narrowly and broadly, with or without specific smart initiatives/projects outlined (according to e.g. ASCIMER Smart City Projects Assessment Guidebook[21]). In other words, project areas, within which project activities with specific initiatives/projects can be determined, are defined for each dimension.

Further development and sustainability of the City of Zagreb will be accomplished by combining new technologies, primarily ICT and the integrated platforms of the City of Zagreb, modern infrastructure and new designs of digital services, in accordance with citizens' and economic operators' needs and by integrating smart electricity networks, Internet, mobile networks and networked (smart) devices. Synergy between video surveillance security systems and traffic surveillance and traffic analytics system is especially crucial, since it has the potential to yield multi-faceted positive results regarding traffic flow, transport demand management (aimed at increasing road traffic safety), congestion reduction and the reduction of pollution stemming from harmful gas emissions.

The vision of the City of Zagreb for 2030 is that of a European metropolis, a regional leader in the Southeast Europe able to measure up to the grandest cities in Europe. Digitalisation of

[20]Nam, T, Pardo, T.A. *Conceptualizing Smart City with Dimensions of Technology, People, and Institutions. Proceedings of the 12th Annual International Conference on Digital Government Research, 2011.* Available at: https://inta-aivn.org/images/cc/Urbanism/background%20documents/dgo_2011_smartcity.pdf

[21]*Smart cities: Best practice guide& Case studies, ASCIMER project – Assessing Smart City Initiatives for the Mediterranean Region, 2015.*Available at: http://www.eiburs-ascimer.transyt-projects.com/images/files/best_practices_guide.pdf

overall business and citizen cooperation will ensure an enviable level of quality of life and numerous savings, as well as entirely new business and economic growth models which ensure a high standard of living for the citizens. By implementing this Framework Strategy's measures and activities, the City of Zagreb will gain the reputation of a regional digital innovation centre with:

- Highly educated staff;
- Positive investment climate and organised infrastructure;
- Enviable business culture;
- Development platforms which provide room for innovations and progress;
- High availability of open data and powerful mechanisms for the security and protection of such data.

Every citizen and economic operator will receive their own digital identity which will be completely integrated with the European service provision system, that is, with the e-Citizens system, meaning that everyone staying or living in Zagreb, whether a business user or a tourist, will remain on their digital home turf.

One of the basic smart city attributes is citizen involvement and participation at all decision-making levels (from strategic big picture decisions to the day-to-day ones). For citizens to be actively involved, data from all important areas of life in the City of Zagreb (transport, healthcare, infrastructure, economy etc.) should be widely available, logically organised, easily searched, open and transparent. This precondition also enables and encourages development of smart applications (primarily smartphone apps) by companies and entrepreneurs.

The transformation into the Smart City of Zagreb will affect technological innovations, smart transport, energy efficiency, i.e. reduction in resource consumption, citizens' and workers' lives and companies via numerous changes related to, e.g, teleworking, e-democracy and increased transparency, in addition to enabling stronger involvement in decision-making processes.

In order to accomplish the vision, the following six strategic areas have been defined within the scope of this Framework Strategy:

1) Digital infrastructure;
2) Efficient, transparent and smart city administration;
3) Smart energy and utility services management;
4) Education;
5) Economy;
6) Sustainable urban mobility.

The following table contains the classification of the above-mentioned areas in the context of the six smart city pillars, i.e. fields of action.

Each strategic area, its context, challenges, desired effects and priority measures aimed at achieving goals are then further described. The following chapter contains detailed descriptions of every measure, including specific goals and activities, implementation challenges, possible sources of financing, key stakeholders and implementation dynamics.

Table 4.1 Classification of the Zagreb Smart City strategic areas according to the six fields of action

Field 1: Smart living			
Area	**Description/definition**	**Activity**	**Initiative**
Digital infrastructure	In order for the smart city concept to be realised, a strong, highly accessible and future-proof digital infrastructure is an essential prerequisite, since it is the foundation of every advanced smart service of today and of the future. Utilities infrastructure management is among the key service activities aimed at the clients, both citizens and economic operators. The utilities infrastructure directly affects the quality of life of citizens in every neighbourhood.	• Smart City platform of the City of Zagreb; • Integrated Geographic Information System; • Gigabit broadband user infrastructure; • Sensorial narrowband infrastructure.	• Data aggregation platform supporting real-time data exchange is the basis for status monitoring and analysis of a wide array of infrastructural systems, that is, for defining and providing a wide array of services; • Establishment of the system and creation of application solutions for data collection and dissemination for the stakeholders and end-users (administration, public companies and institutions, industry, citizens); • Integration of all elements of the city's transport system, dynamic overview of the traffic network's load, elements of the city's utilities and energy infrastructure and of data on issued permits, accompanied by diagrams of planned spatial interventions in the integral Geo information system; • Establishment of a quality city broadband infrastructure is a vital prerequisite for performance of services, carrying out of smart city solutions and improving the quality of life.
Field 2: Smart management			
Area	**Description/definition**	**Activity**	**Initiative**
Efficient, transparent and smart city administration	Citizen involvement in decision-making on important city matters and individual city district issues; provision of all the pertinent information and key indicators for the decision-making process via various media and modes of informing.	• Expediting the development of digital public services, increasing digital technology competencies and involving citizens; • Managing the interoperability of the City's electronic services, in accordance with the development of interoperability on the level of the	• E-democracy and e-participation, participation tools (Wiki, online social networks, blogs), electronic voting, reputation systems, online petitions, complaints and requests, cooperative service creation (e.g. participative budgeting enabled by ICT); • Transparency tools (social transparency mechanisms), monitoring and analysis: open data, digital tracing, deep data

	Developing an encouraging business environment for private companies via various forms of public-private partnership, through utilisation of advanced technologies which remove the administrative and bureaucratic hindrances to business operations and through providing publicly available information and data that can help develop innovative applications and solutions for citizens and entrepreneurs.	Republic of Croatia and the EU; • Analysing and elaborating operational processes and establishing a suitable organisational structure with the purpose of integral management of the implementation and coordination of processes and activities; • Generating reference architecture and standardising the technological platform; • Encouraging the innovation culture among the city administration employees and citizens via broader involvement in the processes of creation of new digital public services; • Development of a local infrastructure for spatial data – ZIPP; • Continuous improvement of the quality of city services and research into further improvements in accordance with the international ISO standards.	analysis, data visualisation, simulations, municipal transparency, interactive GIS city maps, social and city services information (open data on the performance of city services, visually available to all citizens, public sector information portals); • E-city districts, online public and social services (information and procedures), social network presence of city district councils, integrated platforms for public and social services, data exchange between public services, smart judiciary and administration (e.g. the e-card system for accessing city services); • Policies and measures strengthening smart city initiatives on different levels, platforms connecting different services, measures ensuring programmes for strengthening smart city initiatives nationally.
Field 3: Smart surroundings			
Area	**Description/definition**	**Activity**	**Initiative**
Smart energy and utility services management	A complete energy solution for smart cities and regions with high percentage of urban population and a large share of information and communication technology (ICT) in use. Various networks that mutually make up the basic infrastructure for the supply of energy, water and other goods	• Smart electricity networks; • Smart lighting; • Smart heat energy networks; • Smart gas networks; • Smart water supply and drainage; • Integration of smart buildings and infrastructure.	• Installation of smart meters and control devices on the high, middle and low voltage levels of the electricity network; • Networked smart lighting system, which supports two-way communication and cloud computing control, in addition to the possibility of digital monitoring of the lighting system service life , including maintenance; • Networked smart systems for

	and services vital for everyday life, such as electricity, lighting, heat, gas, telecom, water, road, railroad, tram, traffic and other networks. A smart energy system integrates all networks into a single entity with the help of ICT and coordinates their work in order to accomplish optimal solutions for individual sectors and users, as well as for the system as a whole.		heating and cooling for all categories of consumers; • Networked system for gas distribution and supply for all categories of end-users; • Interaction between the buildings of consumers (prosumers) and networks, aimed at stronger integration of renewable energy sources.
Field 4: Smart people			
Area	**Description/definition**	**Activity**	**Initiative**
Education	Digital education implies technology-aided learning methods, strengthening technology competencies in people and improving all levels of education and training (academic excellence, equal opportunities). Smart learning is a learning system which advises and guides users in learning in real world (environment). Educating citizens of all ages is vital for a systematic development, that is, a widespread implementation of smart solutions in the City of Zagreb area. A quality education received through the school system and lifelong learning, education which raises competitiveness at the open labour market, creates the preconditions for the	• Introduction of modern ICTs, smart devices and solutions into all primary and secondary schools in the City of Zagreb area ; • Organisation of regular competitions in development and application of smart solutions and tools for primary and secondary school students in the City of Zagreb area; • Organisation of regular courses and lectures for primary and secondary school teachers and of educational, informative and promotional activities (panels, seminars, workshops etc.) for all citizens of the City of Zagreb.	• Education programmes and centres for new technologies, Internet in schools, technological devices in schools and faculties, simplification and encouragement of lifelong learning, interactive boards, e-learning systems; • Organisation of competitions in the development and application of ICT solutions and tools; • Organisation of regular courses and lectures for primary and secondary school teachers needs to take place in cooperation with experts from leading companies involved in the development of smart solutions and information and communication technologies.

	development of creativity and innovations necessary for the development of the smart city concept.		
Field 5: Smart economy			
Area	**Description/definition**	**Activity**	**Initiative**
Economy	Creation of a complete and comprehensive environment which enables and encourages innovation and creation of new business models. Improving the quality of innovations in economic policies of the existing and new companies, entrepreneurs and workers; promoting skills and innovations on all levels in public and private sectors. Research, development and innovations establish partnerships between companies, research centres and institutions for higher education.	• Raising the level of entrepreneurial competences; • Use of financial instruments and alternative sources of financing for early stages of entrepreneurship; • Creation of a city platform for testing innovative solutions (Living Lab) and strengthening of creative innovative spaces (maker spaces).	• Developing entrepreneurial skills, entrepreneurial initiatives, innovative entrepreneurship and business management, R&D+ projects which partner the industry with research centres, encouragement of employment and investment in knowledge-powered sectors; • Living laboratories for user open innovations (cooperative and collaborative creating, research, experimenting and evaluation); • New business concepts applicable to the city.
Field 6: Smart mobility			
Area	**Description/definition**	**Activity**	**Initiative**
Sustainable urban mobility	A holistic approach to urban mobility that optimises demand and supply solutions, a proactive model which predicts future changes and trends and utilises the advantages of new solutions. Establishing a safe, environment-friendly and efficient traffic system, based on modern technologies.	• Increased attractiveness of public passenger transport in the urban agglomeration; • Improvement and development of traffic management system; • Improvement of bicycle and pedestrian traffic; • Use of innovative operative systems (primarily electromobility systems); • Use of innovative video analytical	• Introduction of a unique ticket system for integrated passenger transport, based on a unique contemporary ICT integrated transport system with a mobile application and contactless card (payment according to the actual number of kilometres/stops covered); • Introduction of a passenger informing system, route planning system and a public urban passenger transport video surveillance system; • Introduction of a system for dynamic informing on the

	Improvement of passenger experience and more precise calculation of journey duration and cost, for both physical persons and business users. Improvement of traffic analytics system in synergy with the City's video surveillance system, aimed at increasing traffic safety, decreasing traffic congestion and introducing advanced management of transport demand.	systems which support advanced traffic analytics and integration with an automated traffic management system.	availability of parking spots, a system for navigating towards available street and off-street parking spots, a system for remote reservation of and payment for parking spots (including charging stations for e-vehicles); • Integration of the parking payment system with the system of a unique ticket for public passenger transport in the city agglomeration (urban area); • Park&Ride systems (inhabitants which live in city peripheries or outside of the city can park their vehicles at tram terminals free of charge and continue their journey by public transport); • System and applicative solution for cyclists (information on cycle lanes, bike sharing, planning journey routes and duration, traffic, electrical vehicle charging stations, pollution etc.) within the public bicycle system; • Introduction of a system for automated traffic management, which would ensure complete integration with the City's video surveillance system, public transport, parking system, prioritising emergency services etc.

Strategic area no 1: Digital infrastructure

Context and challenges

In order for the smart city concept to be realised, a robust, highly accessible and future-proof digital infrastructure is an essential prerequisite, since it is the foundation of every advanced smart service of today and of the future. The early, concept planning phase requires taking the future into consideration, as well as all the aspects of the operating of a city in the 21st century.

Broadband networks are the backbone of the envisioned information society, as outlined in *A Digital Agenda for* Europe (*DAE*[22]). The DAE is a strategic framework for the development of digital technologies, aimed at accelerating economic growth in the EU Member States. It

[22] *Digital agenda for Europe*, available at: https://europa.eu/european-union/file/1497/download_en?token=KzfSz-CR

is an integral part of the Europe 2020 umbrella strategy, the purpose of which is to promote reforms and modernise the economies of the Member States, increase the capacities of the existing and create new institutions, improve the global competitiveness and create the conditions for performing activities suitable for a country's specific position. The DAE defines strategic goals and supporting measures aimed at increasing the availability of the advanced broadband infrastructure. The importance of the broadband network today can be compared with the importance of road, railroad and electricity network, making it a key component in everyday life and progress of the contemporary society.

The development, installation, maintenance and utilisation of the electronic communication infrastructure (ECI) is of importance for the Republic of Croatia (according to Article 3 of the Electronic Communications Act) and it should be planned with the purpose of advancing the economy and improving the quality of life, protecting the environment and health of the population, without hindering the development of electronic communications and market competition. Electronic and tele-communications are the foundations of today's society development and, with quality planning, the ultimate goal of broadband access for every user can be realised. ECI should be considered a utilities infrastructure, which is why same regulations can be applied, especially regarding the encouragement of integrated planning and construction.

The City of Zagreb has been continuously investing in expanding the capacities of access points for wireless broadband Internet with the purpose of making free wireless broadband Internet widely accessible. The system is currently implemented in the city centre, with expansion planned to squares, parks and means of public transport (trams and buses).

Utilities infrastructure management is among the key service activities aimed at clients, both citizens and economic operators. The utilities infrastructure directly affects the quality of life of citizens in every neighbourhood. In order to provide a quality service and accomplish customer satisfaction, as well as to efficiently manage the infrastructure, it is necessary to be acquainted with the exact three-dimensional positions of utility services and keep track of the existing and obsolete parts of the public infrastructure. In order to generate a quality operative cadastre of infrastructure, it is extremely important to improve the quality of the existing data (in most cases, a specific z-coordinate is missing, that is, the depth of the infrastructure), collect missing data and establish an information system accessible to all stakeholders. In doing that, it is necessary to coordinate all planned measures and activities with the legislation, primarily with the State Survey and Cadastre of Real Estates Act (Official Gazette no 112/18) and the Ordinance on Cadastre of Infrastructure (Official Gazette no 29/2017), as well as with the Cost Reduction Measures in Installing High Speed Electronic Communication Networks Act (Official Gazette no 121/16).

The criteria for the development and selection of specific measures and projects in this strategic area should be based on transparent criteria of cost efficiency and benefits for the community. These projects should be aimed at establishing an open system for collection and distribution of data on above-ground and underground utilities infrastructure, as basis for every project aimed at developing advanced digital infrastructure. This will enable a technologically and economically efficient construction of broadband and narrowband communication infrastructure that can satisfy the needs of both citizens (making it consumer oriented), and economic operators (making it technology oriented), including sensorial and analytical networks of the utility companies and city administration.

Special attention in carrying out these projects should be paid to the interoperability of various systems in use or those that are to be used (meters, sensors, scanners, wireless networks etc.). To optimally utilise the existing solutions, it is vital to enable data exchange between devices (e.g. sensors) and communication protocols, and not only between applications. Achievements in communication technologies, specific domain requests of individual stakeholders, as well as regulatory legislation, such as the Information Infrastructure Act, and directives such as the General Data Protection Regulation (GDPR) should be kept in mind during implementation.

Another vital feature is the drafting of a special strategy regarding usable blockchain technology, that is, the strategy that anticipates the possibilities of creating new systems and distributed applications that are based on blockchain technology. Blockchain technology has become the backbone of a new type of Internet, a new way of utilising a distributed platform, and the possibilities of application of such technologies in, for instance, contracting, protecting intellectual property, IoT etc. should be researched. The blockchain strategy should research the possibility of integration within the existing systems and the Croatian legislation, suggest several e-services of the City of Zagreb and its connected companies, based on the smart city vision, that would develop via blockchain technology, as well as present the cost-benefit analysis.

Goals and effects

The specific goal within this area is the development and upgrade of the existing digital infrastructure, that is, electronic communication infrastructure in the City of Zagreb area, with a special stress on the various systems' interoperability . When utilising blockchain technology, its effects should be studied so that its additional value could be determined.

The more general strategic goals and desired effects are the following:

- Continuous increase in availability of the advanced broadband infrastructure for all users (citizens, entrepreneurs, institutions etc.) in the City of Zagreb area;
- Continuous increase in the quality of utilities infrastructure management, accompanied by integration and synergy between smart electricity, lighting, heat, gas, water and other systems.

Priority measures

The priority measures for this area are the following:

a. The *Smart City* platform of the City of Zagreb should enable the collection, processing, storing and sharing of every relevant sector's data between the involved smart city stakeholders;
b. A multidimensional infrastructure cadastre which includes 360 degree centimetre-precision images of underground and above-ground infrastructure, interpretations and determination of property title over individual segments of the infrastructure, information updating process etc;
c. A gigabit broadband user infrastructure should encourage the implementation of advanced landline (FTTH, G.Fast, DOCSIS 3.1) and wireless (5G) broadband technologies, especially via ultrafast fiber-optic access networks, for the purpose of

quickly providing the infrastructural prerequisites for the realisation of the European Gigabit Society[23] and a robust, future-proof Zagreb Smart City platform;

d. A sensorial narrowband infrastructure will serve as foundation for sensorial infrastructure and applications that require long-lasting energy sources and transmit small amounts of information, such as traffic and parking sensors, air and water quality sensors, structural or seismic sensors etc.

Strategic area no 2: Smart public administration and citizen inclusion

Context and challenges

Smart cities require smart city administration, efficient and transparent, one which intensively utilises advanced information and communication technologies and encourages maximal involvement of citizens in the decision-making on important city matters and individual city district issues, as well as provides all relevant information and key indicators for the decision-making process via various media and information channels. Apart from being aimed at citizens, city administration activities should also be aimed at developing an encouraging business environment for private companies – from small- and medium-sized enterprises to large multinational corporations – via various forms of public-private partnership, through utilisation of advanced technologies which remove the administrative and bureaucratic hindrances to business operations and by providing information (which may be publicly available, subject to the data protection regulations) that can help develop innovative applications and solutions for citizens and entrepreneurs.

In the process of smart city creation, it is vital to set up new administrative structures and methods of cooperation/communication between various city offices, institutions and companies, as well as towards the citizens, all of which has to do with all the aspects of administration, meaning that a smart city administration provides its services to the citizens primarily on-line. It is impossible to imagine a modern administration which does not utilise modern information and communication technologies that expedite and simplify administrative processes, meaning that they save both time and money, in addition to being more transparent and simpler for the citizens. Smart services in this area are simple to use and find, as well as safe and certified thanks to the unified and standardised concepts. Information exchange between various city bodies is another vital feature, one that can be achieved by setting up interoperable data exchange buses, access to which must be secured by advanced digital identity checks.

Smart administration utilises technology and data potential, as well as efficient, internal innovation processes in all value chain segments. The smart city administration value chain is started by analysing perceived social issues, if possible, on the basis of established facts. The availability of large amounts of data and advanced analytical techniques, in addition to new types of digital democracy and active involvement, significantly increase the possibilities and potential of practical utilisation of the analyses' results . As a result of such a process, public policies become more efficient, primarily due to the relevance of the feedback and available alternatives in the early phases of policy drafting.

The most demanding challenges and preconditions for achieving the goals of this strategic

[23] European Commission – Digital Single Market policy *"Connectivity for a European Digital Society"*, https://ec.europa.eu/digital-single-market/en/policies/improving-connectivity-and-access

area are the following:

- Inadequate possibility of adjustment of the existing organisational structure, inadequate flexibility and the pace of adjustment to the dynamic conditions of the environment in which the city administration operates in order to provide the level of service that its users are expecting;
- Lack of transparency, standardisation and efficient communication leads to multiplication and overlap of activities, leaving information in silos, and making the decision-making and matter-resolving processes too long;
- Efficient coordination of strategic and operative goals with business processes and available resources is necessary;
- Improving the planning system and the system for monitoring city administration efficiency on the basis of key efficiency indicators;
- Planning and launching initiatives for the improvement of business processes and services;
- Providing timely access to information based on facts to the highest administrative structures for the purpose of improvement decision-making process efficiency;
- Raising the level of transparency and purposeful communication towards all stakeholders;
- Developing a service catalogue in compliance with legislation, as well as with sectoral strategic planning documents;
- Continuous staff training, depending on change management, and not exclusively on expertise, in order to adjust to the development of the system;
- Funding – the required investments aimed at development and implementation of smart utilities and applications which will accomplish the smart city administration goals, including the applications for collection and processing large amounts of data (the big data applications and solutions), are undoubtedly significant, which is why, in addition to investing the City's funds allocated in the City of Zagreb Budget, the grants from the European Structural and Investment Funds will have to be utilised, as well as other types of aid via various models of public-private partnership;
- Increasing citizen interest (e-Involvement) – one of the key preconditions for accomplishing the smart city administration goals is active involvement, especially in the decision-making processes on all levels, of key stakeholders – a large number of citizens, private companies and entrepreneurs, as well as all city administration employees. Citizens are the end-users of smart utilities and solutions, such as the already developed MojZagreb platform and e-forums in general, as well as e-consultations etc. The existing practice and experience in the City of Zagreb, as well as in cities of EU Member States, have shown that lack of citizen interest in involvement and participation is one of the main challenges. It is also necessary to develop an environment that encourages maximal involvement and proactive approach of entrepreneurs and national and private companies in view of developing new smart solutions and utilities, as well as involve city administration employees on all levels in order to increase the proficiency in command of digital technologies;
- Digital literacy – basic digital literacy is vital for efficient utilisation of advantages and possibilities offered by advanced information and communication technologies and utilities, but it is obvious that this poses an issue with some categories of the population (e.g. the elderly and pensioners, as well as the socially disadvantaged and the unemployed). Furthermore, in order to utilise the full potential of smart solutions and technologies, it is vital to continuously improve the level of digital literacy of city administration employees on all levels.

Goals and effects

The most important goals and effects in the smart city administration area are the following:

1) Expediting the development of public services for citizens and economic operators and increasing the level of their involvement

Numerous activities of the city administration often include several different offices, institutions and companies, which is why one of the main goals in the smart city administration area is to continuously increase the level of digitalisation by introducing modern information and communication technologies and connecting the operational processes of the city administration. Stronger digitalisation will result in better efficiency, decrease resource consumption (primarily human resources) and expedite the provision of services. The citizens, business sector, academic community and other interested stakeholders will directly feel the positive effects. In order to accomplish the goals and effects, the coordination and implementation of data standards and elaboration of procedures and operational processes are necessary, as is the establishment of a system of real-time monitoring and pinpointing key performance indicators for all areas, in accordance with the ISO 37120:2014 standard, i.e. with the ISO/TS 37151 technical specification, which will enable comparisons with other cities. This information should be constantly available to all citizens in order to achieve their maximum involvement.

2) Continuously raising the level of knowledge, abilities and innovativeness of the city administration and maintaining a high level of service quality and efficiency of investments in the projects of the smart City of Zagreb

Raising the level of knowledge, abilities and innovativeness of the city administration, improving customer experience, introducing new business models and improving business excellence will be constant guidelines for the development of city offices, institutions and companies. Developping the the city offices, institutions and companies' employees e-skills will be a continuous process within the scope of lifelong learning and the e-Learning programme. One of the city administration's key assignments is to provide support to and simplify the citizens' everyday activities. Filing of requests for permits, e-Schools and applications for reporting various utility service issues are just some examples of e-services. One of the ways in which the development of applications and e-services can be encouraged is through a comprehensive innovation process which would be deployed in all sectors and related to the entire infrastructure. All of the City's business and utility activities can be perceived as possessing the potential for innovation and as opportunities for the involvement of citizens and various organisations in the development of new e-services.

Priority measures

The priority measures aimed at achieving the goals are the following:

1) Expediting the development of digital public services, increasing the digital technology competencies and citizen involvement ;
2) Managing the interoperability of the City's electronic services, in accordance with

the development of interoperability on the Republic of Croatia and the EU level;
3) Analysing and elaborating operational processes and establishing a suitable organisational structure with the purpose of integrated management of the implementation and coordination of processes and activities;
4) Generating reference architecture and standardising the technological platform;
5) Encouraging the innovation culture among the city administration employees and citizens via broader involvement in the processes of creation of new digital public services;
6) Developing a local infrastructure for spatial data – ZIPP;
7) Continuous improvement of the quality of city services and research into further improvements in accordance with the international ISO standards.

Strategic area no 3: Smart energy and utility services management

Context and challenges

The energy area encompasses a very wide spectrum of activities, such as energy production and the supply of energy and energy sources, energy efficiency, utilisation of renewable energy sources and utilisation of traditional, i.e. fossil fuels. In order to achieve the ambitious energy efficiency goals and levels of utilisation of renewable energy sources in the Republic of Croatia, as well as in the whole of the EU, exceptionally large financial investments will be necessary, as well as smart solutions for better interaction between energy efficiency measures and installation of renewable energy sources. Such smart solutions will give optimal effects to financial investments.

The City of Zagreb has adopted strategic and implementation documents for energy efficiency and utilisation of renewable energy sources area (mentioned in the overview of the strategic documents in Chapter 2), which anticipate implementation of an array of measures and projects that require significant investments, such as energy efficiency renovations of buildings (residential, commercial and buildings intended for public use), installation of energy efficient lighting systems and installation of technologies for renewable energy sources usage. Therefore, this framework strategy, in the part related to the strategic area of smart energy management, anticipates activities that have not yet been covered by the existing strategic and implementation documents, i.e. activities aimed at establishing a smart energy system.

The *smart energy system* is being increasingly perceived as a complete energy solution for smart cities and regions with high percentage of urban population and a large share of information and communication technology (ICT) in usage. Urban areas of different purposes share the presence of various networks that mutually make up the basic infrastructure for the supply of energy, water and other goods and services vital for everyday life, such as electricity, lighting, heat, gas, telecom, water, road, railroad, tram, traffic and other networks.

A smart energy system integrates all networks into a single entity with the help of ICT, and coordinates their work in order to accomplish optimal solutions for individual sectors and users, as well as system as a whole.

The development of smart energy systems is taking place alongside the development of advanced markets of energy and energy sources, which is why it is vital to inform all the

stakeholders in a timely and transparent fashion, whether they are the producers, consumers or prosumers (end-users with their own production facilities), suppliers, distributors or market regulators. The main guidelines for the smart system development include reduction of energy consumption by implementing cost effective energy efficiency measures, increase in the share of renewable energy sources, integration of energy storage systems and digitalisation.

The criteria for the development and selection of specific measures and projects within this strategic area should be the time of return on investments and contribution to the security and quality of energy and water supply, with a minimal cost for the consumers. An exceptionally high level of technical suitability of the system should be achieved (taking the requests of different stakeholders into consideration) with the purpose of maximising the effect of greenhouse gas emissions reduction. Also, continuous monitoring and adjustment to climate change should be enabled, in addition to providing room for innovation to small- and middle-sized enterprises, academic community and the industry, all of which should be accompanied by an open dialogue with the public.

The most demanding challenge for the implementation is posed by an exceptionally large number of the key stakeholders that must be included, primarily companies dealing with the supply and distribution of energy and energy sources, most of which do not operate under direct influence of the City of Zagreb (primarily the companies of the HEP Group). Smart energy management implies an integrated approach to planning and energy management, with the challenge in this field being posed by the drafting of a framework which would enable the City of Zagreb to have maximum influence on the matter of integrated energy planning, since all energy efficiency goals, as well as the goals of utilisation of renewable energy sources and reduction of greenhouse gas emissions depend on it.

Goals and effects

The strategic goals in this area include creating a basis for the development of a smart energy system, primarily via installation of smart equipment in certain networks, laying the foundations of the future information and communication platform for the collection, processing and exchange of data, and calculating and pinpointing the necessary indicators. Establishment of a central communication platform presents a big challenge due to a wide array of regulations, the regulatory framework, as well as the mediocracy, which hinders many initiatives on various levels. In planning the above-mentioned activities, sectoral integration should be considered as a means of achieving synergy between smart electricity, lighting, heat, gas, water and other systems, which is also one of the goals, i.e. desired effects.

Priority measures

In order to simplify the preparation and implementation of these measures, i.e. projects, the measures for this strategic area have been grouped according to sectors, networks and the supporting infrastructure:

- **Smart electricity networks** –installation of smart meters and control devices is possible on the high, middle and low voltage levels, with the implementation of activities mostly falling under the authority of the companies within the scope of the HEP Group;

- **Smart lighting –** includes a networked smart lighting system, which supports two-way communication and cloud computing control, in addition to the possibility of digital monitoring of the lighting system service life , including maintenance. The lighting system should be integrated with other elements of the ICT infrastructure and with smart city sensors and field signalisation;
- **Smart heat networks** – include networked smart systems for heating and cooling for all categories of consumers (building management, industry and entrepreneurship, public sector, utilities sector etc.). HEP-Toplinarstvo d.o.o. is the company largely responsible for the implementation of heat activities;
- **Smart gas networks** – include a networked system for gas distribution and supply for all categories of end-users (building management, industry and entrepreneurship, public sector, utilities sector etc.). Gradska plinara Zagreb d.o.o. is the company largely responsible for the implementation of gas activities;
- **Smart water supply and drainage** – includes water network and a system for drainage of waste- and precipitation water;
- **Smart buildings and infrastructure integration** – includes the interaction between consumer buildings (prosumers) and networks, aimed at stronger integration of renewable energy sources, as well as economically optimal building and infrastructure management.

Strategic area no 4: Education

Context and challenges

The key element and the essential precondition for the achievement of smart city goals and concept is maximum inclusion of citizens – informed, educated and capable of using all opportunities and benefits offered by smart technologies and solutions. Education – formal, through the school system and lifelong learning creates conditions for active inclusion of citizens, but also enables the development of innovation and creativity, necessary in order for the city, i.e. society to be generally characterised as smart. Citizen competences, necessary for the establishment of a smart city, are acquired via adequate education for the open (competitive) labour market. Zagreb Smart City therefore puts education in focus, especially:

- Primary and secondary schools – first and foremost by introducing contemporary information-communication technologies (ICT) and devices, i.e. generally by furnishing all schools so that ICT technologies be available to every student, used along with traditional learning methods in everyday studying process for every subject;
- Citizens of the City of Zagreb as a whole – through lifelong learning about ICTs, including informing and promotion related to all smart solutions which have been implemented or will be implemented in the City of Zagreb area. The basic implementation challenge will be raising interest and motivating a significant number of citizens to use ICT solutions, i.e. providing user feedback which would be used for continuous improvement of advanced ICT services intended for citizens, but alsoof the system as a whole.

“Smart learning” has still not been clearly and generally defined; however, researchers of various scientific fields and education experts have defined some of its common and essential elements. In the technical sense, smart learning is based on smart devices and smart technologies. Smart devices include e.g. portable interfaces, such as glasses or even clothes, while smart technologies include e.g. cloud business, big data, datafication (process of

collecting information on everything that surrounds us and its later transformation into data format so that it could be counted and further analysed) etc. in order to improve and support personalised and adaptive learning. Smart learning is adjusted to the location, context and social relations, interoperable, adaptive, all-present, universal, complete, highly engaging and naturally interactive. In other words, real-time location is important to systems in order for them to adapt the content and situation to the user (learner). The context is important so that various scenarios of activity and informing could be researched, whereby it is important to recognise (*feel*) social relations. Interoperability implies the setting of standards for various resources, services and platforms so that continuous service could be provided when connecting any device. Considering access, preferences and needs, learning resources predict users' needs and are adjusted to them (multi-modal interaction). The most important feature is the system's capability to put forward and foresee users' needs.

Smart learning is a learning system which advises and guides users in learning in real world (environment). During the last decades, it has been repeatedly pointed out that IC technologies enable learning from anywhere at any time. Indeed, IC technologies have modified the concept of studying time and location, providing new possibilities as to information access and their adjustment and to the knowledge creation process. The use of mobile devices has generated the idea that the location and context of studying are not an important factor any more. However, today we know that locations (physical and virtual) are very important in the creation of an educational environment which combines and integrates formal and informal situations. The implementation of smart studying environment goes beyond the usual implementation of smart technology. Smart environment does not only enable the user to access digital resources and interact with user systems at any place at any time, but also provides necessary studying guidelines, offers advice and recommendations – at the right place, at the right time and in the right form.

The inclusion of citizens into education for all age groups is absolutely necessary for a systemic development, i.e. widespread implementation of smart solutions in the City of Zagreb area. Without the implementation of activities from the area of citizen education, it will not fully take off. Via the school system and lifelong learning, quality education competitive at the open labour market creates the preconditions for the development of creativity and innovation necessary for the development of the smart city concept.

The City Office for Education Sector for Education covers the activities being conducted in the function of the branch of state administration in the county (City of Zagreb) and all activities in the area of education that the City of Zagreb performs as a unit of local self-government. Activities which refer to the organisation of work in educational institutions, maintenance, furnishing, construction of facilities and implementation of various activities which improve the educational process or contribute to the raising of work standards in educational institutions, implemented by the City of Zagreb – City Office for Education as a unit of local self-government (founder of educational institutions). The activity of the City Office for Education depends on the good organisation of work and the available funds used via programmes of public needs for the financing of various activities in the educational process (extended schoolday programme, Nature School, school assistants, free transport for primary school pupils, co-financing of transport for school and university students, scholarships, free textbooks, traffic education etc.). Having in mind the high number of educational institutions and the age of facilities in which the educational process takes place, it can be concluded that big investments into their maintenance are needed, while the securing of funds for the construction of new contemporary capacities for the needs of

education poses a special challenge.

On the other hand, all activities related to the preparation/approval and surveillance of the implementation of educational programmes and curricula in the educational process and all activities related to employment and employee care in the implementation of obligatory educational programmes fall into the domain of the Ministry of Science and Education.

Inadequate connection between the economy and the education sectors is evident, be it through the development of educational curricula, or the direct contribution of the economy sector to the improvement of work conditions in the educational process. The educational system needs to be further developed and improved according to the needs of the economy by including the economy sector more directly into the proposing of profiles of necessary occupations and enrolment quotas, development of educational and training programmes, construction and equipping of spaces necessary for teaching which will result in an adequately educated occupational profile.

Our assessment is that the current model does not use all the possibilities at hand, which calls for synergy between key institutions (Ministry of Science and Education, City Office for Education, Croatian Employment Service, Croatian Chamber of Economy, Croatian Chamber of Trades and Crafts etc.) at the development of models of closer interconnection between the educational system and economic sector. The achievement of synergy and coordination of joint work of the aforementioned institutions represents an operational challenge.

Goals and effects

Specific goals in the area of education include:

1) use of contemporary IC technologies and smart solutions in the overall learning process in primary and secondary schools, which will enable students to significantly develop their digital skills and will bring about an increase in the quality and efficiency of the learning process, as well as create equal opportunities;
2) encouragement of innovation and creativity among primary and secondary school students in the area of development and use of smart solutions and tools, resulting in the development of problem solving skills, personal initiative and teamwork, i.e. cooperation;
3) strengthening of cooperation between educational institutions, economy sector and industry in the area of development of smart solutions and IC technologies through the development of educational programmes and through direct contribution of the economic sector to the improvement of work conditions in the educational process. The final objective is the education of experts, i.e. occupational profiles which will suit the needs of the economy (with the obligatory implementation of lifelong learning which can follow technological progress);
4) maximum involvement of citizens as final users of all smart solutions and services, via education on contemporary IC technologies and smart solutions, along with informing and promotion of the implemented and planned smart solutions in the area of the City of Zagreb.

Priority measures

Priority measures which will be used to achieve the set objectives are the following:

1) introduction of contemporary IC technologies, smart devices and solutions into all primary and secondary schools in the City of Zagreb area ;
2) organisation of regular competitions in development and application of smart solutions and tools for primary and secondary school students in the City of Zagreb area;
3) organisation of regular courses and lectures for primary and secondary school teachers and of educational, informative and promotional activities (panels, seminars, workshops etc.) for all of the City of Zagreb citizens.

Strategic area no 5: Economy

Context and challenges

Cities are the key drivers of social and economic development of every country and society. Dynamic, efficient and innovative cities have a strong impact on the development of national economy and consequently, better quality of living and general welfare. Sustainable city growth is possible only through an efficient model of innovations in the institutional, business and educational segment, and innovations represent a key factor leading to economic growth. Economic development of smart cities is based on the creation of a complete and comprehensive environment which enables and encourages innovation and creation of new business models.

In spite of the leading position in comparison to the other parts of the Republic of Croatia, as to the number of entrepreneurs and their generated income, number of protected patents and legal entities, whose business is based on knowledge, the City of Zagreb is faced with many challenges related to connecting science and research centres, innovative companies, public administration and citizens into the process of joint development of smart solutions which will improve the efficiency of public services and service providers, improve citizens' quality of living and encourage innovations in the economy.

On the other hand, the City of Zagreb has a significant potential related to the development of innovative solutions which would bring about a stronger development of economic activity based on knowledge and contemporary business models. Institutional support to the development of entrepreneurship, such as Zagrebački inovacijski centar d.o.o. za inovativno poduzetništvo – ZICER, provides support in the initial phases of entrepreneurial initiatives. However, it still does not have all the tools necessary for a stronger development of entrepreneurial activity. Among others, this refers to the lack of financial instruments which would support innovative business models without which such projects cannot be implemented.

In particular, one of the most important obstacles to the development of innovation-encouraging environment is the lack of a financial instrument for early phases of entrepreneurial activity, or a seed equity fund, whose goal would be to encourage and enable the development of companies in the early phase of development (start-up companies). The lack of such a fund makes access to commercial loans for micro- and small-sized companies in early stages of development harder, i.e. prevents initial development and commercialisation of knowledge and results of research and innovative ideas.

It is also necessary to connect the research and laboratory equipment of public and private scientific research organisations, companies and entrepreneurial support organisations in the

Zagreb area into a single Zagreb digital innovation hub, i.e. a single and publicly available catalogue, along with the development of an appropriate business model of using the aforementioned equipment by companies, which will directly contribute to the development of innovations and commercialisation of knowledge and innovations.

The City of Zagreb has great potential and the leading role in the Republic of Croatia in the development of creative and culture industries. The sector of creative and cultural industries comprises: electronic media, publishing and promotion, market communication, architecture, design, cultural heritage, scenic art, film, art crafts, interactive entertainment software, including computer games (Croatian computer game industry grows at a +50% rate per year and generates huge revenue), new media. This industrial sector is exceptionally resilient to the economic crisis and generates a significant GDP share and a large number of jobs (estimated 2.3% of GDP and 42,000 employees), which renders it exceptionally important for economic development. Creative and cultural industries employ culture as the initial value, and they are tied to knowledge, innovation, new technologies and promotion of the sustainable development concept, and have a great potential for creation of jobs through development and exploitation of intellectual property. Moreover, creative industries are drivers of innovation in other sectors as well. It can be ascertained that cultural entrepreneurship is entrepreneurship of future as creativity has become the crucial factor of competitiveness. It is also important to mention the role of creative and cultural industries in urban revitalisation, where these industries can be the key tool of change.

The City of Zagreb has great potential for the development of social entrepreneurship and social innovation as well. Social entrepreneurship is based on the concept and has the characteristics of traditional entrepreneurship, but differs from it as social entrepreneurs do not aim only at generating profit, but also at solving a certain social problem, i.e. a problem of the community in which they are active. An additional incentive for the development of social entrepreneurship in Croatia was, unfortunately, given by some specific situations – war, transition, large-scale unemployment (especially of hard-to-employ groups), and the last several years have been characterised by the migrant crisis and an ever-increasing number of asylum seekers. Social entrepreneurship represents a rare opportunity for employment of these categories of inhabitants.

Furthermore, every progress, economic included, has a social component to it and, contrary to exclusively technological development, social innovations are to a greater extent inspired by citizens' needs. City authorities need to encourage them in order to improve the quality of public services and in order to simplify and shorten administrative processes.

A significant possible measure for encouraging innovative solutions and entrepreneurial environment refers to the collection of data on citizens' habits and situation in the City area (e.g. use of energy products, traffic movements, air pollution etc.) via smart sensors and IoT devices, supported by public services, and storage and analysis of complex data. Collected, stored and analysed data need to be made available to scientific research centres and innovative companies via a digital platform, the City Data Hub, which enables the development, testing and commercialisation of a series of innovative smart solutions and applications. An additional possibility is the development of a platform for access to information related to new technologies and business intelligence in individual industry branches, which enables the activities aimed at *technology scouting*.

Goals and effects

The strategic goal within this area is the creation of a basis for the development of innovative business models, which would enable companies to adapt to a new, more innovative and competent access to market. This process necessarily includes technological upgrades (digitalisation) and an improved integration of new models of services, adapted to changes in clients' requirements. Such programmes bring about a strong development of economic activities in the priority areas such as energy, mobility, healthcare, utility services etc.

Specific goals which will contribute to the achievement of the main objective are:

1) continual development of entrepreneurial skills and entrepreneurial initiative;
2) enabling innovative start-ups to access fund for the financing of the early development phase (seed equity) and other forms of alternative sources of financing;
3) networking, promotion and, via a financially sustainable business model, offering to the market the available public and private technological, laboratory and research equipment;
4) encouraging the development of smart solutions via the creation of a digital platform which would enable the interested parties to access information necessary for adaptation of their strategies and give them the possibility to test innovative solutions;
5) strengthening of the social innovations sector;
6) strengthening of the creative and cultural industries (CCIs) sector by:
    a) raising awareness on the potential of these industries for economic growth;
    b) investing into the education of creative sector workers;
    c) encouraging new employments and self-employment in this sector;
    d) creating organisational and spatial preconditions for cultural and creative industry activities;
    e) profiling the city as a centre of creative industries;
    f) using CCIs for urban revitalisation of neglected city districts;
    g) encouraging the use of EU funds – Creative Europe programme.

Financial instruments, exchange of ideas and technical support in skills and technology upgrades will present a direct link between small- and large-sized companies, facilitate cooperation and build capacities for competitiveness and innovations. The set up of an information-communication platform for collection, processing and exchange of data and for the display of necessary indicators will enable new business initiatives to take off.

The objectives to be achieved include:

1) significantly increased cooperation between scientific research institutions with innovative companies;
2) commercialisation of innovations and smart applications and solutions;
3) significantly increased inclusion of citizens into the creation and use of smart applications and solutions;
4) increased number of innovative companies.

Priority measures

Priority measures which will enable the achievement of the aforementioned goals, i.e. the achievement of effects are:

1) raising the entrepreneurial competences level;

2) use of financial instruments and alternative sources of financing for early stages of entrepreneurship;
3) creation of a city platform for testing innovative solutions (Living Lab) and strengthening of creative innovative spaces (maker spaces).

Strategic area no 6: Sustainable urban mobility

Context and challenges

The growing trend of urbanisation leads to the increase of urban population, thereby increasing traffic system challenges in cities, making sustainable urban mobility a key challenge. The existing mobility systems cannot respond to the increased traffic demand. Cities have most often dealt with these challenges in the usual manner, almost exclusively by increasing capacities. However, such an approach is not efficient nor viable in the long run. Along with the growing demand, mobility challenges change and evolve, while users' needs related to limitless and efficient mobility grow. A holistic approach to urban mobility which optimises solutions of supply and demand is necessary in order to apply maximally sustainable solutions. This calls for a departure from the reactive approach to urban mobility to a more proactive model which foresees future changes and trends, and uses the benefits of new solutions. A new manner of urban mobility management, innovative financing, regulatory support and citizen inclusion need to be vehicles of change.

An efficient traffic system for citizens and for the business sector increases city attractiveness and competitiveness, with mobility being one of the preconditions of social inclusion. Everyday life is heavily influenced by the possibilities of journeys with as little interruptions as possible, both in business and private life. There are several main guidelines in this strategic area, which are directly or indirectly related to traffic, which are based on European and national strategic documents. The main objective of these measures is a safe, ecological and efficient traffic system, based on modern technologies.

Mobility is in the function of individuals, community and economic activities. People need to be able to move to satisfy their basic needs, but also additional needs which include relaxation and recreation. High quality urban mobility is necessary for successful functioning of various sectors and creation of new jobs, and has a key role in the creation of an attractive environment for citizens and the business community. At the same time, efficient mobility is one of the main challenges faced by cities in the sense of increased challenges, very often in the context of existing (inadequate) infrastructure, with citizens' awareness of newly available, more ecological and more efficient technologies increasing.

Mobility has traditionally been perceived as a system including vehicles, physical infrastructure and energy for passenger transport. Mobility awareness is ever more concentrated on the perception of service, i.e. type of service which directly and significantly depends on the use of modern technology. In the gradual transition to sustainable urban transport, demand will be addressed as a part of long-term strategy, aimed at eliminating negative aspects of mobility on human health and environment.

Mobility context is even more complex due to the fact that cities are becoming the drivers of development, regional, national and international economic centres and centres of social development. The combined impact of population growth, demographic changes and urbanisation increases the need for travel to city centres, suburbs and commute between them. Increase of mobility needs also brings about increased awareness and concerns over

the increase of greenhouse gas emissions and noise, as well as air pollution, which is to a great extent also caused by traffic.

Smart mobility system calls for the availability of infrastructure, including physical, communication and information infrastructure, IoT platform, application level. Without equal representation of all components of this system, smart mobility solutions cannot reach their full potential in the management of operative efficiency and user demand. Coordination and integration between various components in the structure is extraordinarily important.

Goals and effects

Main goals need to be analysed through main groups of participants affected by planning and functioning of urban mobility:

1) passengers – improvement of passenger experience, increased safety and more precise calculation of journey duration and cost, for both physical persons and business users;
2) transport operators – balancing of supply and demand as a guarantee for functionality improvement, possibility of more efficient use of transport resources, promotion of alternative means of transport and provision of environmentally sustainable transport;
3) urban planners – improvement of urban planning procedures based on real and modelled data on passenger requirements and their behavioural patterns;
4) city authorities – generation of economic growth by the development of economy sector based on technology, data and information;
5) adopt/draft a plan of joint decision-making, harmonisation and adoption of plans comprising all competent organisations (road traffic – cars, trams, buses, trains, bicycle traffic, pedestrians etc.).

In the long term, implementation plans will need to show economic and environmentally sustainable benefits and increased passenger satisfaction via following effects:

- reduced fuel and electricity consumption aimed at the reduction of emissions of greenhouse gases and gases which have a negative impact on air quality in cities;
- reduction of traffic congestion and traffic jams;
- increased security;
- simpler, better, more efficient and cost-optimum system more attractive to passengers and economically more viable to transport service providers;
- reduction of requirements for the building of additional traffic infrastructure in urban centres;
- adopt/make a traffic map of the City of Zagreb.

Priority measures

This framework strategy proposes short-term, medium-term and long-term measures, i.e. projects whose implementation will help in solving problems of increased mobility needs within the urban agglomeration. Projects aimed at increasing the attractiveness of public city passenger transport as the primary basis of City of Zagreb mobility system have been defined. They address solving the pronounced parking problem, which is one of the strategic elements aimed at eliminating the excess number of vehicles from the urban agglomeration centre and reduction of unnecessary rides. Therefore, projects from the domain of automatic traffic management system (ITS system)have been proposed, as key ICT upgrade of traffic and transport system, with the primary focus on automatic traffic management system. The

informatisation of participants' business process in the mobility domain brings about the definition of measures related to the set-up of an integrated central system for collection of data related to mobility, which will help with the vision of integration of existing silo solutions into a unique system. In particular, the following measures based on the digital infrastructure have been proposed:

1) increased attractiveness of public passenger transport in the urban agglomeration;
2) improvement and development of a traffic management system;
3) improvement of bicycle and pedestrian traffic;
4) use of innovative operative systems (primarily electromobility systems).

5. Priority measures for achieving the vision

Strategic area no 1: Digital infrastructure

Priority measure 1.1: Integrative Smart City platform of the City of Zagreb

Goals and activities

The data aggregation platform, which serves all the domains addressed by a smart city, is an indispensable and fundamental segment of smart city development on which other segments are built. Real-time data exchange is the basis for status monitoring and analysis of a wide array of infrastructural systems, i.e. for defining and providing a wide array of services. A smart city data aggregation platform should be based on the open integrated platform concept, which will enable collection, processing and sharing of data from all the pertinent sectors between the involved smart city stakeholders.

The data aggregation platforms will primarily serve the purpose of advanced visualisation, interpretation and statistical analysis of planning, construction and exploitation of the digital infrastructure. Utilising data aggregation platforms enables the isolated ICT systems of the digital infrastructure stakeholders to be integrated, a situation that is common in most of the world's metropolises, including Zagreb. By introducing the platform, these systems become mutually connected and data exchange between them is enabled, which creates the basis for upgrading the existing or defining new services in the domain of the digital infrastructure and smart city exploitation. This solution ultimately enables a more efficient usage of the public infrastructure, public buildings and smart infrastructure elements in general.

Therefore, within the scope of this measure, it is vital to identify all of the involved stakeholders, mode and type of the source of data, as well as to elaborate the concept of integration with the connected systems. It is necessary to define all the stakeholders and the value chain elements which will be integrated and provide a basis for the development of services, such as the *Call before digging*. The data aggregation platform must support standardised data exchange protocols in order to allow third party applications to connect to it via suitable application interfaces. It must also support real-time data reception and transmission of collected data to dedicated applications. Furthermore, the key performance indicators need to be defined, since they are vital for monitoring the results of the smart solutions implementation of and for the success of the smart city strategy.

The activities aimed at the establishment and development of the platform include:

- Development of the shared data aggregation platform for the needs of a smart city – the platform needs to be designed so as to meet all the above-mentioned conditions;

- Identification and involvement of all key stakeholders in the digital infrastructure domain;
- Establishment of the system and creation of application solutions for data collection and dissemination for the stakeholders and end-users (administration, public companies and institutions, industry, citizens);
- Defining of guidelines for application solution development with the help of the collected data;
- Defining of guidelines for the development and establishment of new services, as a result of the implementation of the platform;
- Development and integration of the platform and the existing systems;
- Continuous maintenance and upgrading of the platform and integration of future systems (ITS etc.).

Challenges

The integrated platform for advanced visualisation, interpretation and statistical analysis of planning, construction and exploitation of the digital infrastructure must be established with the help of modern technologies in order to enable modifications and integration of new and other systems, which might happen quite often considering the exceptional dynamics of technology change and development.

The platform must support mechanisms that enable secure collection, processing and dissemination of collected, as well as processed data. The integrity of the data must not be compromised. Considering the fact that a wide array of stakeholders has been defined, from city administrative bodies, through the stakeholders in the mobility system, other service providers, to the very citizens, it is necessary to enable various user roles with different authorisations to be defined.

Furthermore, the experiences of the cities that have established platforms of this type have shown that, most often, the problems are not technical in nature, but rather, that special attention should be paid to ensuring the support for the project from all of the involved stakeholders.

Possible implementation financing sources

- City of Zagreb Budget;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- City of Zagreb;
- Zagrebački holding d.o.o;

- University of Zagreb;
- APIS IT d.o.o;
- Publicly owned companies;
- Private companies;
- Citizens;
- Institutions from various sectors (healthcare, education, environment protection etc.).

Priority measure 1.2: The integral Geo information system

Goals and activities

The infrastructure cadastre contains information on the type, purpose, general technical characteristics and the position of the existing utility services, as well as names and addresses of infrastructure operators. The Ordinance on Cadastre of Infrastructure (Official Gazette no 29/2017) regulates the content, manner of conception and management of the infrastructure cadastre, establishment of a single database for infrastructure and information on the on-going and planned construction work, availability of data on infrastructure and on-going or planned construction work, manner of delivery and the type and structure of infrastructure data, as well as the alterations to the infrastructure and to the information on on-going or planned construction work.

According to the State Survey and Cadastre of Real Estates Act (Official Gazette no 112/18), the State Geodesic Administration is responsible for the conception, management and maintenance of the infrastructure cadastre. In accordance with Articles 156 and 162 of the Act, the body responsible for these activities in the City of Zagreb area is the City Office for Cadastre and Geodetic Activities.

The *Kataport* system supports business processes, outlined under 2 and 3. Kataport, which should remain the central system of the City Office for Cadastre and Geodetic Activities, as well as expand to other processes within the scope of the responsible office, should be upgraded and reengineered in the near future. The system is currently integrated with other information systems, which should enable further development, as well as the establishment and management of the infrastructure cadastre.

The disorganised state of the land registry and cadastre for both public and private real estate is hindering the settling of proprietary and legal relations (PLR), which would enable construction of line infrastructure (e.g. broadband network), that is, the obtaining of the documents required for the construction of such structures (in order to contractually establish easement, the registered landowner's signature is required on the agreement, as well as the inscription of the right in the land registry; the incomplete expropriation process lasts very long – an extensive expropriation study with a determination of the property owner must be conducted).

A significant share of the data on registered landowners in land registries still does not reflect reality and the process of setting the land registry matters of the public real estate in order has been going on for a very long time now. Such a situation is hindering the settling of PLR and the obtaining of the permits necessary for the construction of the infrastructure.

The current situation in the spatial data registries is as follows:

- Land registries cannot allow for the registration of line infrastructure as a whole, but

via limited property rights (easement, building lease) established for the purpose of constructing parts of the infrastructure on single plots, with a link not having been established between the plots through which a corridor of a certain type of line infrastructure is running;
- The real estate cadastre cannot facilitate registration of line infrastructure;
- A registry of concessions on maritime domain is a special public registry, established upon the same principles as land registries, of all the maritime domain concessions, including, among others, offshore cables and pipelines (constituting a special use of maritime domain);
- The time component and the historical overview of changes to the infrastructure are lacking.

Therefore, it is vital to synchronise the mentioned spatial registries and coordinate the pertinent operative processes in order to maintain data quality.

In order to generate a quality integral Geo Information System (GIS), it is extremely important to improve the quality of the existing data (in the vast majority of cases, the correct z-coordinate, i.e. the depth of the infrastructure, is missing), to collect the missing data and to establish an information system accessible to all stakeholders. According to the official Cadastre of Infrastructure (ducts), 17,000 km of various ducts have been laid in the City of Zagreb area, while 23,000 geodesic duct (infrastructure) studies and more than 1,700 analogue archival technical duct maps are kept in the archives.
The data on electricity, electronic communication, heat, gas, oil, water and drainage duct infrastructure is entered daily into the VodGIS – a management system for the City of Zagreb duct (infrastructure) cadastre data, which has been in use since 2005 with the basic purpose of forming a single digital City of Zagreb duct cadastre database. When creating a quality GIS of the infrastructure of the City of Zagreb, the VodGIS information should also be taken into account since it contains the data on the infrastructure registered since 1971, which was measured with geodesic precision, in accordance with the applicable regulations over the last 50 years. The vast majority of the VodGIS data is three-dimensional, i.e. it indicates the height and depth data of the infrastructure.

An integral GIS must include the elements of the city's transport system, from the public urban transport (stations' locations, design of the station/bus turnout, number of passengers, station facilities – roof, info-pole, bench etc, timetables etc.) to the dynamic overview of the traffic network load (data obtained from the Automated Traffic Management system). The GIS must include the elements of the City's entire utilities and energy infrastructure, so that they could be utilised in spatial analysis and planning, as well as the data on granted permits with diagrams of the planned activities for a given space.

The key activities for the establishment of a multidimensional infrastructure cadastre are the following:
- Identification and inclusion of all interested stakeholders in the domain of digital and utilities infrastructure management, which especially refers to matters regarding underground ducts;
- Establishment of a concept of the system for collection, processing and utilisation of underground and above-ground infrastructure data, which should be conducted in accordance with the State Survey and Cadastre of Real Estates Act;
- Establishment of the system and creation of application solutions for data collection and dissemination for the stakeholders and end-users (administration, public

companies and institutions, industry, citizens);
- Integration of the system and all data with the previously outlined data aggregation platform.

In order to reduce costs and risks, the system needs to be implemented in several phases:
- Collection of the existing data aimed at outlining the existing status, defining the historical context of infrastructure development and preparing operative plans for surveying;
- Purchase and preparation of surveying and data processing equipment;
- Education of all the stakeholders involved in the project;
- Collection of road data;
- Collection of sidewalk data and data from inaccessible areas;
- Establishment of the system for the presentation of collected data, the integral Geo Information System, on the basis of the official Cadastre of Infrastructure data.

Challenges

Reaching the consensus on the manner of collection and especially on maintenance and utilisation of data between all stakeholders, staying at the same time within the parameters of the State Survey and Cadastre of Real Estates Act, is the key challenge this measure is facing. The system will fulfil its purpose only if it includes all the key stakeholders and if they promptly perform their obligations. According to Article 21 of the Ordinance on Cadastre of Infrastructure (Official Gazette no 29/2017), in surveying the existing, unregistered infrastructure, a meter (cablemeter, georadar and other equipment used in discovering underground infrastructure) may be used. However, no geodesic study of infrastructure that has utilised that technology has yet been conducted, nor submitted for review and approval. Furthermore, georadars currently cannot survey all the elements and radar technology does not provide satisfactory effects prescribed for geodesic infrastructure surveying in the event of high ground humidity (when surveying after rainy periods). A technological challenge is posed by the vast amount of data collected and processed during and after surveys. However, considering the significant decrease in the price of data processing and storing equipment, this challenge has been constantly becoming less demanding.

A special challenge is also posed by the logistics of implementation, especially in the dense urban areas, where the large number of parked vehicles might be a serious issue.

Possible implementation financing sources

- City of Zagreb Budget;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors;

Key participants

- City of Zagreb;
- Vodoopskrba i odvodnja d.o.o;
- Zagrebački holding d.o.o;
- ZET d.o.o;
- State Geodesic Administration;
- APIS IT d.o.o;
- Underground and above-ground infrastructure operators;
- University of Zagreb.

Priority measure 1.3: Gigabit broadband user infrastructure

Goals and activities

A robust, reliable and accessible broadband network is essential for the implementation of smart technologies and solutions. Components of a modern broadband infrastructure include fiber-optic cables, wireless networks, sensors, data centres and access points that support a data-transfer rate of at least 1 Gbps.

The main goal of this measure is the construction of a quality city broadband infrastructure, as the main prerequisite for the provision of services and implementation of smart city solutions, especially significant for the construction of the systems outlined in the previous priority measures. One can undoubtedly ascertain that a reliable infrastructure is vital for the reliability of services, which means that it will be necessary to significantly upgrade the existing city networks, as well as private ones.

The quickest and most economically favourable effects of broadband infrastructure development can be achieved by promoting open broadband networks. Openness of electronic communication networks implies that all operators and providers of electronic communication services are enabled access to the network and that they can easily offer their services to all the network end-users via the network. In doing so, equal conditions for everyone must be ensured, in compliance with the national and European legislation.

Depending on the type of funding of the open broadband network, one can differentiate between a market (commercial) network and a network constructed, entirely or partially, with public funds. Market networks are built by electronic communications operators, using their own funds, while the facilities and networtk services are offered on the market at commercial basis, thereby generating profit.. Networks constructed with public funds are financed by national and EU funds. Such networks' operators mustn't generate excessive profit from such facilities, and the amount of such profit is defined by national regulatory agency. Public funds may be used for construction only when no market interest has been determined.

New access networks are, in principle, constructed as fiber-optic networks (in accordance with the EU recommendations for development of gigabit society), regardless of the types of end-users. The guidelines for the implementation of rules for state aids, regarding the fast development of broadband networks, outline in detail the fundamental broadband technologies and provide general requirements for the fast and ultrafast access networks *(Next Generation Access – NGA)*, as well as describe several NGA technologies.

In the preparation of the implementation of this measure, a comprehensive survey and estimation of the networks' capacity in the City of Zagreb area needs to be conducted in

order to draft a specific plan of activities aimed at the establishment of broadband infrastructure in the entire City area. The next step is to conduct, via cooperation between private and public partners, the planned agenda and proactively ensure that the broadband infrastructure remains adequate in order to satisfy the current, and especially the future needs, in accordance with the EU and national recommendations.

In the implementation of this measure it is vital to maximally utilise the available grants from the European Structural and Investment Funds in order to co-finance the establishment of a broadband Internet.

When carrying out the projects aimed at energy efficiency renovations of buildings (and other comprehensive work on buildings), it is necessary to install the physical infrastructure that supports high speed networks in the buildings, which implies vertical and horizontal fiber-optic cabling from access points to each individual residential or business unit and the installation of the equipment necessary for each residential and business unit in an individual building to connect to the high speed electronic communication access network. The installation of this infrastructure, the cost of which occupies a very small share of the entire cost of energy efficiency renovations, directly supports this priority measure from the Strategy (as well as Priority measure 3.6 – Smart buildings and infrastructure integration), and provides strong support to further development of the electronic communications market in the City of Zagreb, considering the fact that one of the main challenges for further development of gigabit broadband networks is the lack of adequate infrastructure in the last mile segment of the network (from the headquarters to the end-user).

Challenges

Technologically speaking, no significant challenges to the establishment of broadband infrastructure have been identified. The most significant challenges concern organisation, optimal cooperation between the private and the public sector and quick withdrawal of funds from the European Structural and Investment Funds.

Possible implementation financing sources

- Budget of the City of Zagreb;
- European Structural and Investment funds;
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- City of Zagreb;
- Zagrebački holding – the Zagrebački digitalni grad branch;
- Private companies – electronic communications operators.

Priority measure 1.4: Sensorial narrowband infrastructure

Goals and activities

The goal of this measure is the establishment of a platform to support the sensorial narrowband infrastructure and applications that require long-lasting energy sources and transmit small amounts of information, such as traffic and parking sensors, air and water quality sensors, structural or seismic sensors etc. No generally accepted European standards exist in this area, but industry standards with a relatively transparent ecosystem (technologies coexist on the market because experts spot the advantages and limitations of one technology in comparison with the others) that create entire arrays of communication solutions do exist at several levels. Each of the solutions possesses specific advantages and limitations generated by the physical nature of the relation between modulation, spectrum width, transmission frequency etc, the understanding of which is vital for the selection of the optimal technology for a given purpose.
Two general directions of development can be defined:

i. Via mobile operators, by using next generation M2M (Machine to Machine) solutions (Narrowband IoT (NB-IoT; Cat NB1) and LTE M (Cat M1)) as upgrades to the existing mobile networks; and
ii. Via independent manufacturers which are attempting to form their own ecosystems, the current status of which developments is outlined below.

SIGFOX
Sigfox is a French company, founded in 2009, that offers the most suitable solutions for applications which require a very low network throughput, achieving at the same time high energy efficiency. What makes Sigfox unique is its fully complete ecosystem with a large number of distributors of IoT devices and applications. Its solutions are widely utilised in Western Europe, whereas pilot programmes for the expansion of the infrastructure have been initiated in South America and Asia. The existing standard for Sigfox communications operates via open frequencies (868 MHz in Europe and 900 MHz in the USA) and it can be used on any radio device. It is potentially the most stable solution, limited by exceptionally small throughput and the inability to cover difficultly accessible areas (underground ducts, basements, manholes). The company's business model is similar to a telecom operator model, where traffic is paid on a monthly basis, with the possibility to pre-pay on an annual or multiannual basis, which makes the customer eligible for discounts. Sigfox controls the network server and does not allow more than one operator per country, generating thusly a monopoly situation and acting as a global operator. Speed and two-way operating mode are limited – a maximum of 140 messages can be sent from a referential device per day and up to 4 messages can be sent from the network server to a referential device per day, with each message not exceeding 12 bytes.

Wireless M-bus
Designed as a wireless version of the EN 13757-4 M-bus standard, this system cannot be called a network in the true sense of the word since it is essentially a bus with very limited features. It operates in the free 868 MHz band and is mostly used for the walk-by and drive-by solutions for readings of water meters, gas meters etc. It supports the installation of one repeater, which makes it stable enough, but its constant data transmissions dramatically impact the service life of the batteries. Regardless of the limitations, the system's simplicity has made it exceptionally well received among manufacturers of water meters, heat cost allocators, gas meters etc, which is why it can be referred to as the wireless network most widely implemented in meter reading.

IEEE 802.15.4

Another type of the LR-WPAN (Low-Rate Wireless Personal Area Network) wireless networks characterised by exceptionally low energy consumption and a very good reach. The standard defines the physical layer and media access control, creating the basis for ZigBee, WirelessHART, BeeKON etc, which all further expand the standard by developing the higher layers. It is compatible for use with the 6LoWPAN technology, which is utilised for the delivery of the IPv6 version of Internet protocol (IP) via WPANs. The main advantages of this solution are low price, low speed, widespread inter-device communication and the possibility of creating mesh networks. Compared to other approaches, such as Wi-Fi (IEEE 802.11), it offers lower throughput and generates significantly lower consumption. Devices compatible with IEEE 802.15.4 can operate on one of the three possible frequency bands (868/915/2450 MHz). This network's big advantage lies in the ability to utilise inactive repeaters, which makes it an exceptionally flexible solution and the best solution for readings of difficultly accessible locations. In the City of Zagreb, this network is used by Vodoopskrba i odvodnja for the purpose of reading water meters in buildings and manholes, as well as dominant solution for remote reading of consumption of all energy sources in more than 50 buildings owned by the City of Zagreb.

LoRaWAN technology

LoRa is among the youngest technologies and is suitable for low- and high-throughput IoT networks. It was developed by Semtech, a company that manufactures computer chips, and it falls under the category of LPWAN (Low Power Wide Area Network) technology for IoT, M2M and industrial applications. The LoRa protocol is an open standard of the LoRa Allianze organisation. More than 500 equipment manufacturers, telecom operators and other organisations participate in its development. In addition to Semtech's, chips of other manufacturers, such as Microchip, can be found on the market. Microchip. Compared to other similar technologies, it offers a pretty extensive bandwidth. The LoRa technology offers a relatively wide reach between nodes, which is enabled by the adaptive modulation, which also enables the highest possible energy efficiency and a 10-year service life of the referential devices' batteries. Security can be implemented on several levels. The technology utilises the 128-bit AES data encryption, from the referential device to the end-user. The LoRaWAN network was designed without repeaters in mind because it enables a wide reach and it can penetrate walls and other barriers very efficiently (the reception threshold is approximately 140 dBm). Pico concentrators can be used in areas with bad reception. The LoRa network provides a wide spectrum of transmission speed (0.3 – 50 kbps), two-way communication, high energy efficiency, integration with other LoRa networks and an open standard for development in all segments. The LoRa technology can be implemented in a wide array of activities, including readings of water, gas and electricity meters and of temperature, humidity, air quality, parking spots and waste container sensors, as well as in GPS tracking. It also supports integration with other technologies, such as Wireless M-bus, M-bus, digital-analogue inputs, impulse meters and Scada systems, in addition to supporting the integration of the existing referential devices in the LoRa system at a low price. Especially efficient is the integration with the Wireless M-bus, which is widely utilised in the market and is able to transmit data via the LoRaWAN system. An increase in the number of devices based on the LoRaWAN technology in the EU area and an increase in the number of commercial uses of LoRa networks in Western Europe (e.g. France, Belgium, the Netherlands, Germany etc.) were noted. Over 50 million devices use the technology worldwide.

RPMA

The RPMA technology is known under the name IEEE 802.15.4k. It operates on the 2.4 GHz band and, thanks to extremely complex modulation, it achieves exceptionally wide reach and covers difficultly accessible locations (basements, manholes etc.). By using extremely low power and a free frequency band, this network's reach can exceed 12 km for battery-powered devices, which makes this network the furthest reaching one. The RPMA is the most secure of all related technologies. This system has been implemented in Vodoopskrba i odvodnja for the purpose of remote reading of water meters and other devices and has shown exceptional performance in terms of reach and signal coverage on the field. Some sensor, meter and manufacturers of other devices, several of which are based in Zagreb, utilise this technology.

NB IoT

The NB IoT specifications were finalised in mid-2016. This new narrowband radio technology provides a suitable LTE category for IoT devices which require a narrow bandwidth. It utilises the existing infrastructure of LTE and GSM network service providers in order to decrease the costs of network construction and exploitation. Initial implementations and tests are being carried out. The technology is available for trial in the Republic of Croatia. Telecom operators are yet to define the frequency bands that would be utilised for that type of communication, which will significantly affect the development of the implementation of this communication platform.

LTE-M

LTE-M is part of the 13th release of the 3GPP standard and was aimed at maintaining a higher data-transfer speed while, at the same time, decreasing energy consumption by reducing device complexity and costs and enabling deeper coverage in order to reach difficultly accessible locations (e.g. offices located deep within buildings, underground garages etc.). This standard will improve the NB IoT bandwidth. The LTE-M is also the most secure of all related technologies.

The key factors for final selection should be performance and the applicability of a solution to a specific purpose, as well as ecosystem development level, openness, availability and price of use. In this phase of development, it is too early to make any recommendations. Therefore, the activities within the scope of this measure are the following:

- Evaluation of the offered technologies through technological pilots;
- Identification and involvement of all interested stakeholders in the sensorial infrastructure domain;
- Establishment of the system and creation of application solutions for data collection via narrowband sensorial infrastructure and dissemination for the stakeholders and end-users (administration, public companies and institutions, industry, citizens, tourists etc.);
- Defining the guidelines for application solution development with the help of the collected data;
- Defining the guidelines for the development and establishment of new services, as a result of the implementation.

Challenges

The main challenge is posed by the absence of complete and ready products that could utilise the best attributes of each network / communication solutions, that is, such products that have proven themselves in the most demanding situations and can answer the challenges of

coverage, accessibility, security and readiness (longer period without communication standard changes). The stability and recognition of industry standards, as well as the availability of the suitable chipsets, i.e. modems, represent issues that are problematic when it comes to manufacturing and developing solutions in the Republic of Croatia. Solutions should be sought through pilots, which can identify the less suitable technologies, and only then can solutions start to be implemented. The existing pilots need to be reviewed, advantages and disadvantages of the utilised technologies need to be determined, as well as used for mapping out the future development of technologies, and fact-based decisions should be reached. The first applications have been developed in Vodoopskrba i odvodnja (**RPMA, IEEE 802.15.4**, Wireless M-bus, LoRa), in the former City Office for Energy, Environment and Sustainable Development (**IEE 802.15.4,** Wireless M-bus), Gradska plinara (Walk by, Wireless M-bus, LoRa) and HEP-Toplinarstvo (**GPRS, IEEE 802.15.4**, Wireless-M-bus).*

Selected technologies in **bold, others were tested.*

Possible implementation financing sources

- City of Zagreb Budget;
- European Structural and Investment funds;
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- City of Zagreb;
- Zagrebački holding d.o.o;
- Underground and above-ground infrastructure operators;
- Telecom operators;
- Private and public providers of IoT services.

As has been mentioned in Chapter 3 (Overview of the current status), pilots have already been launched in Zagrebački holding branches and some technologies and solutions have started to be implemented.

Strategic area no 2: Smart public administration and citizen inclusion

Priority measure 2.1: Expediting the development of digital public services, increasing digital technology competencies and involving citizens

Goals and activities

New developments in technology and new forms of operation and management provide the city administration with new possibilities to manage and advance the quality of services and life of the citizens, as well as perform business activities more efficiently. The high level of digital technologies usage and information and knowledge exchange via social networks have made significant developments in smart concepts and solutions possible, wherein the

key contributing factors of this concept have been new business models and digital technology. A vital prerequisite for increase in service provision efficiency, quality and speed on the part of the city administration is the rapid development of digital public services that the city administration provides, with the help of digital technologies, to citizens and economic operators.

Activities aimed at digital networking should simplify and encourage data and information exchange between the key stakeholders – the city administration, citizens and economic operators. To that end, it is necessary to establish new and upgrade the existing communication (digital) platforms, e.g. the C2C (Citizen to Citizen) platform, which provides the citizens, as the end-users of the system, with a quality communication platform for managing everyday issues and suggesting and developing new ideas and initiatives aimed at improving all aspects of city life. In order to lay the foundations for the implementation of the activities aimed at management of digital networking, a mechanism for the implementation of the standards and solutions pertinent to this area need to be established.

A comprehensive *Public Services Management System* needs to be established in order for the outlined goals to be accomplished, which requires an array of preparatory and implementation activities to be carried out:

- Strategic analysis of smart city trends, including best practice analysis;
- Establishment of a smart solutions and digital services catalogue;
- Establishment and continuous maintenance of the City of Zagreb Service Catalogue ;
- Defining the City of Zagreb Business Process Architecture (BPA) and a horizontal organisation for internal networking;
- Establishment of a Government Service Integration Platform, which enables the establishment of a single access point for data and document exchange, integration of business processes, automatic activation of e-Requests from portals and a comprehensive audit of transactions;
- Defining a digital public service concept;
- Defining the structure of the digital services management system, as well as that of systems of liability and functionality;
- Establishment of a platform for continuous surveying of public opinion on current city topics;
- Systematic involvement of citizens in city policy and priority drafting via central platform.

Innovative services and applications can be developed by smaller companies on the basis of open data and open and interoperable city infrastructure, which requires adequate control of access to data and infrastructure. Furthermore, citizens can also be a source of data on environment/the city, e.g. they can collect sensorial data via their mobile phones.

Challenges

In order to better utilise the potentials for the implementation of digital technologies in the work of the city administration, as well as the potential of the open data approach, it is vital to upgrade the implementation of the following concepts and principles through initiatives and projects that fall under the authority of the City of Zagreb:

- Data openness as a concept for the establishment of digital platforms;
- Ensuring citizen involvement and two-way cooperation in order to develop new services on the basis of the Open Innovation concept;

- Ensure privacy and data protection for citizen sources;
- *Data Lake* approach to data management, aimed at consolidating information within a central repository for various sources and users of data.

Managing a city in the digital business era requires the city to be run as a digital ecosystem that is an independent network of companies, their competition, consumers, regulators and every other stakeholder that might participate in the process of creating value. The C2C atmosphere, as one of the measures, must provide the citizens, as the system's end-users, with a quality platform for problem-solving and new, ready initiatives. To that end, the city must provide a platform that would, along with the outlined functionalities, enable a high level of user experience for the end-users. *User experience*).

In order to protect key resources and the city's infrastructure it is necessary to ensure continuous management for protection of the city's public and digital services critical infrastructure (CIP) . To that end, it is necessary to guarantee:

- A systematic management of resources and critical infrastructure;
- The establishment of the critical infrastructure repository;
- The establishment of risk management for the critical infrastructure, which includes:
  - Risk identification; and
  - Risk treatment – activities and countermeasures.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Various modes of partnerships with private capital.

Key participants

- City of Zagreb;
- APIS IT d.o.o;
- Citizens;
- Entrepreneurs;
- University of Zagreb.

Priority measure 2.2: Managing the interoperability of the City's electronic services, in accordance with the development of interoperability on the level of the Republic of Croatia and the EU

Goals and activities

When developing new and advancing the existing digital public services, it is necessary to take into consideration the interoperability requirements, i.e. the features of mutual and synchronised cooperation of the new services and applications with the existing applications

and systems, without any limitations to access and implementation. In accordance with the recommendations outlined in the European Interoperability Framework (EIF)[24], it is necessary to develop a concept of a digital public service which would provide a framework for development of new and improvements to the existing services, while taking all the interoperability requirements into consideration.

As one of the key factors in the development of digital services, the activities referred to in this segment should enable the establishment of a governance structure for the digital data and information exchange channels between the system stakeholders. Regulation of the methods of utilisation of the digital channels and their interoperability should enable them to be used efficiently, economically and securely, as well as provide a high level of user experience. In addition to interoperability of the City's services and processes, it is necessary to achieve interoperability with the National Information Infrastructure (NII) of the Republic of Croatia, as well as with the other EU Member States.

In order to better utilise the potentials for the implementation of digital technologies in the work of the city administration, as well as the potential of the open data and data lake approach, it is vital to ensure the implementation of the following concepts and principles through initiatives and projects that fall under the authority of the City of Zagreb:

- Data openness as a concept for the establishment of digital platforms;
- Ensuring data interoperability in the digital ecosystem by utilising standardised dictionaries and ontologies;
- *Data Lake* approach to data management, aimed at consolidating information within a central repository for various sources and users of data.

Goals of this measure include establishing, that is, enabling the following:

- Framework of governance for the interoperability of digital services and processes;
- Control of the components that enable the system's interoperability;
- Interoperability of the service and solutions with the NII and the EIF.

Activities aimed at interoperability management include the following:

- Ensuring the implementation of pertinent norms within the European Interoperability Framework (the new EIF, Connecting Europe Facility (CEF), ISA2);
- Ensuring the implementation of pertinent norms within the National Interoperability Framework and the City of Zagreb eGovernment Interoperability Framework (e-GIF);
- Establishing a framework for the management of interoperability agreements and digital channels;
- Initialising and supporting the realisation of the implementation potential of digital technologies in the work of the city administration and the potential of the open data and data lake approaches;
- Establishing a security framework in compliance with the Cyber Security requirements, as well as establishing governance of Information Security Management System (ISMS);
- Critical infrastructure protection (CIP).

Challenges

[24] *New European Interoperability Framework – Promoting seamless services and data flows for European public administrations*, available at: https://ec.europa.eu/isa2/eif_en

In order to lay the foundations for the implementation of the activities aimed at management of digital networking and interoperability, a mechanism for the implementation of the norms and principles pertinent to this area should be established. According to the EIF, system interoperability must be contemplated on all levels of interactions, from the legal to the technological level. The consolidation of all levels, that is, the utilisation of different interoperability solutions on different levels, poses a demanding challenge. In addition to ensuring compliance with the EU standards and regulations, it is necessary to ensure the compliance of digital business activities with the national interoperability framework. This ensuring of interoperability at all levels should be defined in agreements for all interactions via digital channels, that is, for digital content and documents.

In order to expedite the digital transformation of the economy of the City of Zagreb, it is necessary to significantly expedite the utilisation of 4IR (fourth industrial revolution) technologies and the implementation of the recommendations outlined in the ISA2 – CEF DSI (Connecting Europe Facility – Digital Service Infrastructures) initiative for ensuring and expediting the establishment of a single European interoperability market, which prescribe measures necessary for the establishment of components of digital platforms, as the means of implementation of interoperable solutions.

In addition to ensuring compliance with the EU standards and regulations, it is necessary to ensure the compliance of digital business activities with the national interoperability framework, as well as with the e-GIF of the City of Zagreb, as the interoperability management framework in the scope of the digital ecosystem of the City. In accordance with the EU and national interoperability frameworks, it is necessary to regulate all interactions in the City ecosystem via interoperability agreements in order to ensure interoperability on all levels. These agreements regulate interactions taking place on digital channels and the traffic of digital content and electronic documents.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- EIB Group.

Key participants

- City of Zagreb;
- APIS IT d.o.o.

Priority measure 2.3: Business process analysis and management and advancements to the operational organisation of the City of Zagreb

Goals and activities

The Service for Analysis and Improvement of Business Processes of the Office of the Mayor initiated in 2012 organisational advancements of the business operations of the City of Zagreb on the basis of business process and change management by conducting several projects aimed at quick adaptation to new business conditions and implementation of European administrative standards, as well as at introducing continuous advancements as everyday activity.

With the goal of providing a timely, reliable and quality public service to its users and in order to ensure a higher standard of living for all citizens, as well as create an encouraging entrepreneurial environment, the City of Zagreb is developing a system for business process management and a system for change management on the basis of the ARIS value engineering methodology and the ARIS technology platform, which is the world's leading digital platform for agile and flexible change management. The following documents have been drafted with the goal of establishing the above-mentioned systems:

- City of Zagreb Business Process Management Programme;
- Roles in the Business Process Management System of the City of Zagreb;
- Change Management Procedure;
- "Change Proposal" Form;
- Conclusion on Establishment and Appointment of the Working Group for Change Management.

In the process of system establishment, more than 300 workshops have been conducted with all the administrative units of the City. All the City processes have been defined, and new processes have been designed and implemented: Business process management process, Change management process and Project cycle management process – processes vital for a more agile, effective and efficient development management, as well as for a quicker provision of reasonably priced and services of higher quality, in accordance with the City's jurisdiction and the citizens' needs. A process organisation system has been established and process ownership has been introduced with the objective of continuous improvement of the City's business operations.

The measure anticipates continued activities aimed at business process analysis and management and the improvement of the City of Zagreb operational organisation . It needs to be stressed that it is necessary to define processes and determine process ownership before defining a specific organisation structure.

Specific activities being carried out include the following:

- Development, implementation and maintenance of the business process management system and change management system;
- Supporting the planning, guiding, control and implementation of the strategy of continuous improvement of business processes in the city administrative bodies;
- Supporting the defining of strategic goals, process initiatives and key indicators of the accomplishment of set goals and monitoring the fulfilment of the set goals;
- Design of business processes;
- Establishment of a business process repository;
- Carrying out qualitative and quantitative business process analyses;
- Optimisation of business processes;
- Standardisation and synchronisation of business processes;
- Supporting organisation advancements ;
- Supporting the projects which develop new processes, implementation of changes, business process transformation, organisation and technology transformation, implementation and business process monitoring;
- Administering and presenting the business process repository to the city administrative bodies, drafting documents aimed at business process management and the improvement of business processes;

- Preparing analyses, programmes, plans, reports and other expert materials, providing professional assistance to users or city administrative bodies in order to continuously advance business processes and cooperating with the city administrative bodies, national administrative bodies and other national bodies and institutions;
- Establishment of a platform for consolidation and unifying of process management and organisational resource management on the City and city companies level , aimed at achieving optimal management.

Challenges

This framework strategy sets goals and defines the priority measures for their accomplishment. Therefore, the key challenge for the execution of the entire strategy, i.e. for the achievement of the vision and the goals set, is the successful implementation of the priority measures. A very wide array of stakeholders, outlined in all the measures, must be involved in the implementation, with the key task, i.e. challenge, being the coordination and active involvement of these stakeholders.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds (potentially technical aid).

Key participants

- City of Zagreb.

Priority measure 2.4: Generating reference architecture and standardising the technological platform

Goals and activities

ICT reference architecture implies a comprehensive overview of IT systems, their interdependence and building blocks. Architecture granularity can be defined according to actual needs and gradually optimised.

Reference architecture describes all systems (infrastructure, databases, applications etc.) in detail level necessary for supporting business needs. This architecture will, at the same time, describe the interdependence of individual system components.

Designing the ICT reference infrastructure will expedite the establishment of new services and achieve technological consistency and standardisation, which generates the following advantages:

- Increase in interoperability between heterogeneous IT systems brought on by the establishment of standardised solutions and joint data exchange mechanisms;
- Reduction of IT development projects' costs brought on by re-enabling the utilisation of the existing system components;
- Improving the quality of internal communication, as well as of that towards external suppliers, for well known reasons.

The most important goals of this measure are the following:

- Designing the ICT reference architecture;
- Standardisation of technological platforms;
- Standardisation of data infrastructure;
- Ensuring platform access via API;
- Utilising the capacity of cloud computing technologies;
- Increasing the management quality of city employees' digital identities;
- Enabling the utilisation of smart sensors;
- Advancing the quality of geospatial data and services;
- Utilising large amounts of data (Big data) for the purpose of increasing the quality of the management of the City;
- Implementation of artificial intelligence and machine learning concepts in the creation of new e-services;
- Ensuring continuous availability of IT services.

Challenges

This framework strategy sets goals and defines the priority measures for their accomplishment. Therefore, the key challenge for the execution of the entire strategy, i.e. for the achievement of the vision and the goals set, is the successful implementation of the priority measures.

A very wide array of stakeholders, outlined in all the measures, must be involved in the implementation, with the key task, i.e. challenge, being the coordination and active involvement of these stakeholders. The implementation unit must therefore be properly staffed and receive clearly outlined authorities and responsibilities.

This measure is specific in that the proper level of knowledge of technology must be ensured

in order for the standardisation guidelines to be adequately defined, while, at the same time, the importance of protecting the existing investments in ICT solutions must be kept in mind.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds.

Key participants

- City of Zagreb.

Priority measure 2.5: Encouraging the innovation culture among the city administration employees and citizens via broader involvement in the processes of creation of new digital public services

Goals and activities

Increasing the digital productivity of the employees of all the city administrative bodies is an important factor in the process of overall digital transformation of the City of Zagreb. Raising the level of communication and cooperation between city employees, by determining the unified application solutions for use, will result in quicker solving of citizens' requests, reduce the cost of individual processes of request solving, as well as improve the perception of the quality and transparency of the local administration work and, ultimately, lead to an increase in employee satisfaction.

Once the city employees' environment has been standardised, with certain organisational preconditions met, it shall become a solid foundation for implementation, encouragement and maintenance of the innovation culture. Innovation stems from an individual who is motivated to articulate the innovation, regardless of how small it might appear, because the multiplying effect of small innovative ideas generates the total progress of the entire organisation. Two sources of innovations exist:

- Internal mechanisms of the employees of city administrative bodies; and
- Citizens.

Innovation implies approaching challenges in new and original ways, which address the end-users' needs more effectively. Innovativeness and public administration have often been perceived as opposing concepts. However, the rapid development of technology, which compels one to be prepared to test and utilise "marginal" technologies, so that the project would not result in obsolete products being in use by its completion, imposes the need to create and implement innovation culture in the City of Zagreb.

Preconditions have already been met through the continued work and activities of the Development Agency and the Technology Park, as well as through continuous enhancement of the city administration employees skills .

The most important goals of this measure are the following:

- Encouraging the innovation culture among the city employees by establishing a system for structured collection, processing and evaluation of suggestions for improvement of internal business processes (*Innovation Management Hub*);

- Managing new initiatives and innovations by establishing adequate procedures for monitoring and management of innovative ideas;
- Establishment of a platform for online citizen and employee education on new services and processes, the citizens' rights and city administration initiatives, as well as ways of participation in the decision-making processes in the City;
- Encouraging innovativeness in ICT sector employees by introducing a system for spotting innovative initiatives of the ICT sector employees, with the ultimate goal of increasing the overall efficiency of the sector;
- Increasing the efficiency of utilisation of the innovative potential of the Zagreb Innovation Centre and Technology Park Zagreb;
- Involving the citizens in the innovation process by advancing the e-services for collection and processing of citizen suggestions;
- Establishment of a platform for citizen and employee education on new services and processes.

Challenges

This framework strategy sets goals and defines the priority measures for their accomplishment. Therefore, the key challenge for the execution of the entire strategy, i.e. for the achievement of the vision and the set goals, is the successful implementation of the priority measures.

A very wide array of stakeholders, outlined in all the measures, must be involved in the implementation, with the key task, i.e. challenge, being the coordination and active involvement of these stakeholders. The implementation unit must therefore be properly staffed and receive clearly outlined authorities and responsibilities.

This measure is specific in that the main challenge is posed by the perception of the lack of innovativeness in the public sector, as well as of the lack of a formal backing, processes and means for a wider implementation of innovation in the City of Zagreb.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds (potentially technical aid).

Key participants

- City of Zagreb;
- Zagrebački inovacijski centar d.o.o.

Priority measure 2.6: Continuous improvement of the quality of city services and research into further improvements in accordance with the international ISO standards

Goals and activities

One of the most important Smart City components are the city services and the supporting catalogue of the City's services, which includes city administration, institution and utility company services. Operations of a city must be efficient, which requires decisions to be made and problems to be solved in real-time. In 2014, the International Organisation for

Standardisation (ISO) adopted two city management standards (ISO 18091 – Quality management systems in local government and ISO 31720 – Sustainable development of communities – Indicators for city services and quality of life) which enable the desired levels of service quality and the efficiency of the operations of the City and city institutions to be set, as well as enable monitoring of the progress of Smart City developments. ISO has also established a special Technical Committee, whose task is to define the standards for the establishment and development of smart cities, resulting in four standards – ISO 37150:2014 – Smart community infrastructures – Review of existing activities relevant to metrics; ISO 37151:2015 – Smart community infrastructures – Principles and requirements for performance metrics; ISO 37152:2016 – Smart community infrastructures – Common framework for development and operation; and ISO 37154:2017 – Smart community infrastructures – Best practice guidelines for transportation.

In February 2016, the City Office for the Strategic Planning and Development of the City, as coordinator of local activities in the City of Zagreb, was invited to participate in a pilot programme organised by the Local Governments for Sustainability (ICLEI) and World Council on City Data (WCCD), whose partnership is aimed at implementing the new ISO 37120 international standard, the first one to define city indicators and which was designed by the cities. The ISO 37120 outlines a comprehensive set of 100 indicators (46 primary and 54 secondary), which enables cities to compare their social, economic and environmental results with those of other cities of the world. The project enables city development indicators for all areas in which a city administration operates to be defined (e.g. economy, planning, environment, infrastructure, transport, education etc.), entered in a worldwide database, compared individually with those of other participants in the project (e.g. London, Los Angeles, Toronto, Shanghai, Buenos Aires, Dubai etc.) and analysed, in addition to enabling an ISO certificate of a certain level to be awarded. The World Council on City Data is a network of innovative cities advocating higher quality of life and service in cities, a network which strives for collecting as much credible data as possible in order to publish it on the network's open portal (http://www.dataforcities.org/). The WCCD network consists of a global series of cities, and since 2016, the City of Zagreb has been added to that network by the City Office for the Strategic Planning and Development of the City. The joining process was concluded in June 2016, when an agreement binding the City to collect the requested data in accordance with the methodology outlined in the ISO 37120, in no less than three months, was signed. The collected data was forwarded to the WCCD administrator, who separately analysed them and evaluated their compliance with the standard. After the data had been analysed internally, it was reviewed by independent auditors. The indicator collection process encompassed 17 thematic fields of importance to smart city development, such as economy, education, transport, urban planning etc. After the data collection period, the City of Zagreb brought the project to a satisfactory end in November 2016, when it received the ISO 37120 certificate of the highest, platinum, level in addition to its data being entered into the worldwide database.

The constant advancements in the quality of city services must be conducted in accordance with the mentioned standards and best examples and practices of the leading cities of the world and Europe.

The most important goals of this measure are the following:

- More efficient planning, design and provision of city services;
- Reducing the duration of the process of establishment of a smart and sustainable city;
- Enabling integration between various city systems;

- More efficient decision-making (based on the performed data analyses);
- Enabling benchmarking;
- Evaluating the effect of infrastructure projects on overall City performance.

By optimising and standardising business processes, the following effects are going to be achieved:

- Simpler digitalisation (informatisation) of processes and simpler defining of IT system requirements, accompanied by a significant risk reduction;
- Establishment of efficient business processes which reduce operational costs and enable systematic cost control, workload estimations and adjustments to the varying business circumstances;
- Identifying all stakeholders, activities they perform, their resources and the supporting documentation;
- Clearly established and separated process responsibilities of the stakeholders, especially in complex business processes involving several organisational units;
- Simplified interaction with external stakeholders.

The activities within the scope of this measure are the following:

- Analysis of the requirements of and plan of harmonisation with the ISO 18091 standard;
- Analysis of the requirements of and plan of harmonisation with the ISO 37120 standard / ISO 37120 certification;
- Defining the key performance indicators catalogue;
- Performance assessment;
- Reporting;
- Continuous improvement and monitoring.

Challenges

All of the procedures and processes must be clear, expedient and documented, which implies maximal utilisation of digital technologies and experts. Speed, i.e. efficiency, is an important indicator in the evaluation of administrative work. The ISO 18091 standard also includes a city's business process architecture (BPA), as well as a service development and service provision process model, which enable comparison and identification of differences between the practices of the City of Zagreb and normative practices, help design key activities for improving City services and identify internal owners of individual processes, services and innovations within a Smart City system.

With the goal of providing a timely, reliable and quality public service to its users and in order to ensure a higher standard of living for all citizens, as well as create an encouraging entrepreneurial environment, the City of Zagreb is developing a system for business process management and a system for change management on the basis of the ARIS value engineering methodology and the ARIS technology platform, which is the world's leading digital platform for agile and flexible change management.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds (Operational programme Competitiveness and Cohesion);

- Programmes of the European Commission (Horizon 2020, INTERREG etc.).

Key participants

- City of Zagreb.

Priority measure 2.7: Development of a local infrastructure for spatial data – ZIPP

Goals and activities

Almost all data used in smart city systems has its spatial component and one of the key questions for the vast majority of smart services is *Where*? (location of a certain occurrence, service, device, citizen, economic operator etc.). Spatial data is collected, processed, visualised, analysed and utilised in a way that is specific compared to other, e.g. alphanumeric, data. For the purpose of increasing efficiency of spatial data utilisation and exchange, several models and standards have been established, e.g. ISO 191xx, Open Geospatial Consortium (OGC) etc, with the most significant regulation on the EU level being the INSPIRE Directive (2007/2/EC, Infrastructure for Spatial Information in the European Community). An infrastructure for spatial data encompasses elements such as metadata, interoperability, network services, data exchange and coordination activities.
The City of Zagreb is developing a local infrastructure for spatial data, the Zagreb Infrastructure for Spatial Data (ZIPP), which encompasses the activities of coordination, standardisation, inventory control and advanced utilisation of spatial data, that is at disposal of city administrative bodies, companies and institutions. Developing a smart city requires an exceptional increase in the amount of spatial data, collected by various devices (IoT) or citizens (crowdsourcing, citizen science, volunteered geographic information), which generates new challenges in spatial data management and utilisation.

The most important goals and measures:

- Informed decision-making in City management and planning , based on quality spatial information;
- Standardisation of data utilised by the city bodies;
- Open geospatial data – city bodies should make data available to industry, science and citizens;
- Utilisation of new sources of data (big data) in the city bodies' business processes;
- Connecting the local infrastructure for spatial data with the national and EU ones.

Expected results:

- Drafting of City development plans of higher quality, accompanied by a more efficient implementation of those plans;
- Exchange and utilisation of data between city bodies;
- Development of an economy based on innovations and information technologies and development of science;
- Higher citizen involvement in the process of the City management ;
- Development of innovative solutions and processes in the spatially oriented operations of city bodies;
- Data exchange and comparison with cities and regions of the EU.

The activities within the scope of this measure are the following:

- Functioning of the Coordinating Body for the Development of the Zagreb Infrastructure for Spatial Data;

- Cooperation with the scientific community with regards to researching the possibilities of implementing new data sources;
- Development of the ZIPP Geoportal, as a focal point for searching, viewing and utilising the City of Zagreb spatial data ;
- Standardisation of the City of Zagreb spatial data;
- Performing of the City of Zagreb's obligations outlined in the INSPIRE Directive;
- Preparation of projects aimed at spatial data utilisation in City planning and management.

Challenges

- Lack of coordination between the city bodies;
- Lack of specific competencies in the city bodies;
- Lack of awareness of and desire for making spatial data from one's purview accessible to other city bodies, especially city companies;
- Issues regarding project funding.

Possible implementation financing sources

- City of Zagreb Budget;
- European Structural and Investment funds (Operational programme Competitiveness and Cohesion);
- Programmes of the European Commission (Horizon 2020, INTERREG etc.).

Key participants

- City of Zagreb;
- APIS IT d.o.o;
- The scientific community.

Strategic area no 3: Smart energy and utility services management

Priority measure 3.1: Smart electrical network management

Goals and activities

The basic goal is to establish, i.e. build an electric energy system which intelligently integrates and coordinates the activities of all the users connected to the network (producers, suppliers, consumers and prosumers), with the purpose of efficiently ensuring a sustainable, economically viable, environment-friendly and safe supply of electric energy.

The development of the smart network infrastructure and services is grouped into areas of high, middle and low voltage. High voltage encompasses the infrastructure (110kV and more) necessary for the development of a smart electricity transmission system. The Croatian Transmission System Operator (HOPS) is responsible for operating, maintaining, building and developing the transmission network. Middle and low voltage networks fall under the purview of HEP – ODS (Elektra Zagreb).

A smart electrical network should be considered a two-way channel for exchange of electricity, based on a smart remote reading system, making it the only option for ensuring system monitoring and serious planning and investments, as well as for providing higher

service quality to consumers.

In accordance with the Electricity Market Act (Official Gazette no 22/13, 95/15 and 102/15), as the owner of the 110 kV-400 kV transmission network, HOPS is responsible for drafting and adopting ten-, three- and one-year transmission network development investment plans, with a previous approval of the Croatian Energy Regulatory Agency (HERA). The City of Zagreb smart transmission system includes smart infrastructure (ducts, transformers, ICT infrastructure, reactive power compensation devices, active power regulation devices etc.). The City of Zagreb smart transmission system development plan should include:

1. Smart management of the transmission system;
2. Safe energy supply in the City of Zagreb area, with the possibility of energy storage and energy production from locally available sources;
3. Smart infrastructure, including energy reservoirs, demand response and production facilities.

When it comes to electricity production, a bigger image has to be taken into consideration and, in coordination with the national programmes (and in influencing them via pilots, programmes and institutionally), the establishment of cogeneration and renewable energy plants should be enabled, primarily by utilising the existing city life by-products (cogeneration as part of sanitation and future waste depot, industrial plants), as well as projects such as the Zagreb on Sava and others, with the potential of establishing small hydroelectric, photovoltaic and other power plants.

HEP – ODS is the company responsible for operating, maintaining, building and developing the City of Zagreb distribution network.

In planning the development of the smart distribution system of the City of Zagreb, the following components and stakeholders must be taken into consideration:

1. Smart infrastructure
   a. Ducts (installation of sensors, utilities infrastructure, channels etc, geographic information system (GIS));
   b. Substations (sensors, remote readings, remote control, adjustment of the voltage ratio of a charged transformer, free feeders, the possibility of utilising renewable energy sources according to levels of voltage, the possibility of connecting energy reservoirs, the possibility of construction of e-vehicle charging stations, GIS).
2. Smart meters and services for users
   a. Households, residential buildings, individual houses – HEP – ODS must be enabled to comprehensively collect the consumption data for all energy sources via the most suitable channel of electricity meter or via communication collectors on all structures, which would collect and process data on all energy sources, and, gradually, enable comprehensive monitoring and management of the building management systems (BMS). Synergy can generate larger savings. Building or apartment level BMS (Smart Home) can enable additional advanced services. It is vital to encourage the defining of services, consumption monitoring, advanced tariff systems, Smart Home, smart appliances and lighting, energy production from renewable energy sources, energy storage, consumption management, energy efficiency measures, indicators, provision of supporting services to system operators etc.
   b. Small- and middle-sized enterprises and crafts should be encouraged to create

new products and services for traditional users, as well as to implement, maintain, develop and produce the mentioned smart systems.

c. The industry should launch initiatives for production of meters, information systems, modems, smart appliances, storage systems, renewable energy sources and other equipment and offer them as services to smaller companies, as well as to end-users as off-the-shelf solutions. The ICT industry and smart equipment and system manufacturers must act as pioneers of change which, in cooperation with the academic community and the City, as a strategic stakeholder, provide advanced solutions to all users and encourage these solutions by ensuring the infrastructure and advanced stimuli.

d. Public buildings (installation of smart meters, defining of services, consumption monitoring, tariff systems, Smart Home, appliances, lighting, energy production from renewable energy sources, energy storage, consumption management, energy efficiency measures, indicators, provision of supporting services to system operators, GIS).

e. Public lighting (managing, operating, energy efficiency, power outage, indicators, GIS etc.).

f. Transport (electric vehicles, multi-purpose charging stations, other electrical transport, harvesting braking energy within the network, indicators, GIS).

3. Building owners, building operators – the establishment of smart building management systems (smart building meters, utilisation of renewable energy sources, lighting, consumption management, energy efficiency, indicators etc.) should be encouraged and the creation of a market for innovative ESCO or similar models for management of such private user systems should be enabled.
4. Suppliers and aggregators (smart services aimed at end-users)
   a. The HERA rules;
   b. Stock exchange (fifteen-minute-trades and shorter);
   c. Providing the system with reserves.
5. End-users (production, energy storage, aggregating, co-operatives, indicator, GIS)
6. Urban planning in the City of Zagreb area – smart network zones, connections with other advanced infrastructure, energy-related ICT platform, interaction of public charging station infrastructure and buildings, indicators, GIS. The ten-year planning must anticipate the possibility of utilisation of electric vehicles as electricity depots and, through dynamic tariffs, enable both storage and purchase of electricity via electric automobiles on an hourly basis.

The City of Zagreb is encouraging the implementation of these activities and will participate as a partner, with the goal of improving the citizens' quality of life.

Challenges

Key challenges in the implementation of all the activities encompassed by this measure have to do with involvement and coordination, that is, joint planning and acting of all stakeholders (HEP – ODS, HOPS, building owners and operators, the City of Zagreb, distributors of other energy sources and water), which is of vital importance for the implementation.

Specific implementation challenges include the following:

- Coordinating development plans (of transmission, distribution, the City of Zagreb, the users);
- Development of a joint communication platform or information exchange standard;

- Ensuring funding and business models;
- Education and raising of awareness;
- Activating the existing "dead capital" owned by the City, such as diesel generators on numerous locations, which might provide HOPS with reserves, reducing consequently energy expenses.

One of the challenges will be to provide, in a regulatory way, a possibility for HEP – ODS to lease out its communication channel for the collection of consumption data for all energy sources or a centralised collection of such data, ensuring, at the same time, anonymity, in accordance with the GDPR.

Possible implementation financing sources

- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors (primarily HEP – ODS and HOPS);
- Private building owners.

Key participants

- HOPS;
- HEP – ODS (Elektra Zagreb);
- City of Zagreb;
- Zagrebački holding d.o.o;
- ZET d.o.o;
- Regional Energy Agency (REGEA);
- Building operators;
- Distributers of other energy sources and water (VIO, HEP – Toplinarstvo, GPZ and others);
- Suppliers (HEP, RWE etc.);
- University of Zagreb.

Priority measure 3.2: Smart centralised heat system management

Goals and activities

This measure's strategic goal is to establish a smart central heating system (CHS) in the City of Zagreb area, which would enable safe and sustainable production, distribution and supply of heat energy, as well as to establish a set of smart services for end-users, which would bring losses to a minimum, properly allocate consumption and generate charges on the basis of real consumption, with the objective of reducing CO_2 emissions and increasing efficiency. The largest heat energy distributor and supplier in Zagreb is HEP – Toplinarstvo, which is why most of the following measures/activities have to do with improving the CHS owned by that company, while the stimulative measures have to do with private and public residential and commercial structures.

The specific goal is to upgrade the existing central heating system of the City of Zagreb to

the 4th generation of low-temperature smart CHS, with a constant expansion of the heat network, increase of the production of heat energy from renewable energy sources and utilisation of waste heat. The system must be simultaneously upgraded on several levels in order to develop a modern 4th generation CHS.

The further informatisation of the system should enable remote readings from as many heat substations as possible. Systematic consumption monitoring should be enabled for end-users via the User Portal in order for them to be able to optimise their own consumption. A central monitoring system should also be implemented in order to facilitate advanced planning and prompt malfunction detection, as well as remote troubleshooting. The production system should be optimised, losses reduced, minimal CO_2 emissions achieved and end-user service experience improved by anticipating consumption.

In order to reduce heat energy consumption of the existing structures connected to the CHS, consumers' habits should be steered via construction interventions and smart management systems. Reduction in consumption and required power can be ensured in residential, commercial and multi-purpose buildings, as well as in public buildings, by thermally insulating the building envelopes, replacing the carpentry, heat recovery in ventilation, restoring heating fixtures and via smart management, which automatically generates lower temperatures of the CHS input and output ducts. Smart heat energy meters and automated individual consumer controls for internal temperature regulation must be installed in the renovated structures and data must be entered into a comprehensive information and communication system for the collection and processing data on the consumption of heat energy, consumer habits and needs and data on the heat dynamic of buildings. All the consumers in the renovated structures should be able to heat consumable hot water via CHS. Each building should be surveyed for the possibility of storing heat energy, producing heat energy from renewable energy sources, utilising waste heat and recovery of energy into the heat network. Revitalisation, informatisation and automatisation of heat substations should be carried out in coordination with the heat energy distributor.

Activities within the scope of this measure can be grouped into following programmes:

1. Establishment of a centralised Smart Remote Reading and Heat Energy Distribution and Supply Management System
    a. It is necessary to carry on with the establishment of a centralised information system for the collection, processing, automated charging, integration with other systems (loss reduction, network planning) and a gradual transition to a Central Heat Substation Monitoring System. System expansion should enable control of heat substation parameters and provide a higher service quality through remote monitoring of energy consumption and system pressure and temperature or through optimising pump operations, as well as enable integration with heat cost allocators or internal heat meters, which could potentially solve the existing problems regarding allocators and just allocation of heat energy consumption. The above-mentioned represents a foundation on which the complete digitalisation of the fundamental part of business operations can be conducted, as well as a foundation for numerous savings;
    b. Development and implementation of a smart system for charging heat energy consumption, as well as that of the supporting business system;
    c. Enabling allocators to be automatically read via communication devices in heat substations;

d. Upgrading the models for management, operation, anticipation/estimation, optimisation, simulation and planning, in accordance with the modern heat energy market conditions.

2. Revitalisation of structures connected to the CHS programme (energy efficiency renovation of buildings)
   a. Renovating building envelopes, carpentry, heating fixtures, ventilation systems and recovering heat, as well as renovating and upgrading the system for the preparation of sanitary hot water and renovating heat substations;
   b. Informatisation and automatisation of structure- or individual-consumer-level systems, installation of sensors and collection of data, installation of devices for individual measuring of heat energy consumption, thermostatic valves;
   c. Mapping structure-, neighbourhood- and city-district-level heat needs (GIS, thermographic cameras, existing data);
   d. Business possibilities arising from CHS ICT;
   e. Encouraging production from renewable energy sources, energy storing, utilising waste heat and heat pumps etc.

3. Heat network revitalisation and informatisation programme
   a. Revitalisation of critical parts of pipeline with the use of modern technologies and required upgrades;
   b. System informatisation, installation of sensors, flow, pressure, temperature, data collecting, installation of remotely controlled valves, pumps, remotely controlled substations;
   c. Possibilities of and requirements for connecting heat energy production and storage facilities and sources of waste heat;
   d. Development of an information and communication system for data storage and exchange.

4. Heat energy market development programme
   a. Strategic development of the CHS of Zagreb and the agglomeration;
   b. Remote cooling system as part of CHS;
   c. Integration of utilities infrastructure into a smart energy system.

Challenges

HEP-Toplinarstvo d.o.o. conducts the activities of production, distribution and supply of heat energy and the activity of buying the heat energy for the end-user categories of households, industry and commercial consumers in the Zagreb, Osijek, Sisak, Velika Gorica, Samobor and Zaprešić areas, in addition to being the largest producer of heat energy in Zagreb.

Energy efficiency renovation of buildings in the Republic of Croatia is being carried out in accordance with the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia, which was adopted by the Government of the Republic of Croatia in 2017, that is, in accordance with single energy efficiency renovation programmes (for public, commercial and residential buildings and households). The Ministry of Construction and Physical Planning (MCPP) is responsible for carrying out all the activities.

Key challenges in the implementation of all the activities encompassed by this measure have to do with involvement and coordination, i.e. joint planning and acting of all stakeholders (HEP-Toplinarstvo, MCPP, building owners and operators, the City of Zagreb, Gradska plinara Zagreb d.o.o.), which is of vital importance for the implementation.

Specific implementation challenges include the following:

- Coordinating development plans of HEP-Toplinarstvo, Gradska plinara Zagreb d.o.o, the MCPP programmes and plans, i.e. those outlined in the national strategy, and the City of Zagreb plans, as well as involving the building users/owners and operators in the entire process;
- Development of a joint communication platform or information exchange standard;
- Ensuring funding and business models;
- Education and raising of awareness.

The City of Zagreb will participate as partner in carrying out these activities, with the goal of improving the citizens' quality of life.

Possible implementation financing sources

- European Structural and Investment funds, the Integrated Territorial Investment mechanism;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private and public companies and investors (primarily HEP-Toplinarstvo, in accordance with development plans, priorities and financial possibilities);
- Private building owners.

Key participants

- HEP-Toplinarstvo;
- City of Zagreb;
- Operators of residential buildings (Zagrebački holding d.o.o. – GSKG d.o.o. and others);
- Owners of the buildings connected to the CHS;
- Ministry of Construction and Physical Planning;
- Regional Energy Agency (REGEA);
- University of Zagreb.

Priority measure 3.3: Smart water supply and drainage management

Goals and activities

The general goal of this measure is to build a smart water network monitoring system and a waste/precipitation water drainage system by expanding the remote readings and charging system, as well as enable the citizens to monitor their own consumption and pay on the basis of real consumption. It is necessary to advance operations in general and reduce system losses by drafting detailed plans of development of infrastructure and available services, as well as by implementing carefully prepared actions in the City of Zagreb area.

This measure consists of five specific goals for the water supply and drainage system:

- Digitalisation of business on the basis of the strategic Industry 4.0 concept (CHS, IoT, IoS, IoD, IoP, big data, predictive analytics);
- Further development of the Automated Water Meter Reading (AWMR) system for remote (smart) readings of consumption on main water meters and automatisation of the charging system, as well as upgrading the level of service quality while, at the same time, significantly lowering end-users' costs (less expensive and more accurate readings, loss reduction, charging on the basis of real consumption (instead of estimation), fewer complaints, change in end-users' attitudes etc.);
- Further development of the Water Leakage Management (WLM) system for the reduction of losses and leakage and upgrading the functionalities of the water supply system by replacing worn-out pipelines, installing smart equipment for reading, monitoring and control, as well as by optimising operation and management modes. Due to differences in status of single parts of network (the old and new system), it is necessary to carefully specify the district metering areas (DMA) in order to achieve optimal cost efficiency when installing smart equipment and replacing worn-out parts, as well as to introduce the early water loss detection method;
- Establishment of a smart drainage management system;
- It is necessary to establish a smart energy management system within the water supply and drainage system. One of the rational energy management measures includes redefining, reducing and optimising the number of utility storage points per metering area.

The existing software (e.g. Končar MARS, SCADA, the WLM application etc.) should be upgraded and expanded in order to enable simulations, as well as advanced planning and management. It is also necessary to implement, i.e. further develop a system for contracting, sales and charging (enterprise resource planning – ERP) in order to exchange information more efficiently and to create an advanced user portal modelled on the MojVIO portal. A commercial software for simulating system operations and for simulating connection with other networks, that fits within the budgetary restrictions, should be selected.

Activities within the scopes of the four outlined goals are grouped below.

Upgrades and expansion of the remote reading system (AWMR) – activities

- Increasing the number of main meters by expanding and upgrading the AWMR system, installing devices, systematic data collection per DMAs aimed at enabling simultaneous influence on loss reduction in a selected DMA;
- Upgrading and optimising the RISOV charging app, optimising and automatising the charging system and implementing a more sophisticated ERP system, for which preparations have been made;
- Upgrading the water meter data collection module software should enable monitoring and transmission of additional water meter status data (e.g. alarms for unauthorised removal of transmitters etc.);
- All the data collected off the metering equipment should be submitted to the system's upgraded central application (Meter Data Management System), which will distribute the collected data to other applications that require it: the SCADA application which must possess a feature for controlling the governing elements via data collection devices (Water Leakage Management), a loss management system, the GIS for the purpose of infrastructure maintenance, a charging system, as well as other systems,

such as Workforce Management etc;

- The central application must enable data to be received from a remote station, via TCP/IP packets which should be clearly defined and contain, for each measuring point:
  1. Consumption data with the corresponding time indication, tariffs and other information pertinent to charging;
  2. The unique device address in the communication system;
  3. Data on remaining battery capacity for battery-powered devices;
  4. Signal quality data for devices communicating via wireless network (LQI);
  5. Information on modes of connection with superior devices (data path);
  6. Alarm and diagnostics transmission data;
- A software platform which would connect the water supplier and the consumers and provide detailed consumption data in near real-time should be designed. The platform should enable special system regulation, management and operating strategies, that will reduce and relocate consumption, to be drafted. The platform could also enable consumer habits to be influenced and changed, via actions performed in the virtual, physical and social world. Data indicates that implementing such platforms has resulted in reduction of water consumption by 10-20%, as well as that, in most cases, additional infrastructure expansion brought on by peak loads can be avoided. The platform's main consumer-related functions include a detailed consumption profile overview and enable innovative financing schemes, such as dynamic water supply tariffs, as well as alerts about possible leakage;
- The installation of a smart meter reading system and the consumer service implementation should be carried out by sectors:
  1. Households: residential buildings, detached houses;
  2. Small- and middle-sized enterprises, crafts;
  3. Public buildings;
  4. Hydrant system for fire protection and irrigation;
- Comprehensive urban planning, DMAs, a connection with other advanced infrastructure, an ICT platform that is linked with the distribution of electricity, indicators and GIS should be conducted and carried out for the City of Zagreb.

Water supply loss reduction and optimisation – activities

The distribution system of the water supply network is divided into smaller independent units – DMAs, which means that the quality of water distribution to the consumers is not affected in the case of disengagement with the rest of the system, in addition to simplified monitoring of operations and losses. Over 50 insertion type meters and 4 full cross section meters for monitoring and reduction of losses have been installed in two DMAs. The following activities are to be carried out:

- The utilisation of smart equipment, sensors and regulators should be optimised for each DMA and dividing valves should be specially upgraded with leakage detection equipment in order to meter all consumed water in a DMA on its entrance into that DMA. Network sensors should collect time, spatial coordinate, flow and pressure data;
- Depending on the result of the optimisation, manholes for remote metering and reading of water temperature and quality will be selected. The number and functions of smart meters utilised by end-users should be determined for each DMA;
- The number of telemetric hydrants, smart flow meters, smart pressure regulators and structures for metering and regulative equipment should be determined for each

DMA, and plans should be made for the installation of other equipment required for establishing DMAs;

- The number of existing internal water meters in old buildings, which will be connected to the remote reading system, i.e. with the AWMR network, should be determined for each DMA. The AWMR water meters and equipment should be customised for automatized and remote water consumption reading;
- The concept of replacement of regulating valves with smart water turbines / pumps, which will reduce pressure and recover part of the energy required for pumping into the electric energy system (electrical network), should be contemplated for each DMA, as well as for the city as a whole;
- A mathematical model / computer algorithms of the entire water supply network in the City of Zagreb area should be generated in order to conduct numerical simulations and enable predictive consumption management on the basis of the status of the electricity system, electricity production from renewable energy sources in a DMA or in the City area, the status of the electricity market and the predicted water consumption per individual parts of the water supply network. Predictive management will enable pressure reference values to be determined for locations on which pressure is system regulated, as well as enable flow reference values of pumps for filling of water tanks to be determined in order to facilitate the compliance of water distribution pressure with the technical regulations at every point of the water supply network. Models of correlation of water loss and pressure established at individual network segments should be used in the optimisation process, with the ultimate objective of economically optimal water supply in compliance with the technical regulations. The calculated preset pressure and flow values will be suggested to operators when introducing this mode of operation, via a decision-making assistance system. After the operation mode has been verified, the level of automatisation will keep on rising to the point when human intervention will be removed from the command loop, resulting in the calculated management commands being directly applied to the manageable pumps and valves throughout the water supply system, in accordance with the receding horizon principle;
- The generated algorithm can be further upgraded with identification and estimation algorithms for leakage detection, i.e. for modelling the correlation between losses and pressure, as well as with an algorithm for prompting pipe replacements and installation of additional or reduction of the existing tanks and basins. A digital pipe, duct and inventory of other equipment with the corresponding GIS information will be devised for the needs of simulations.

Smart drainage system – activities

Drainage channels, the waste water treatment facilities network and the precipitation water retention facilities network should be integrated and informatically linked with the water supply system. The existing waste water meters (on over 20 locations) should be integrated into the existing AWMR remote reading system. In order to establish a smart drainage system, the following is required:

- Installation of smart equipment in the system (flow, pressure, contamination and temperature meters, GIS);
- Devising a hydraulic drainage model (pipelines, channels, network, retention);
- Devising a model of transfer and formation of macro- and micropollutatns;
- Embedding the physical model into the existing computing systems for drainage modelling;

- Inspecting the level of compliance with the existing and the future EU water directive system;
- Comparison of databases consisting of desired (simulated) data and databases consisting of real-time data;
- Testing several scenarios for evacuation of waste/precipitation water and anticipating system behaviour under various circumstances;
- Inspecting climate change influence;
- Reducing calculation inaccuracies for waste water drainage via advanced measuring of amount of precipitation and influx of utilised water from water supply systems, wherein data should be compared with the data generated in prediction models;
- Devising a system suitable for increasing water quality and a system for real-time management, e.g. management of retention facilities and pumps with the aim of ensuring the flow of waste water to the central water purification plant in the amount and containing such concentration of pollutants which would enable the plant's optimal operation, wherein predictions for the amount of precipitation water, as well as for the consumption of water from the water supply system should be utilised;
- Examining the drainage system's potential for reducing plant operating costs through pump consumption management, installation of separate retention facilities, tanks, reservoirs and reversible machines (pumps/turbines) or through the monitoring of electricity market and setting up a connection with the electricity system;
- Examining the potential for installation of heat exchanger (for utilising waste heat) and establishing a connection with the centralised heating and cooling system;
- Developing a mutual platform with the water supplier.

Smart energy management system

A system for energy and cost efficient management of the City of Zagreb water distribution system, linked with the active electricity distribution system (virtual power plant), should be established. Such a system could provide significant supporting services thanks to it being flexible in terms of time, when it comes to filling water tanks and ensuring proper system pressure. Furthermore, such a system must take into consideration the predicted water consumption for single parts of the water supply system on the basis of metering and prediction, as well as the factual water losses in various parts of the system. The objective is to maintain the pumping plant and water distribution costs at a minimum, wherein proper pressure, in accordance with technical regulations, must be ensured at all locations in the system. The first step should be the introduction of an operator in the control centre of the water supply system. From there, the level of the system's operational autonomy should be gradually raised.

Challenges

The key elements of the implementation, which are also the challenges, include the following:

- Coordination of development plans (those of Vodovod i odvodnja, ViO d.o.o, the City of Zagreb and the users);
- Further development of applications for smart business advancements (SCADA, WLM, MARS, UPN etc.);
- Further development of a joint communication platform and information exchange standards;
- Further development of remote reading and loss reduction projects;

- Ensuring funding and business models that will support the planned upgrades;
- Following the trends of the imbuing of distribution system information and those of introduction of prediction, identification, estimation and advanced management algorithms into relatively conservative water supply and drainage systems, ensuring cybernetic security in opening and permeating the system;
- Education and raising of employees and system users awareness .

Possible implementation financing sources

- Zagrebački holding d.o.o. – Vodoopskrba i odvodnja d.o.o, in accordance with development plans, priorities and financial capabilities;
- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- City of Zagreb;
- Zagrebački holding d.o.o;
- Vodoopskrba i odvodnja d.o.o;
- University of Zagreb;
- Companies that manufacture the existing WLM and AWMR systems.

Priority measure 3.4: Smart gas network management

Goals and activities

The goal of this measure is to upgrade the existing gas network to a smart gas network which would be closely connected with the electricity, heat and transport sectors and result in maximal energy efficiency for both the end-user and distribution. The measure is based on development plans for smart infrastructure and available services. It includes the following segments:

1. Revitalisation of structures connected to the gas network (energy efficiency renovation of buildings)
   a. Renovating building envelopes, carpentry, heating fixtures, ventilation systems and recovering heat, as well as renovating and upgrading the system for the preparation of sanitary hot water and renovating exhaust gas systems;
   b. Informatisation and automatisation of structure- or individual-end-user-level systems, installation of installation of green IQ gas appliances with intelligent connectivity and remote control, installation of smart gas meters, installation of smart thermostatic valves on individual heating fixtures, smart gas detection systems, installation of smart gas facilities which can be remotely monitored and controlled;

2. Gas network revitalisation, development and informatisation plan

a. Further reconstruction of worn-out parts of the gas distribution system and economically efficient and technically viable upgrades;
b. Hydraulic modelling aimed at optimising real-time operations of the gas distribution system;
c. Further system informatisation and data collection via installation of flow, pressure, temperature, wind speed and direction, cathodic protection potential, safety and real-time sensors for quality control of odorants in natural gas (odour on-line); remote management of the gas distribution system with the purpose of maintaining the distribution system parameters within the limits required for safe and reliable gas delivery;
d. Upgrading the models for management, operation, predicting/estimation, optimisation, simulation and planning, in accordance with the modern heat energy market conditions;
e. Gas storage possibilities and conditions within the existing network (hourly, daily, seasonal etc.);
f. Possibilities and conditions for construction and connection of storage facilities;
g. Possibility of supplementing gas appliances and facilities with energy efficient gas technologies for smart utilisation of the gas distribution system (microcogeneration, cogeneration, trigeneration, gas condensing boilers and gas heat pumps, which can easily be combined with solar collectors, gas air conditioning devices, gas fuel cells, small home filling stations for vehicles running on compressed natural gas and regular natural gas filling stations);
h. Possibilities and conditions for injecting biomethane into the gas network;
i. Possibilities and conditions for injecting unconventional types of gas into the gas network (synthetic gas, landfill gas and gas generated in waste water processing plants, biogas, hydrogen etc.); harmonisation of the control system, Wobbe index;
j. Development of an information and communication system for data storage and exchange, smart management of the system, increased transparency and consumption monitoring.

3. Gas market development
   a. Regulations and legislation;
   b. Strategic development of the gas distribution system and agglomeration;
   c. Integration of utilities infrastructure into a smart energy system;
   d. Gas system market simulator, issuing green certificates.

Challenges

The key challenge in implementing these activities has to do with involvement and coordination, i.e. joint planning and acting of all the stakeholders (Gradska plinara Zagreb d.o.o, Gradska plinara Zagreb – Opskrba d.o.o, the Ministry of Economy, Entrepreneurship and Crafts, the Ministry of Environment and Energy, building owners and operators, the City of Zagreb), which is of vital importance for the implementation.

Specific implementation challenges include the following:

- Coordination of development plans (Gradska plinara Zagreb d.o.o, PLINACRO d.o.o, the City of Zagreb), as well as involvement of end-users and building operators in the entire process;
- Development of a joint communication platform or information exchange standard;

- Ensuring funding and business models;
- Education and raising of awareness.

Another challenge is posed by the development of the gas system, which must comply with the ever more demanding standards imposed by the EU directives and national legislation, regarding activities aimed at increasing energy efficiency and decreasing energy consumption in direct consumption. Improving the air quality in urban environments can be achieved most easily, quickly and in the most flexible way by utilising natural gas in transport and building management, since it significantly contributes to the reduction of greenhouse gas emissions and air pollutants, improving thereby the quality of life and saving human lives. The combustion and exhaust transport efficiency and safety also should be maximised. The energy efficiency of the gas system should be maximised by way of promoting energy efficient gas technology solutions, microcogeneration, cogeneration and trigeneration systems. Introducing renewable energy sources (synthetic gas, landfill biomethane and gas generated in waste water processing plants etc.), as well as issuing of green certificates should be considered. The gas system digitalisation will enable end-users to better predict their consumption, control it and, in that way, avoid issues such as peak loads, system upgrades and optimisation of storage utilisation. Integration with electricity transport systems must be carried out.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors;
- Zagrebački holding d.o.o. – Gradska plinara Zagreb d.o.o.;
- Private building owners.

Key participants

- Gradska plinara Zagreb d.o.o;
- PLINACRO d.o.o;
- Gradska plinara Zagreb – Opskrba d.o.o. and other suppliers;
- City of Zagreb;
- Operators of residential buildings (Zagrebački holding d.o.o. – GSKG d.o.o. and others);
- Owners of the buildings connected to the gas distribution system;
- Ministry of Construction and Physical Planning;
- Ministry of Environment and Energy;
- Ministry of Economy, Entrepreneurship and Crafts;
- Croatian Energy Regulatory Agency (HERA);
- University of Zagreb.

Priority measure 3.5: Smart public lighting management

Goals and activities

The goal of this measure is to develop a smart, energy efficient and environment-friendly lighting system which would be integrated with the smart city infrastructure in its physical, networking and application layers. Smart lighting primarily implies an intelligent adaptive lighting system that can adapt to the needs of a city space in both time and space domains, by monitoring temporal and spatial parameters (level of space crowdedness, affected by density of pedestrians and vehicles) with corresponding sensors, which the system can share with the smart city sensorial network.

By transferring the lighting system to the semiconductor technology, savings of up to 40% can be achieved, whereas another 40% can be achieved by implementing intelligent adaptive controls. Maintenance costs also need to be cut by utilising long-lasting lighting fixtures (up to 25 years of intensive use). System utilisation can be optimised throughout the entire service life, including installation, utilisation, maintenance and recycling, by implementing intelligent systems in the application layer. All activities, used materials and parts are monitored in the application layer of the cloud. Modern smart lighting systems also affect health positively by eliminating UV radiation, light pollution and interference, as well as by utilising a high quality light spectrum and optimised light colour for pedestrian and vehicular traffic zones, which, therefore, become safer. The effect on the environment is also mitigated by reducing the production of dangerous waste, which is symptomatic of traditional lighting systems (lead, heavy metals and harmful gases). Cities are primarily concerned with lighting systems from the perspective of the physical layer because city ownership of lighting infrastructure represents a highly valuable economic resource, since such infrastructure, considering its physical density and location, as well as its access to energy infrastructure, represents an ideal physical platform for the majority of field sensorial (traffic, noise and air quality sensors, GPS locators, videocameras etc.), signal (digital indicators and pointers, speakers etc.) and communication (base stations for broadband Internet and telecom systems) elements.

The City of Zagreb should utilise features of big data systems regarding data collection and distribution in the application layer and field communication with citizens, in order to achieve the economic advantages of utilising physical lighting infrastructure. The lighting systems infrastructure possesses high economic potential, since profits predominantly outweigh the total cost of the lighting service provided to citizens. Optical communication infrastructure aimed at lighting points need to be installed as part of the smart lighting systems installation process , in accordance with the predictable density of base communication stations of the future ICT systems.

The City of Zagreb and the European Investment Bank have signed a Contract for Funding of Project Development Services for the Energy Efficient Reconstruction of Public Lighting in Zagreb (RePubLEEc) project, which is encompassed by the ELENA (European Local Energy Assistance) financial instrument, that provides grants for the implementation of activities within the scope of the Horizon 2020 programme. The main objective of funding the Project Development Services is to prepare and initiate reconstruction and modernisation of the City of Zagreb public lighting system, with the purpose of achieving operative cost savings (electricity and maintenance) and increasing citizen safety and standard of living in the City of Zagreb. The project was initiated on 1 January 2018 and is estimated to last for 36 months.

In carrying out the RePubLEEc project, i.e. reconstructing and modernising the City of

Zagreb public lighting system, strives will be made to take full advantage of the possibilities for installing communication and signalisation elements and field sensors. Integration of all systems with the data aggregation platform (Measure 1.1) will also be strived for.

Challenges

The technological challenge lies in the identification of a proper technological direction and the selection of an existing smart lighting concept which would be widely and openly enough positioned to enable long-term and broad integrations with other smart city systems. The method of monitoring individual lighting fixtures service life cycle in the conditions of exquisitely rapid technology development also needs to be devised in order to enable long-term system maintenance.

Another challenge lies in synchronising lighting systems with long-term urban development plans in a way that situates the lighting systems into the urban exterior as adequate and aesthetically acceptable elements. The financial potential of the fact that the City owns the physical public lighting infrastructure especially needs to be utilised, since such infrastructure is suitable for facilitating the majority of the physically distributed elements of modern ICT and smart city systems.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- City of Zagreb;
- Regional Energy Agency (REGEA);
- Private companies dealing with public lighting installation and maintenance and installation and maintenance of ICT systems and devices.

Priority measure 3.6: Integration of smart buildings and the infrastructure

Goals and activities

The goal of this measure is to enable information exchange between buildings and the infrastructure in a regulated way, wherein buildings receive the information about the conditions of exchange of energy sources with the network for a foreseeable period and, simultaneously, on those conditions, inform the network about the planned energy source exchange profile for a time horizon in the near future (one or two days). A simple method of connecting buildings to such information exchange platforms will provide a strong further impetus, increase the efficiency of the buildings and distribution networks since it opens many opportunities for savings on both sides, as well as open a platform for developing the software of small- and middle-sized companies aimed at improving the functionalities of

various building configurations integrated with the network.

Activities aimed at achieving this goal are the following:

- Advanced energy source meters and a micronetwork need to be introduced. Potential unauthorised consumption can be identified with the help of smart meters and consumers can be classified per levels of energy efficiency. ESCO services can be provided on the basis of consumer evaluations, i.e. the most rewarding energy efficiency investments can be determined. The advanced meters also facilitate the introduction of micronetworks in certain city districts. They would be introduced in the city districts with buildings that produce their own energy (photovoltaic systems, CHP etc.) and can provide flexibility to the system (by having their own reservoirs or are equipped for smart internal heat energy management). This would result in reduced costs for all users within a micronetwork, who would be jointly optimised towards an external network. Such development would also fulfil the preconditions for introducing blockchain technology (peer-to-peer trading) into the energy system. The starting point could be the buildings owned by the City of Zagreb, the faculties and other public buildings interested in modern technologies.
- Furthermore, it is necessary to transform city buildings into prosumers and the existing resources need to be activated in order to provide the system with reserves. In the long-term, it is necessary to implement technologies for energy production from renewable energy sources (e.g. photovoltaic panels etc.) in all buildings which can facilitate such upgrades, i.e. stronger integration of renewable energy sources into the system should be enabled, in which activities the City of Zagreb, as a big consumer, can participate with the purpose of regulating the system. Implementation of such solutions should be encouraged in both residential and commercial buildings. A significant number of diesel generators owned by the City of Zagreb (City Administration building, the City Assembly and numerous other locations), which are generally standing by and generating expenses, could expedite the implementation. The possibility for including the diesel generators in the provision of tertiary reserve to HOPS, by utilising biofuel or installing biofuel-powered engines, as well as by automatisation and networking, resulting in additional income for the City, should be researched.
- The city distribution systems need to be connected with buildings (public and private) for information purposes via a platform which would enable exchange of data on predicted consumption, energy pricing in time and requests for providing supporting services to infrastructural systems. This would result in numerous possibilities for savings in maintaining comfortable working and living conditions in the buildings, which would incidentally be encouraged to implement energy management systems that, in real-time, coordinate all the relevant energy subsystems of a building, which would ultimately enable innovative software development for the purpose of optimising both building functionality and the infrastructure (exemplified in the CEKOM GEZI platform, or the Centre for Competencies in Advanced Energy Management in Buildings and Infrastructure, ran by the Innovation Centre Nikola Tesla). In doing so, a strong impetus would be given to software and application development in various high-tech companies, and especially small- and middle-sized companies.

Challenges

At this moment, the most demanding challenge in connecting buildings with the

infrastructure lies in the relatively underdeveloped market of various energy sources and in the required installation of advanced meters for all users that would be connected to this permeated system. Significant technical challenges lie in ensuring data privacy and high level of cybernetic security.

Optimisation routines can be provided to either buildings or networks by various companies, on the basis of a defined environment in which they should function, but information exchange interfaces would also have to be defined. Several pilot projects from this area are being carried out, including the 3Smart project, which is coordinated by the Faculty of Electrical Engineering and Computing and is being carried out in six Danube Region countries. The project is implementing building-to-network interaction in five separate pilots, which are expected to result in recommendations regarding the above-mentioned interfaces.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors (primarily HEP ODS and HOPS);
- Private building owners.

Key participants

- Distribution systems operators;
- Energy suppliers;
- End-users;
- City of Zagreb;
- Regional Energy Agency (REGEA);
- University of Zagreb.

Strategic area no 4: Education

Priority measure 4.1: Introduction of contemporary information and communication technologies into primary and secondary schools

Goals and activities

The goals of this measure include the development of digital skills, increase in the quality and efficiency of the learning process, and creation of equal opportunities for primary and secondary school students by introducing contemporary IC technologies, smart devices and solutions into all primary and secondary schools in the City of Zagreb area , i.e. equipping all schools so that they be available to every student. The general goal is the creation of a smart learning environment.

A smart learning environment is characterised by three key features: (a) contextual sensitivity (support to learning based on online and user status in the real world), (b)

adaptable support (immediate support adaptable to the user from various perspectives, e.g. individual learning and behaviour capacity and to online and real user context), (c) adaptable interface (interface adaptable to the user in the sense of information presentation, study preferences, dynamics and possibilities). User interface can be any mobile device (smartphone, tablet etc.), portable device (e.g. smartwatch) or any computer system installed into devices for everyday use. In short, smart learning environment is tasked with enabling self-learning, services which are self-motivating and personalised.

Smart learning environment needs to be able to motivate a wide variety of users by identifying their competences, learning styles and interests. It has to be able to provide personalised tasks and/or formative feedback and be founded on pedagogical strategies which support:

a) conversation (environment which includes the user into dialogue or facilitates group conversation on a relevant topic or problem);
b) reflection (environment generates self-assessment based on user progress and efficiency; proposal of environment activities and features is desirable; by their adaptation, overall efficiency can be increased);
c) innovation (smart learning environment creatively employs new technologies and technologies in the creation process to support learning and teaching);
d) self-organisation (environment needs to be able to reorganise resources and control mechanisms so that with time efficiency is improved, based on data automatically collected and used to refine environment interaction with users in various circumstances).

Use of technology in everyday life experiences of service users has significant consequences on pedagogical methods of formal education. As the inclusion of smart learning environment into the educational context increases complexity, experts and educational workers have to introduce innovativeness and new pedagogical approaches. One of the key pedagogical challenges in the creation of a learning ecosystem (education) that integrates smart learning is the shift of paradigm to the student as the central factor, which includes formal and informal learning, social and collaborative learning, personalised and situational learning, focus on content application. This particularly opens the question of competences in knowledge creation (technology use competences of teachers themselves) in order to move from low technology use (manipulative use) towards research and building of a relationship between the teacher and the student, students and other learning partners (colleagues, mentors and other people with a similar interest in learning). This implies a move from mastering content towards explicit development of capacities for learning, creation and proactive implementation of students' knowledge. When designing smart learning environment, experts especially point out two key things: user involvement into design and provision of useful support to students by giving them appropriate feedback.

Implementation needs to take into account the fact that all activities related to preparation and monitoring of implementation of educational programmes are in domain of the Ministry of Science and Education, a key participant that needs to be actively involved into implementation.

Implementation also needs to actively include leading companies from the sector of smart solution development and IC technologies by participating in the definition of technologies and smart solutions which will be introduced into primary and secondary schools.

All activities need to be coordinated with the project *e-Schools: Creation of Digital Schools Development System (pilot project),* in which the City of Zagreb actively participates, as indicated in the third chapter.

Within this measure, it is also necessary to upgrade and improve the existing smart solutions, implemented within the educational sector, used by teachers, school administrative personnel and citizens, and connect them with the related smart solutions used by city authorities. The implemented smart solutions have been presented in the third chapter (current state). Examples of possible additional solutions involve:

- E-system support to scholarship award;
- E-system support to maintenance and equipping of education facilities;
- E-system support to Nature School.

Specific technologies, smart solutions and schools into which they will be introduced will be defined on a yearly basis and will be aimed at introduction and monitoring of newest trends and technologies, while taking into consideration the possibilities of implementation financing.

Therefore, the initial implementation activity needs to be the definition of yearly needs for introduction of contemporary information-communication technologies, with a detailed definition of concrete technologies and sources of funds needed for the implementation. Afterwards, it has to be included into the programme of public needs for primary and secondary schools.

Challenges

In the technological sense, it is a challenge to follow the newest development trends and introduce contemporary information-communication technologies with the biggest perspective of further development and future use into schools.

As far as implementation is concerned, coordinated action of key participants (Ministry of Science and Education, City Office for Education, leading companies involved into the development of IC technologies, school staff and students) presents a challenge.

Possible implementation financing sources

- City of Zagreb Budget ;
- State budget;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- Private companies and investors.

Key participants

- City of Zagreb;
- Ministry of Science and Education;
- Croatian Academic and Research Network – CARNET;
- Private ICT companies;
- Primary and secondary schools staff;
- Primary and secondary schools students.

Priority measure 4.2: Promotion and informing of students on new technologies

Goals and activities

The primary goal of this measure is the promotion of smart solutions and encouragement of creativity and innovation among primary and secondary schools students in the City of Zagreb area .

The planned activities include the organisation of competitions in the development and application of ICT solutions and tools. Competitions need to have a pronounced promotional component and visibility so that the number of students participating be as high as possible. It is necessary to foresee individual student competitions and student group or class competitions in order to encourage both individuality and team work.

Competition topics will be defined on yearly basis, according to latest trends and technologies, but also in cooperation with relevant companies involved in the development of smart solutions and information-communication technologies.

Moreover, promotional activities such as printing and distribution of leaflets and promotional materials etc. are also planned.

Challenges

The key challenge is related to promotion, visibility and raising of interest for active participation of the highest possible number of primary and secondary schools students.

Possible implementation financing sources

- City of Zagreb Budget ;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- private companies and investors.

Key participants

- City of Zagreb;
- Ministry of Science and Education;
- Private ICT companies;
- Primary and secondary schools staff;
- Primary and secondary schools students.

Priority measure 4.3: Organisation of regular courses for primary and secondary school teachers and of educational, informative and promotional activities (panels, seminars, workshops etc.) for citizens of the City of Zagreb.

Goals and activities

The basic goal of this measure is increased knowledge and capabilities of target participant groups – primary and secondary school teachers and City of Zagreb citizens in general, resulting in a significantly increased inclusion of citizens as final users of smart solutions and services.

Organisation of regular courses and lectures for primary and secondary school teachers needs to take place in cooperation with experts from leading companies involved in the development of smart solutions and information-communication technologies. Lecture/course topics need to be defined by experts in cooperation with teachers on a yearly basis. This activity needs to be implemented in cooperation with the Ministry of Science and Education. The possibility of formal inclusion of such lectures into classes, introduction of a special elective course on this topic etc. needs to be analysed.

Topics of educational activities for citizens include terms and concepts related to smart cities, information-communication technologies, use of data (*Big data*) – citizens need to be informed on topics such as private data protection, technologies for display and interpretation of data, i.e. have knowledge necessary to use programme solutions and applications (e.g. MojZagreb portal etc.). Moreover, active citizen involvement is key in the sense of providing feedback related to all implemented or planned smart solutions in order to maximally adjust them to needs and requirements.

Specific activities and topics need to be defined on yearly basis, and the implementation needs to actively include representatives of companies which have developed or are developing smart solutions in the City of Zagreb area in order for the information given to citizens be as specific as possible.

Challenges

The key challenge is raising a sufficient level of interest, i.e. participation in educational activities.

Possible implementation financing sources

- City of Zagreb Budget;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- Private companies and investors.

Key participants

- City of Zagreb;
- Ministry of Science and Education;
- Private ICT companies;
- Primary and secondary schools staff;
- City of Zagreb citizens.

Strategic area no 5: Economy

Priority measure 5.1: Raising the level of entrepreneurial competences

Goals and activities

The basic goal of this measure is the creation of an innovative educational ecosystem which needs to be available to all citizens in order for them to develop own entrepreneurial competences.
Entrepreneurial competences have been recognised in the framework of Council of Europe strategic goals as one of the eight key basic competences of every individual in a knowledge-

based society.

Entrepreneurial competences are based on creativity, critical thinking and problem solving, taking initiative and perseverance, and on the capacity of cooperation with others in order to plan projects and manage projects of cultural, social and commercial value.

Entrepreneurial competence, as a key competence, consists of specific and defined knowledge, skills and attitudes.

Entrepreneurial competence implies awareness of various situations and opportunities for turning ideas into action in personal, social and professional activities and understanding of how they occur. Individuals need to know and understand the approaches to planning and management of projects which include processes and resources. They need to understand economy, social and economic circumstances and challenges faced by the employer, organisation or society. They also need to be aware of ethical principles and of own strengths and weaknesses. Entrepreneurial skills are based on creativity which includes imagination, strategic thinking, problem solving and critical and constructive thinking within the framework of development of creative processes and innovations. They involve the capacity to work both independently and in a team, as well as the capacity to mobilise resources (people and objects) and perform activities. This involves the capacity to make financial decisions related to price and value. The capacity of efficient communication, negotiation and addressing uncertainty, ambiguity and risk, which are part of making informed decisions, is also important. Entrepreneurial attitude is characterised by a sense for initiative and action, proactivity, focus on the future, courage and perseverance in goal achievement. It involves a desire to motivate other people and value their ideas, empathy and care for people and the world, as well as accept responsibility while applying ethical approaches in the whole process.
It is necessary to simultaneously develop two concepts of entrepreneurship education: broad and narrow. The function of the broad concept of entrepreneurship education is the development of entrepreneurial inclinations, skills and capabilities, which includes the development of certain personal virtues such as creativity, initiative, independence, responsibility and other qualities, as well as adoption of basic economic concepts. The narrower concept is that of entrepreneurship education and training aimed at establishment of economic operators and their management.
Along with the development of entrepreneurial competences, it is necessary to improve the use of digital technologies in education along with the parallel development of digital competences necessary for doing business in the digital transformation age.
Digital competence involves secure, critical and responsible use of digital technologies for studying, work and social participation. It includes IT and data skills, communication and cooperation, creation of digital content (coding included), safety (including digital welfare and cybersecurity competences) and problem solving.

Digital education availability offers equal accessibility to citizens of various economic, cultural, social and physical backgrounds.
ICT implementation aimed at the development of entrepreneurial competences needs to enable citizens to access tools for self-assessment, creation of own educational programmes, support and analysis of feedback related to education outcomes. Such an approach needs to foresee needs and adapt to them.

Use of digital communication tools is an important element for change and encouragement

of entrepreneurial culture. Clear, positive and interesting information on challenges and benefits of entrepreneurial career aims to neutralise the negative perception of entrepreneurship in the society.

The pointing out of existing entrepreneurs' achievements is aimed at the promotion of entrepreneurship, its value and impact on the society as a whole and possibility to create or acquire new business goals as career destination.

Appropriate wider public discussion, especially in the media, is necessary for the development of entrepreneurship culture and generation of new, future entrepreneurs.

Activities

- Develop innovative educational programmes, new interactive forms and methods of education for successful development of entrepreneurial competences;
- Develop a system of assessment of educational programmes' impact based on user feedback on acquired knowledge outcomes;
- Development of an IT platform for learning via simulation of business activities;
- Enable every participant in knowledge transfer to apply IC technologies and contemporary educational approaches and encourage their further training;
- Use all available expert potentials of lecturers with practical experience at local, national, regional and international level;
- Create an atmosphere which encourages and supports entrepreneurial thinking, innovation, capacity to recognise opportunities and lifelong learning;
- Develop a system of support to entrepreneurs in order to facilitate their access to current support programmes and develop a system for analysing financing needs;
- Develop support programmes which will increase entrepreneurs' absorption capacities and strengthen capacities for preparation of sustainable and profitable investment projects;
- Develop a system for measuring the effects of active support programmes and informing of creators in order to improve measures;
- Develop a system for networking, exchange of examples of good practice and information among entrepreneurs and for dialogue between entrepreneurs and creators of development policies;
- Encourage dialogue aimed at strengthening the awareness of the role and importance of development of entrepreneurial attitudes, knowledge and skills for future personal and professional development.

Challenges

According to international GEM research (*GEM Croatia 2017*[25]), in Croatia only 33.6% of adults recognise business opportunities, while in the EU, the number is 42.6%, which testifies to a significant difference in the potential determining the entrepreneurial capacity of the country. Moreover, according to the perception of the social status of entrepreneurs, media attention and successful business ventures, GEM research puts Croatia to the low end of the list. In order to increase the potential of citizen inclusion into entrepreneurial activities

[25]Global Entrepreneurship Monitor (GEM) Croatia, 2017 – Što čini Hrvatsku (ne)poduzetničkom zemljom?, available at (in Croatian): http://www.cepor.hr/wp-content/uploads/2018/05/GEM-2017-za-web-FINAL.pdf

and reduce risk of their entrepreneurial ventures not succeeding, it is important to provide a quality educational platform for future and existing entrepreneurs in all business growth phases.

It is necessary to maximally use the existing infrastructure, i.e. established entrepreneurial support institutions, along with continuous expansion and improvement of educational programmes in line with the newest development trends.

Possible implementation financing sources

- City of Zagreb Budget;
- State budget via various entrepreneur training and educational programmes etc;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);

Key participants

- City of Zagreb;
- Zagrebački inovacijski centar d.o.o;
- Croatian Employers' Association;
- Croatian Chamber of Economy;
- Croatian Chamber of Trades and Crafts.

Priority measure 5.2: Financial instruments and alternative sources of financing for early stages of entrepreneurship

Goals and activities

Different phases of company life cycles are characterised by different requirements as to sources of financing. In the initial, i.e. development phase, companies usually have a negative cash flow and weak financial capacity. However, in this phase, the need for financial sources which would be used for the development of new products, prototype testing, new employments and marketing is strong. In the next phase of company growth, all profit is usually used for further development, research activities and commercialisation of new solutions. In the advanced phase, stable sales enable stabilisation and own financing of business and developmental initiatives.

Small and medium-sized enterprises (SMEs) are a vital part of the economy, not only due to making the overwhelming majority of economic operators but also due to their importance for economic development and growth. In fact, it is SMEs that have the key role in innovation processes due to their flexibility and openness to new solutions. One of the basic obstacles to initiation of innovation activities is the lack of affordable financial sources, which experts usually refer to as "financing gap". According to OECD report *Financing SMEs and Entrepreneurs 2014*[26], bank loans are still the most common external source of SME financing, including those most innovative with the highest growth rates. Bank loans are usually not financially convenient and require significant collaterals, which are difficult to secure if you are a company in initial stages of operation. On the other hand, alternative financing (non-bank) models, e.g. *mezzanine* and *crowdfunding* financing and similar, enable companies to improve their capital structure, reduce vulnerability in times of crises and

[26]Financing SMEs and Entrepreneurs 2014: An OECD Scoreboard, available at: http://www.oecd.org/cfe/smes/financing-smes-scoreboard-2014.htm

dependence on the banking system, and enter into the next phase of business growth.

As far as SME access to alternative sources of financing is concerned, there is a strong need for public sector support at all levels. Among others, this support refers to preparation and initiation of campaign at crowdfunding (CF) platforms, running of campaigns aimed at target markets, choice of CF platforms and receiving information on campaign running conditions and process and intellectual property protection.

Zagrebački inovacijski centar d.o.o. manages a pre-acceleration programme which offers financial, infrastructure, mentor and educational support to beginner entrepreneurs and development teams aimed at the development of selected innovative smart solutions. Financial support to the selected teams refers to grants, i.e. de minimis aid. In order to additionally accelerate and encourage the development of smart solutions, the pre-acceleration entrepreneurship development programme has to be upgraded to a full acceleration programme which, along with a suitable seed equity fund, will support the development of innovative smart solutions.

The primary goal of this activity is the removal of the financing gap for innovative companies in their initial stages of operation, i.e. enabling of investments into innovations and growth.

The creation of a financial instrument for early phases of entrepreneurship is a complex process, whose basic steps/activities are:

1) Assessment of financing needs

At the very beginning, it is necessary to make a detailed demand analysis, i.e. ascertain the number of innovative companies in early stages of operation and their specific needs for financing. Moreover, it is important to understand future trend movements and the impact of the measures proposed for entrepreneurship development. Besides the demand, it is necessary to analyse the existing offer of financial sources, which currently primarily refer to bank loans as the primary source of financing and their shortcomings.

2) Definition of financial fund size

Prior analysis is followed by demand assessment, resulting in the definition of the desired financial fund size in the sense of financial capacity.

3) Definition of investment strategy

The definition of investment strategy involves decisions on the sectors into which to invest and on the development stages of target companies. It is assumed that the financial instrument will be directed on early entrepreneurial phases of companies in innovative sectors, such as digital technologies, biotechnology and similar.

4) Selection of financial fund manager

The selection of a professional financial fund manager is a necessary precondition of successful operation.

5) Collection of financial funds from investors

Along with the City of Zagreb, which can invest a part of financial funds, it is necessary to attract various investors in order to achieve the target financial plan.

6) Choice of companies for investments

Aside from the aforementioned activities aimed at the creation of a financial instrument / fund, it is necessary to carry out activities aimed at the preparation and initiation of campaigns at crowdfunding platforms.

Challenges

When creating a financial instrument, it can be difficult to collect sufficient financial resources from various investors. In order to reduce that risk and ensure potential investors' confidence, it is necessary to ensure institutional support and choose a credible team which will manage the fund. One of the risks for the successful implementation of the measure is the inadequate number of quality projects/companies into which to invest. Moreover, entrepreneurs' reluctance to adopt non-traditional forms of financing, especially those in which the investor enters into the owner structure, can have an impact on the number of quality projects/companies for financing. In order to reduce these risks, it is necessary to systemically implement all measures proposed in this document, which will bring about an increase of the entrepreneurship potential, growth of the number of innovative companies and entrepreneurs' awareness of the benefits of alternative forms of financing.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- World Bank;
- Institutional investors;
- Private investors.

Key participants

- City of Zagreb;
- Zagrebački inovacijski centar d.o.o;
- Financial institutions (HBOR, FINA and others);
- Economic operators.

Priority measure 5.3: City platform for testing innovative solutions (Living Lab) and strengthening of FABLAB makers space infrastructure

Goals and activities

In order to encourage cooperation between companies in the development of innovative solutions, it is necessary to set up an open innovation ecosystem at the level of the City of Zagreb in which companies would work together in order to test innovative smart ideas, solutions and products (Living Lab). The set-up of the Living Lab, as the central point for collection, storage and processing of data collected via smart sensors and Internet of Things (IoT) devices, as well as enabling of access to data via the Smart City platform (Measure 1.1) and supporting applications, will contribute to the process of co-creation of smart solutions by citizens themselves (as final users), scientific research companies and innovative SMEs. Such a platform can help companies, especially SMEs, to collect references, necessary for the project realisation, by public procurement of innovative

solutions, in accordance with the Guidance on Public Procurement of Innovation issued by the European Commission[27]. Projects ready for realisation can be financed from various sources, and the procedure of project selection needs to take into account the possible speed of implementation.

Living Lab platform also enables access to information related to new technologies and business intelligence in single industries, i.e. technology scouting. In fact, inclusion into specialised activities within global value chains requires specific technical information which are not easy to access. For example, global industry standards for smart network have still not been fully developed, which makes it impossible for manufacturers to adequately analyse business opportunities. Procurement of such information is usually too expensive for single companies, and joint procurement is rare due to inadequate coordination. Access to information will help local companies to choose manufacture innovations, investments and business opportunities.

Before Living Lab set-up, it is necessary to set up a city platform for integral collection and display of data, described within the framework of priority measures for the area Development of Digital Infrastructure. More precisely, it is necessary to develop Living Lab as an upgrade and integrate it into the Smart City platform (Measure 1.1).

In the Technology Park Zagreb, which acts within Zagrebački inovacijski centar d.o.o, a project with the aim of establishing a platform for creation of new products and services of higher added value has been initiated by efficient cooperation between interested parties (FabLab makers space), aimed at the attainment of the following results:

- Formation of programme and operative framework of Technology Park Zagreb FabLab;
- Developed participant competences for the implementation of FabLab activities;
- Establishment of a collaborative innovation ecosystem of mentors, moderators and lecturers;
- Carried out pilot project and successfully developed new prototypes (products);
- Completed managing TPZ FabLab web platform.

Zagrebački inovacijski centar d.o.o. infrastructure foresees prototype laboratories (CNC laboratory, additive technologies laboratory, IoT lab, reverse engineering, ECO laboratory for material analysis etc.) and connection of research and development departments (R&D) of companies (big national and international companies in search of new solutions) with such infrastructure in the aim of cooperation and development of new products; these activities need to be continued and improved.

The basic goal of this measure is to use the potential for cooperation between the existing business associations, clusters and professional organisations. Many high value sectors are developing too fast for individual initiatives to follow. At the same time, many companies are burdened by everyday operative problems which keep them from upgrading and prospering.

A testing platform will create a favourable atmosphere for innovations based on processes or technology, by including various companies' solutions into unique business solutions which would be jointly implemented and tested via the platform. Moreover, the platform will

[27] *Guidance on Public Procurement of Innovation*, European Commission 2017. Available at: http://ec.europa.eu/docsroom/documents/25724

encourage innovative activities in companies, providing an opportunity for testing of common ideas with simultaneous collection of references.

In relation to platform set-up, three activities which will enable companies to solve technological gaps and discover target possibilities for improvement of competitiveness have been proposed.

1) Set-up of cooperation platform:
   a) Create a clear working plan with conditions for member administration and timeline;
   b) Prepare the plan of attracting key participants and make a participant list;
   c) Promote the platform at relevant business events in order for it to become recognisable and diffuse information on what companies can expect from participation.

2) Creation of a procedure for the selection of pilot projects:
   a) Creation of selection criteria and procedure;
   b) Testing of selection process and publication via an interactive web-site.

3) Pilot project implementation: New services and solutions, such as mobility management systems, energy efficient equipment etc. require references in order for them to be exported with success. Platform participants are responsible for implementation, with cooperation and support offered by Zagrebački inovacijski centar d.o.o. and North-West Croatia Regional Energy Agency. If necessary, platform administrator will help with project implementation.

Challenges

Intellectual property over technologies and their commercial development need to be defined in advance. Public financing needs to be used in such a manner that the results affect commercial overflow on non-participating companies (e.g. by providing technologies which will be commercially used by more companies). On the other hand, it has to be taken into account that applicants will not take part if they cannot be guaranteed that they will own intellectual outcomes.

The process of selection and inclusion of final users and other participants is also key, as well as their continuous engagement in joint development of innovative solutions. The solution of this challenge is not unequivocal. Optimal functioning of the joint creation process requires every participant representative to guarantee a high level of motivation and usefulness so that the processes of research and experimentation, as well as the final result of project activities, be implemented in the best possible manner.

When determining the criteria for project selection, i.e. receiver, it is desirable to condition innovation in one or more specific topics, along with a financially assessed business plan. Platform administrator communication needs to show system transparency. It is necessary to define and implement responsibility for expenses for which fund sources are used, via business visits aimed at check of expenses and their outcomes. Payments need to be carried out as set out in the financing agreement. When considering risk, portfolio approach needs to

be taken into account; i.e. not every investment has to be successful, but the portfolio in total has to generate positive commercial value.
Possible implementation financing sources • City of Zagreb Budget ; • European Structural and Investment funds; • Programmes of the European Commission (Horizon 2020, INTERREG etc.); • EIB Group; • European Bank for Reconstruction and Development (EBRD); • World Bank; • Institutional investors; • Private investors; • Various forms of innovative financing (Challenge fund, Repayable grants, Matching grants).
Key participants • City of Zagreb; • Zagrebački inovacijski centar d.o.o; • Groups of public, private and academic institutions and investors.

Strategic area no 6: Sustainable urban mobility

Priority measure 6.1: Increased attractiveness of public passenger transport in the city agglomeration

Goals and activities

This measure is all-encompassing and implies numerous activities aimed at the achievement of expected and desired results. Activities which will be proposed in the continuation of this strategic area are covered in detail in strategic documents on traffic, first and foremost in the Traffic Master Plan of the City of Zagreb, Zagreb County and Krapina-Zagorje County.

Increase of attractiveness of public city passenger transport is a key measure aimed at its increased use, and it can be achieved by key measures such as the introduction of a system of integrated passenger transport, introduction of a unique ticket system for all providers of public transport services, introduction of a system of real-time passenger informing and reduction of crowds in city public transport vehicles.

Integrated passenger transport system has to include all participants providing public transport services, first and foremost providers of transport by bus, train or tram, but also other service providers, such as providers of transport services on demand, car sharing systems and similar. The precondition for a successful set-up of an integrated public passenger system is unique timetable and fares, alignment of transport supply with the demand, and creation of a unique payment and ticket sale system for the public city transport of passengers.

The system for informing users of public city passenger transport services is the key channel of communication between the service provider and final users. Passenger and driver information systems include passenger information services via pre-journey and journey information services, by using static and dynamic information. The biggest benefit of the implementation of this system is the provision of timely and correct information to the passenger and increased reliability of journey duration predictions, which significantly improves the quality of public transport service, resulting in growing user number and reduction in the use of personal vehicles. Thereby, the perception of care and a better relationship with the users increases, while the perception of waiting time falls; the negative impact of possible delays of public city transport vehicles minimises.

Unique ticket system enables the user to buy one passenger ticket for transport service from the starting to the final point. Such a ticket can be used for services offered by one or more operators of public city transport. The system needs to be easily expandable to other means of transport, so that the current mechanisms of ticket issue, sale and use can be transparently applied to other means of transport and journey planning with the possibility of buying a unique ticket for the chosen journey plan. A special focus needs to be put on contemporary sales channels which include the sale of tickets and service payment via mobile applications and web. Contactless card standards need to be aligned and if possible, they also have to be aligned with standards used for contactless cards in the existing systems. Moreover, it is recommended that the support for the implementation of this service include a passenger counting system in public city transport vehicles, which would enable detailed analyses of individual public city transport lines' use, service optimisation, as well as the creation of a basis for revenue distribution among service providers according to the actual number of transported passengers. In order to increase the feeling of safety among the users of public

city passenger transport, it is recommended to implement video surveillance system into vehicles. The increase of attractiveness of public city transport is also evident following the introduction of free broadband Internet access into public city transport.

Key activities which need to be implemented are:

- Introduction of an integrated passenger transport system;
- Introduction of a unique ticket system for integrated passenger transport, based on a unique contemporary ICT integrated transport system with a mobile application and contactless card (payment according to the actual number of kilometres/stops covered);
- Introduction of a system for passengers informing and journey planning;
- Expansion of the unique ticket system by including other means of transport (car sharing, bike sharing, taxi etc.);
- Introduction of the public city passenger transport video surveillance system;
- Construction and reconstruction of traffic ways used by public city transport vehicles in order to improve the conditions for the increase of speed and safety.

Challenges

Providers of public city transport services are faced with increasing challenges as the transport service per se is not sufficient in order for users to choose public city passenger transport as the preferred option. Public city transport has to be safe, affordable, reliable and punctual and as such, offer users an alternative to the use of personal vehicles as their currently preferred means of transport in cities. The challenges faced during implementation of these measures will primarily refer to achieving compatibility between the existing systems and participants which, in order to reduce expenses, need to be used and integrated into the newly proposed integrated solutions as much as possible. In order for the system to enable fair fares, it is recommended to change the concept of public city passenger transport payment, i.e. introduce the concept of payment according to the actual service use. Moreover, it is necessary to guarantee that, when defining minimum technical requirements and general characteristics of the system, the same business terms be applied to all service providers, and all passengers need to be enabled service of the same quality, no matter the operator or means of transport.

Possible implementation financing sources

- City of Zagreb Budget ;
- State budget of the Republic of Croatia;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- ZET d.o.o;
- Integrirani promet zagrebačkog područja d.o.o;

- City of Zagreb;
- Zagrebački holding d.o.o;
- HŽ-Infrastruktura;
- HŽ-Putnički prijevoz;
- Ministry of Maritime Affairs, Transport and Infrastructure.

Priority measure 6.2: Improvement and development of traffic management system

Goals and activities

This measure involves all components of the project *Automatic Traffic Management System of the City of Zagreb*[28], by which activities related to the improvement of City of Zagreb parking system, traffic light system, public transport and emergency services (fire-fighters, ambulance) right of way, emergency situations etc. have been planned. Automatic Traffic Management System measures include:

- Measure no 1: establishment/upgrade of the Main Traffic Centre with the aim of traffic system integration, management, decision-making and optimisation and connection to the system of City video surveillance;
- Measure no 2: installation of additional traffic light devices, sensors, video analytics cameras, measuring equipment, variable traffic signs and appropriate parking system;
- Measure no 3: public transport – tram, bus.

At the moment, the City Office for Physical Planning, Construction of the City, Utility Services and Transport is in the process of initiating the procedure of public procurement of feasibility and cost-effectiveness study related to automatic traffic management in the City of Zagreb, which will define and analyse the aforementioned measures in more detail. This framework strategy defines activities related to system upgrade and connection to smart communication-IT solutions.

The main data required for road network traffic planning or management is traffic demand (assessed by counting traffic) with all important features: number of vehicles, flow structure, approximate speed, manner of movement (gaps and intervals of following), total and approximate journey duration between characteristic points. Traffic counters count entities at a determined section without possibility of identification where they will continue to move (their journey destination and route). It is crucial to perform technological synergy by synergically using video analytics cameras in the City video surveillance system for traffic analytics. No matter if used in planning or project documentation or everyday traffic centre operator tasks, the basic designer/operator task is to know the movements of a single vehicle / group of vehicles in the traffic network in order to determine certain objectives: infrastructure construction or reconstruction, management strategy, promotion of certain transport modes, measurement of certain indicators for other needs (e.g. economic or environmental studies). Modern traffic prediction technologies and techniques (short-term, long-term, study/plan, at macro-, mezzo- and micro level) are implemented via *Dynamic Traffic Assignment*. Dynamic Traffic Assignment is a series of procedures used for predicting drivers' behaviour within the traffic network, especially by looking at the behaviour in case of incidents, congestion, traffic light malfunction, orientation to public transport corridors etc.

[28]*Automatic Traffic Management System the City of Zagreb* project has been defined within the framework of National programme for the development and introduction of intelligent road traffic transport systems 2014-2018 (Official Gazette 82/14).

One of the important areas of the traffic management system as a whole refers to smart parking management as a measure of sustainable mobility which results in the reduction of the number of vehicles in urban centres, eliminates unnecessary rides in search of free parking spots, rendering the traffic system more ecological, efficient and safe. The basis of the system is the provision of correct and up-to-date information on the availability of parking capacities already at the entry to the city zone in order for the driver, based on the information, to be able to make a decision on the choice and route to the parking destination. In accordance with the smart city development guidelines defined by the European Commission, indicators which point out to the need of introducing a system for smart free parking spot management are: large number of vehicles which take up the traffic infrastructure and unnecessarily burden it in search for a free parking spot, general traffic congestion in the zone network, parking spot waiting lines and a large number of tourists and non-residents in the traffic system. Via modern communication channels characteristically applied on smart cities (mobile phone application, Internet site, panels, variable traffic signs), the system needs to provide real-time information on free parking spots to the user, as well as information on the distance and journey duration, and guidance to the parking location. Information on parking possibilities needs to be available to smart city and its urban area residents, tourists and guests which are not familiar with the local situation. System implementation provides information which will provide decision-making support to the smart city user when choosing a free parking spot in relation to his/her destination, resulting in the reduction of the total journey duration. Along with providing basic information on parking spot availability, the system can enable advanced services such as parking spot / electrical vehicle charging station reservation, connection with other services (public transport, bike sharing, gastronomy, tourism, free time etc.). The system needs to enable obtaining of information on every parking spot in the street (street parking) or outside of the street (garages, closed car parks). This measure will have a direct positive impact on the traffic network as a whole and on mobility, as it will considerably reduce the duration of unnecessary rides (up to 30% of traffic in city centres refers to free parking spot search), reduce the number of vehicles and traffic in the zone (city centre), and an additional benefit of the implementation of such a system refers to the reduction of negative impacts of pollution and to increased safety, entry traffic management and an increase in parking system effectiveness and parking operator revenues.

Key activities which need to be implemented are:

- Introduction of an automatic traffic management system (Main traffic centre), which will be fully integrated with the current City video surveillance system realised within the Sector for Communal and Traffic Constabulary;
- Introduction of a system of dynamic informing on free parking capacities (or free parking spots);
- Introduction of a system for navigation to free street and other parking spots;
- Establishment of a system for remote car park reservation and payment (including electrical vehicle charging stations);
- Introduction of a system for automatic traffic management, which will be integrated with City video surveillance system;
- Integration of the parking payment system with the system of a unique ticket for public passenger transport in the city agglomeration (urban area);
- Park&Ride systems (inhabitants living in city peripheries or outside of the city can park their vehicles at tram terminals free of charge and continue their journey by public transport);
- Selection of traffic network parts for the development of ITS groups and relative

services, especially of at least three ITS groups initially, according to the ISO 14813-1 standard: *Traffic management and operations* and *Public Transport Management*, followed by *Traveller information* group.

The measure needs to be developed through the following indicators:

- Traffic network priority aimed at the increase of approximate commercial speed – for trams, from current 12 km/h to more than 15 km/h (+25%), and current bus speed from 18 km/h to more than 22 km/h (+20%);
- Passenger information system based on a mobile communication platform and currently available IT infrastructure; connection to other platforms; public bicycles, public city services etc;
- Generally, focus goals (KPIs) on public transport commercial speed increase and changes in journey distribution manner.

Such initiated activities will enable the achievement of ISO 37120 standard key goals:

- Better traffic indicators (speed, journey duration etc.);
- Energy efficiency: measured by traffic indicators;
- Economy – increased economic activity in the City;
- Ecological effects – reduced gas emissions by changing transport distribution manner and reducing traffic congestion;
- Effects on health – increased general traffic safety;
- Development of the City as a whole due to better traffic function.

Challenges

Smart city traffic policy is reflected in the reduction of traffic congestion, environment protection, increased safety and reduction of personal vehicle use. Smart city traffic system needs to be adapted to the urban whole and guarantee good personal and professional life to the citizens. One of the most critical elements of the traffic system in urban agglomerations is parking. Due to urbanisation and increase in the number of urban dwellers, resulting in a significant growth of the number of personal vehicles, the disproportion between free parking space and parking needs is growing, and it is especially evident in the city centre due to activity concentration and inherited urban structure. Taking into account that urban centres have been formed by their historical development, that their capacities are limited and that they do not offer the possibility of freeing space for reconversion or an increase of parking infrastructure, the lack of space needs to be compensated by solutions based on modern technologies. An additional challenge is the coordination of the national and urban level of traffic management and the problem of competence over road and railway systems, both in the context of traffic development concept and in the dynamics of document adoption and project implementation.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;

- Private companies and investors.

Key participants

- ZET d.o.o;
- Zagrebački holding d.o.o;
- City of Zagreb.

Priority measure 6.3: Improvement of bicycle and pedestrian traffic

Goals and activities

It is necessary to make cycle lanes more available, build new ones and reconstruct the existing ones, in accordance with the Rulebook on Bicycle Infrastructure. Cycle lane and track network needs to be well interconnected and connected to other forms of transport, and first and foremost, be safe for use. The network needs to be connected to national and European cycle routes. Public bicycle system with parking lots and garages needs to follow the development of the cycle network and be adjusted to users. Special attention needs to be paid to the availability of free and protected bicycle parking lots at intermodal nodes in order to guarantee uninterrupted journeys when changing transport means. In order to additionally improve bicycle traffic, additional bike sharing system capacities need to be employed. It has to be integrated into application and transaction solutions (payment) for using all forms of transport. Bike sharing systems are ideal for connecting various forms of transport. In this context, *last mile journeys* have to be specially pointed out. For the City and transport operators, as well as for surveillance and management purposes, the availability of bike sharing system provides flexibility in passenger distribution towards various forms of transport, reducing the burden on the overburdened. As with time there will be more and more data on the use of this service, it can be used for planning purposes so that new locations, new cycle lanes and development of additional services could be planned in a more efficient manner. Development of additional services which will enable easier connection to other forms of transport, e.g. Bike on Bus project, needs to be encouraged.

Key activities which need to be implemented are:

- System and applicative solution for cyclists (information on cycle lanes, bike sharing, planning journey routes and duration, traffic, electrical vehicle charging stations, pollution etc.) within the public bicycle system;
- Intensified integration of bicycles into public transport;
- Introduction of additional capacities and expansion of system functionality for the use of bike sharing service which needs to be connected to the application for use of public transport system in real time;
- Bicycle parking lot safety surveillance;
- Introduction of a public bicycle (classical and electric) system;
- Establishment of centres for increased cyclist safety;
- ITS (and smart city) cyclist system integration;
- Bicycle parking lot safety surveillance.

Challenges

One of the key parameters of bicycle traffic improvement is raising of the level of safety of cyclists as road users. This needs to be paid due care when constructing and reconstructing cycling and supporting infrastructure. However, it is also necessary to intensively work on

campaigns aimed at raising security awareness and on training, for which support and infrastructure is needed.

When referring to pedestrian traffic, measures aimed at expanding and tidying pedestrian surfaces, including the elimination of barriers to persons with mobility difficulties, need to be undertaken. Pedestrian zones need to be expanded, and new zones formed. Frequently used pedestrian crossings need to be appropriately equipped in order to improve passenger safety.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- ZET d.o.o;
- Zagrebački holding d.o.o;
- City of Zagreb.

Priority measure 6.4: Use of innovative operative systems (primarily electromobility systems)

Goals and activities

This measure is focused on all types of mobility which can achieve the transition from fossil fuels to new types of available fuels e.g. electrical energy. This includes public city transport system, private cars, e-taxi services, e-car sharing systems and logistic traffic systems. Encouragement of innovative power systems use will have direct impacts on the economy and the environment, thereby positively affecting life quality. Transition from traditional power systems to e.g. electric power has a direct impact on the reduction of pollutant emissions into the air (CO, NO_x), reduction of CO_2 emissions and of noise. Currently available and future power technologies have a significant potential to radically change and improve public city transport and private car transport, which still has a very large share in the overall transport structure of the City of Zagreb, in the holistic approach to sustainable traffic system. As part of this solution, it is necessary to plan and map needs for charging stations and integration with the electrical energy system. The mapping will include current and future needs for electrical vehicle charging station infrastructure, and will take both slow and quick charging stations into account, as well as potential advanced solutions, i.e. electrical vehicle battery change stations. The planning of needs has to be comprehensive, based on the cooperation between all current and future providers of e-mobility services. It is also necessary to elaborate the concept of implementation of electrical buses and small city electrical vehicles (cat sharing service), as a potential supplement to city transport. The integration of electrical vehicle charging stations connected to public buildings into energy management systems in buildings *(prosumers*) is also planned. The objective is the

achievement of as low vehicle charging price for the final users as possible, introduction of electrical vehicle charging stations connected to public buildings into an information system by which it will be possible to announce vehicle arrival and, considering the foreseen working conditions of other energy systems in the building, achievement of the lowest possible prices of charging, possible integration with Zagrebparking services, competence between buildings in the sale of energy to vehicles, introduction of direct trade between buildings and vehicle owners, e.g. via blockchain technology. The information system can be connected to the service provider's / charging station operator's applicative solution, which needs to take into account that they do not necessarily have to be compatible with all current and future interoperability platforms. Moreover, building charging station connections require certain rules of connection to the electrical energy network aimed at enabling the monitoring of consumption at the charging station itself and two-way electrical energy flow in the future.

Transport sector is constantly facing challenges related to limited energy resources and efficient environmental protection. Public city passenger transport electrical vehicles have a very important role in sustainable development of urban areas due to a favourable relationship between energy efficiency, environmental impact and passenger and cargo transport capacity. In order to keep these benefits, it is necessary to further develop and improve features of electrical vehicles by investing into new technologies and innovative solutions. One of the directions in which it is necessary to do research is further increase of energy efficiency by storing electrical vehicle stopping and braking energy into energy reservoirs in order to later use this energy for vehicle ignition and partly for autonomous driving as well. As far as electrical trams are concerned, by introducing new energy storage technologies, such as the application of super condensers, apart from energy savings, there is the possibility of autonomous driving, without the need to use contact lines at squares, underpasses, intersections and similar (e.g. Ban Josip Jelačić Square without poles and tram powering contact network).

In the broader city area it is necessary to plan the use of electrical passenger transport buses in order to reduce the emissions of greenhouse and other gases which have a negative impact on the atmosphere and in order to guarantee lower energy consumption and noise reduction.

Key activities which need to be implemented are:

- Continuation of personal electrical vehicle charging station construction and introduction of a business model for the charging station operator;
- Continued introduction of advanced systems for electrical charging station reservation and service payment via contemporary platforms;
- Gradual replacement of the current fleets of the public city transport service provider, city administrative bodies and Zagrebački holding with electrical vehicles aligned with the construction of the network of electrical charging stations for such vehicles;
- designing and implementation of the system for encouraging the procurement of electrical personal vehicles for citizens;
- Expansion of the network of the e-car sharing service;
- Increase of the e-taxi service share;
- Development of the applicative solution for the integration of all information on electromobility and connection to the journey plan application and locations for real time charging;
- Integration of all systems into a unique system for electric vehicles;
- ITS (and smart city) electric vehicle system integration.

Challenges

The encouragement of electromobility needs to be systematic and the same level of attention needs to be paid to the infrastructure, vehicle fleet and educational-communication activities, all with the aim of achieving the best possible results in relation to the money invested. Taking everything into consideration, it is necessary to continue with the existing good practice activities, such as electrical vehicle charging station construction projects, but also plan new innovative activities such as the introduction of advanced systems for electrical charging station reservation and service payment via contemporary platforms, such as mobile phones. Although the method of action in relation to the encouragement of innovative power systems use depends on the participant sector, the final goal should be the same, i.e. reduced dependency on fossil fuels, reduced negative environmental impact and improved citizens' life quality. Finding adequate locations for charging stations and obtaining necessary permits also presents a big challenge.

Possible implementation financing sources

- City of Zagreb Budget ;
- European Structural and Investment funds;
- Programmes of the European Commission (Horizon 2020, INTERREG etc.);
- EIB Group;
- European Bank for Reconstruction and Development (EBRD);
- Croatian Bank of Reconstruction and Development (HBOR);
- Commercial banks;
- Private companies and investors.

Key participants

- ZET d.o.o;
- Zagrebački holding d.o.o;
- HEP group;
- City of Zagreb;
- Croatian Energy Regulatory Agency (HERA);
- Ministry of Maritime Affairs, Transport and Infrastructure;
- University of Zagreb;
- Technological companies.

6. Mitigation of and adaptation to the negative effects of climate change

Cities are already facing a series of challenges, which will become even more prominent over the next decades and will have an impact on the nature of urban growth and development. One of the most important challenges are climate changes which will directly affect urban processes by changing temperature and precipitation intensity. Since European cities, including the City of Zagreb, which give their contribution and support, are closely connected by global socio-economic networks, among which many are influenced by weather and

climate, changing climate will cause complex, unknown and indirect impacts that cities will have to face. Adaptation to climate change refers to reacting to risks and potential opportunities related to climate change. Although such adaptation currently seems to be of relatively low priority for city planners and city administration in general, there are policy and practice examples which point to positive activity in this area, and some related projects are currently being implemented. Despite the fact that these initiatives do not always put adaptation in its primary focus, they point out progress in this area and offer implementation in other cities as well, all in the aim of limiting impacts of a changing climate. However, a series of obstacles referring to issues such as politics, management frameworks and unclear issues, including the complexity and uncertainty arising in climate sciences and institutional structures, remain.

Considering the fact that climate change, which has a direct impact on city functioning, has been proven, adaptation to such impact is of key importance. Cities are in the focus of the adaptation process for three main reasons. Firstly, urbanisation is an ecological and social 21st century phenomenon and, in the coming decades, population growth will primarily take place in cities. Secondly, most cities' spatial plans actually create good preconditions for the development of their own microclimates, which have a direct impact on temperature and wind parameters, and thereby precipitation intensity. A key example which is most often mentioned are urban heat islands. It is a fact that cities are warmer than their rural surroundings, even up to several degrees Celsius, due to topographic factors, large number of buildings which have replaced green spaces and anthropogenic heat emissions. In the future, climate change will additionally contribute to the heat island effect. Thirdly, due to factors which include strong dependence on the level of built infrastructure, high population density and high concentration of material assets and cultural heritage, cities are especially sensitive to climate change.

Key processes, which in this context need to looked at from the cities' perspective, refer to the reduction of the impact on the climate change process (mitigation) and climate change adaptation. In most cities and in Zagreb as well, mitigation is directly reflected through measures aimed at reducing CO_2 emissions, which are primarily implemented in the traffic and construction sector and are imposed by national and EU legal requirements. Adaptation is actually system adjustment in response to actual or expected consequences of climate change which mitigate damage and use potential benefits. In the context of this framework strategy on the City of Zagreb climate change policy, adaptation can be autonomous or prompted by policy change. Activities of the local self-government will have to be directed towards activities which reduce the impact on the climate change process in single sectors and reduce climate change effects and use potentials by creation, communication and application of proactive adaptation strategies and by creation of a participant network by connecting with the business and academic community, NGOs and citizens. In this context, the main mechanism is the spatial planning process, which falls under the competence of the City, with all its elements and with the required stronger integration of energy and climate adaptation planning. In some cases, mitigation and adaptation processes can have a synergetic effect, while in some they are rather incompatible.

The database of parameters affected by climate change, as well as of those that directly affect it, is utterly important for clearly determining the challenges on a local level. Such parameters do not include only the physical ones, such as temperature, wind and precipitation, but also the data on the effects on social vulnerability, economy and health impact. Data is not the same as information and should be interpreted properly in order to generate reliable information on climate change effects and required adaptive actions. In addition to those that

have already appeared, cities should also be prepared for any climate effect that can appear at a certain area. In the context of this Framework Strategy, utilising geographic information systems (GIS) and other forms of ICT enables comprehensive analyses of environmental, social and economic factors. Efficient modelling and visualisation of data is a powerful means for communicating the risks and including the stakeholders and the local community. It can also assist in ensuring political recognition through presenting the scope of an area or communities that are potentially at risk.

Climate change projections predict temperature increase, seasonal differences in precipitation amounts, decrease in the number of rainy days for all seasons, decrease in the number of cold days for all seasons and a significant increase in the number of hot days during the summer and autumn months. In general, the following potential impacts can be defined:

- Occurrence of heat waves;
- Occurrence of drought;
- Occurrence of floods.

Considering the strong interdependence of numerous climatological, environmental, economic, social and other factors, the above-mentioned impacts are definitely continuously developing and may result in altering some species' habitats, air and water pollution, soil erosion, occurrence of some diseases, impediments to water supply and electricity production, behavioural changes in citizens, affecting human health etc. The above-mentioned changes may negatively impact numerous aspects of life and it could be asserted that this subject requires a separate strategic document. However, what follows here is an overview of measures that could generate a result complementary with the list of priority measures for adaptation to climate change, and the implementation of which is based on utilising innovative technologies and means.

Examples of specific activities to be implemented (along with the already outlined measures in previous chapters):

1. Creating a database (information base) on climate change which will contribute to the decision-making process. This activity is taxing, but it is also the only way to systematically analyse situations, in addition to being the basis for the selection of suitable adaptive measures. It includes analyses of critical temperatures, precipitation and other physical parameters that carry a high risk of generating negative effects.
2. Utilising GIS tools for processing data and information on risk levels, as well as for communicating with stakeholders and politicians.
3. Participation in project consortia on the EU level that are aimed at carrying out pilot projects that could raise awareness and provide guidelines for far-reaching and comprehensive activities.
4. Integrating the Croatian Meteorological and Hydrological Service (DHMZ) data on the condition of the environment into the City of Zagreb platforms and communication channels for citizens.
5. Utilising advanced technologies in microclimate modelling, simulating the future impacts in the City of Zagreb and devising emergency response protocols.
6. Promoting and implementing green technologies in every sector.

7. Possibilities for financing the implementation of measures and activities

The implementation of measures of this Framework Strategy requires a comprehensive and systematic approach which, in the long-term, would be supported by the most appropriate financing mechanisms in order for the goals to be accomplished. When implementing this Framework Strategy's measures, procurement models of the projects and possible and available sources of funding should be taken into consideration in order for the combination of most economically advantageous models and sources for the taxpayers to be selected. In addition to ensuring the sources of financing for the implementation of measures, the City also needs to create the conditions for advancing the business environment. Such conditions would encourage stronger private investments and a stronger cooperation with the city administrative bodies. Via its fiscal policy, which consists of taxes, contributions and public expenditure, the City must efficiently divert its budgetary funds towards those areas which are important for development and which would encourage innovations and technological progress.

Smart development projects generally result in a more efficient utilisation of City resources, which is why they possess a significant market potential, i.e. they are characterised by quick financial returns. That is why it is important to separate the socially relevant projects, which generate low financial income, from the commercial ones in order to distribute financial resources accordingly. However, most infrastructure investments require significant capital expenditure and the existing national sources of funding do not possess the financial strength necessary for bearing the load of accomplishing all the goals defined in this Framework Strategy at the moment. This is especially true for the limited City budgetary funds, that need to be unburdened by new and innovative financing mechanisms.

The European Union has identified this problem and has, in the Europe 2020 umbrella strategy, stressed the role of a smart and sustainable economic growth in overcoming structural flaws of the European economy and in improving its competitiveness and productivity. The European Structural and Investment Funds (ESIF), which have allocated 6.881 billion euro for environment protection projects, research and innovations, education, strengthening public administration capacities, ICT and developing small- and middle-sized companies, are the primary source of financing smart development strategies of all the cities in the Republic of Croatia. The increasingly larger role of cities in generating smart development has been recognised by introducing the Integrated Territorial Investments (ITI) mechanism, which will enable the City of Zagreb to define and finance the urban agglomeration development priority areas through ESIF. This trend of decentralisation of ESIF will be continued in the future financial perspectives, which provides the City with significantly larger financial resources for carrying out development projects. In addition to the ESIF grants, are awarded via traditional mechanisms, the European Union has established several innovative programmes which encourage smart city development:

- Horizon 2020 – the EU's capital programme for research and innovations. The special "Smart Cities and Communities" initiative, which financially supports the demonstration of advanced information and communication solutions in urban areas, operates under this programme
- Urban Innovative Actions (UIA) – a European Commission initiative which provides cities throughout Europe with resources for testing new solutions for sustainable urban development, relevant on the EU level;
- European Local Energy Assistance (ELENA) – a European Investment Bank and European Commission programme for technical assistance in the preparation of investment projects from the fields of energy efficiency, distributed renewable energy sources and urban transport sectors;

- Joint Assistance in Supporting Projects in European Regions (JASPERS) – a European Commission, European Investment Bank and European Bank for Reconstruction and Development instrument for technical assistance in the preparation of large infrastructure projects related to traffic, water, waste, energy and urban transport;
- CIVITAS Activity Fund – a programme which supports sustainable urban mobility activities;
- European Territorial Cooperation (ETC) programmes (INTERREG) – enable projects which promote smart and sustainable development, pilot project research and demonstration and knowledge exchange between European cities and regions to be carried out.

The role of ESIF for the period up to 2020 is being purposefully strengthened by further development of smart financial instruments which mobilise additional public and/or private sources of financing projects that generate significant financial income. The public funds serve the purpose of the financial lever, i.e. capital which is one of the sources of financing and provides the basis for private investments. Through this initiative, the ESIF resources are invested into urban development funds (revolving funds), which possess financial instruments (guarantees, loans, profit shares) that can optimise risk allocation, making the risks more acceptable to commercial banks which are involved in the financing. The ESIF financial instruments aimed at entrepreneurs were first introduced in Croatia by the Croatian Agency for Small- and Medium-Sized Enterprises, Innovations and Investments (HAMAG-BICRO). Development of new instruments aimed at other development sectors pertinent to the goals of the Framework Strategy is expected.

Development banks have been among the most significant sources of financing utilities infrastructure and the development of the entrepreneurial sector for years now, primarily thanks to them providing more advantageous conditions for crediting in comparison to commercial banks. The most significant development banks are:

- Croatian Bank for Reconstruction and Development (HBOR) – offers a wide array of credit facilities and guarantees for facilities infrastructure projects, energy efficiency renovations and development of small- and middle-sized enterprises;
- European Investment Bank – the central financial institution of the European Union which financially supports large infrastructure projects and cooperates with the national development bank (HBOR) on placements of credit facilities for smaller development projects;
- European Bank for Reconstruction and Development (EBRD) – the principal international bank for financing transition countries which credits long-term development projects in both public and private sectors;
- World Bank (WB) – encourages key public administration and fiscal adjustment reforms, focuses on the traffic and entrepreneurial sectors and on crediting via programmes of its branches: the International Bank for Reconstruction and Development (IBRD) and the International Finance Corporation (IFC).

European development banks have developed an array of additional financial instruments aimed at smart city development:

- European Fund for Strategic Investments (EFSI) – provides EU guarantees for mobilising private investments into high-risk capital projects;
- InnovFin – a system of guarantees and credit facilities for entrepreneurs and cities, aimed at providing access to capital for research and development projects, conducted in cooperation with HBOR;

- Connecting Europe Facility (CEF) – provides guarantees and financing via investment bonds aimed at construction of new and upgrading of the existing European traffic, energy and telecommunication infrastructure;
- European Energy Efficiency Fund (EEEF) – combines long-term credit financing of projects and free technical assistance to investors in sustainable energy and urban mobility projects;
- Private Finance for Energy Efficiency (PF4EE) instrument – provides loans for investments into energy efficiency projects, in accordance with the national energy efficiency action plans' priorities;
- Natural Capital Financing Facility (NCFF) – provides credit investments or equity contribution for climate change adaptation pilot projects.

Due to the nature of investments into the smart development of the City, as well as to legal restrictions on budgetary borrowing, it is necessary to ensure broader involvement of the private sector and market mechanisms in the funding of projects. A public-private partnership or concession model could be optimal for securing a share of public investments if a project were to result in an increase in the quality of public services and in reduction of public expenditure and risks to the service availability to citizens.

Other, alternative financial mechanisms of supporting smart city development, which should be encouraged, should enable the citizens to play a more active role in the financing of smart development projects in the capital market, via:

- Investing in city (municipal) bonds for financing large development projects; and
- Crowdfunding smaller, socially relevant city projects and innovative entrepreneurial projects.

The development of City digital infrastructure must be accompanied by the establishment of a platform that would provide citizens and entrepreneurs with information on available sources of financing, which, in turn, would generate public-private structural cooperation of higher quality.

8. Conclusion and recommendations

The Zagreb Smart City Framework Strategy has been drafted by the Working Group for Development and Implementation of Zagreb Smart City Projects, which was founded in October 2016 by a Conclusion of the Mayor of the City of Zagreb. Its preparation also involved many external associates, who are leading Croatian experts in various fields of applied smart solutions and technologies. This Framework Strategy's primary purpose is to determine the vision and strategic goals of future development of smart solutions, technologies and applications in the City of Zagreb area, on the basis of an overview of the state of play, which should pave the way for the definition of specific measures and activities to be carried out in order to achieve the vision and the goals.

The first two chapters of this Framework Strategy provide a general overview, i.e. a description of a smart city, the needs and advantages of developing and implementing smart solutions and technologies, as well as an overview of the strategic framework and the most relevant international and national documents. The state of play overview and opportunities for development and implementation of ICTs and smart solutions in the most important sectors (quality of life, economy, smart city administration, environment protection and fight

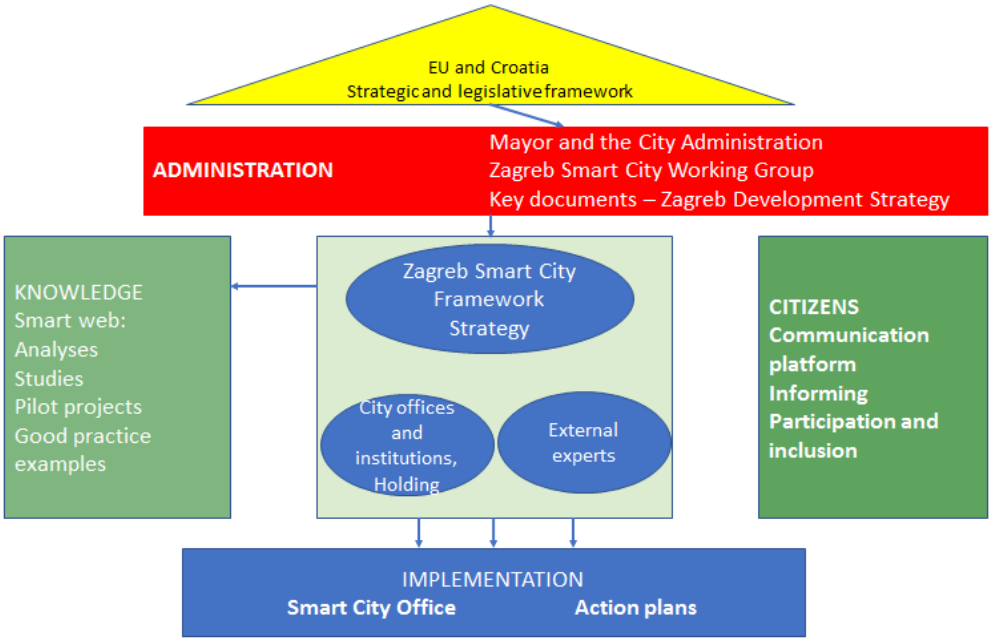
against climate change) and projections for various branches and companies of Zagrebački holding are outlined in Chapter 3. The Zagreb Smart City vision for the period up to 2030, as well as goals and descriptions of single strategic areas are outlined in Chapter 4. The bulk of the Framework Strategy has to do with the priority measures, in the scope of which the specific activities that need to be carried out to achieve the vision and goals are outlined. A total of 27 priority measures grouped by specific strategic areas are defined and a detailed description of measures is provided in Chapter 5. The Framework Strategy also includes two horizontal areas, mitigation of and adaptation to the negative effects of climate change and possibilities for financing the implementation of measures and activities. These areas are designated as horizontal because their effects, or their impact and challenges, are intertwined with the other strategic areas.

The implementation and development of smart solutions are generally possible in almost every area of human activity. Therefore, not every possible area of implementation was encompassed by this Framework Strategy. The recommendations and guidelines from the existing international and national strategic documents on smart city development were taken into consideration in the selection of strategic areas, as were the specificities and implementation potentials of the City of Zagreb area.

Although it contains specific measures and activities, this Framework Strategy is not an implementation document, which is why, in order to carry out the measures and activities, **action plans for single strategic areas, with more implementation details (technological solutions, scope, cost estimates and funding amounts etc.), should be prepared. That is one of the fundamental recommendations for further implementation.** Such action plans could provide the basis for estimates of the required budgetary funds and other sources of financing, which is vital for a successful implementation of the outlined activities.

The City of Zagreb has formed the Department for the Realisation and Coordination of the Zagreb Smart City Projects with the task of coordinating and monitoring implementation of specific projects. Among other activities, it provides support in the preparation of sectoral action plans, i.e. implementation documents, monitors the implementation and overall efficiency of priority measures, collects and analyses the required data and creates the required databases, promotes the Zagreb Smart City project, encourages implementation of smart solutions and innovations, facilitates interactive communication between citizens, the city administration, city companies and city institutions, collaborates closely with other city administrative bodies, central State administration bodies, the Zagreb Technology Park, the City of Zagreb Development Agency and all related and involved institutions.

It is necessary to involve a wide array of stakeholders in the implementation of activities and measures, including the city administration and the competent city offices, city companies and institutions (primarily Zagrebački holding d.o.o, but others, as well), experts, economic operators and private companies, and finally the citizens of Zagreb as the most important stakeholders. **The citizens of Zagreb, along with the city administrative bodies, are the end-users of smart solutions and technologies**, which is why such solutions should be developed for them and **in order to improve the quality of life in the City of Zagreb**. The suggested concept of implementation of the Framework Strategy is based on the best European practices, as well as on the needs and specificities of the City of Zagreb, which have been comprehensively analysed in this document (Picture 3).



Picture 3 Implementation concept of the Zagreb Smart City Framework Strategy

All activities should be coordinated in accordance with the relevant national and European strategies and legislative framework.
In order for the full potential of a smart city to be realised, a necessary prerequisite is also **the involvement of the citizens of the City of Zagreb in the decision-making regarding the important matters in their city**. For the citizens to be actively involved, data from all important areas of life in the City of Zagreb (transport, healthcare, infrastructure, economy etc.) should be widely available, logically organised, easily searched, open and transparent. **Constant informing and educating various groups of citizens is also necessary**, as are the promotion and visibility of the activities being carried out.

Although the citizens of Zagreb represent the most important group of users, measures from all areas also affect tourists, directly or indirectly, i.e. they affect tourism in the City of Zagreb, an important factor in the City's economy. Technology development and the carrying out of the Zagreb Smart City activities will improve both the conditions of tourists' stay and the tourism offer of economic operators in the City of Zagreb.

Various available sources and models for financing the implementation of measures and activities need to be considered in order for the most cost effective combination of models and sources to be selected. It is clear that the City's funds alone, i.e. those from the accounts of the City of Zagreb, cannot finance the implementation of all measures and activities outlined in this Framework Strategy, which is why **additional and innovative models for the procurement of these solutions must be considered, and additional sources of financing need to be secured.** Although the co-financing of renovation and construction of various infrastructure and supply systems has been anticipated by the existing Operative Programme Competitiveness and Cohesion 2014-2020, the implementation of smart solutions and systems to integrate and enable technologically acceptable communication has not been foreseen, which results in lower potential for savings, quality and synergy. **Therefore, we recommend to the City of Zagreb to draw attention, through active communication with the competent ministries of the Government of the Republic of Croatia, to the need for co-**

financing the investments into smart solutions and systems under the existing and future operative programmes, via calls for funding aimed at cities and their utility companies. Furthermore, the financing of such public investments of the City of Zagreb, and **alternative models of procurement, should be based on a closer cooperation between public and private sectors**.

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of the City Assembly
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