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City Lab Lisbon – Development of a Smart Roadmap for the City of the Future

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1 ABSTRACT

Lisbon is a city with more than half a million inhabitants and one of the most touristic capitals in Western Europe, constantly trying to find ways to deal with challenges in a smart and sustainable manner. How to turn Lisbon into a more inclusive, connected, and resilient city going into the future, is the question that researchers in the Fraunhofer project, Morgenstadt, are trying to solve. Lisbon has developed a city development strategy for the next decades, defining goals that aim to create more employment, attract more people and to become a more liveable city. This last goal does not only include the improvements in living standards of citizens, but addresses topics such as new mobility concepts, renewal of old buildings, increased energy efficiency, among others. All this can be fostered by using more participative approaches and an extensive exploration of the local resources to stimulate the economy and incentivize local innovation.

The question that arises is how to get there? How to make Lisbon a more liveable and attractive city not only for tourists but especially for its citizens and workers? This paper is based on an interdisciplinary project in the form of a so-called “City lab” that began in September 2015 in the context of the ongoing long-term research project called “Morgenstadt: City Insights” initiated by the Fraunhofer Society.

This paper therefore first provides a general introduction into the smart city concept (chapter 2) and an overview over the initial position of Lisbon in this regard (chapter 3). In a next step, the research methodology applied in the City Lab will be outlined, dividing the analysis process (chapter 4) and the project development process (chapter 5). In the following the results of the city lab Lisbon will be presented. While the first part of results concentrates on key outcomes such as the sensitivity analysis and exemplary sector specific results (chapter 6), the second part will provide an overview over the developed projects to foster a smart and sustainable development of Lisbon (chapter 7). According to the identified challenges and opportunities in chapter 6 that reveal a good level of smartness among the different sectors, the projects presented in chapter 7 will specifically address the strengthening of interdisciplinary and cross-department as well as cross -stakeholder cooperation, which has been identified as Lisbons key challenge.

2 INTRODUCTION. CONCEPT OF SMART CITIES

A smart city refers to a concept of integrated urban planning that emphasizes achieving efficiency and sustainability in all aspects of its development from economic and social to technological development. In collaboration with key stakeholders, the intelligent integration of data and ICT, the smart city aims to create a framework for its citizens that enables and promotes intelligent innovation and creativity. Among the principal goals of a smart city is the reduction of the city’s ecological footprint, high resource efficiency and increased economic competitiveness, all with the underlying objective of maximizing the welfare of urban dwellers. A smart city follows the principle of good governance, referring to the institutional capacity to design, manage and implement strategic long-term goals, openly share information, provide data and create an innovative network with business, scientific and institutional actors. Therefore, the smart city allows for interdisciplinary collaboration, provides access to financing models, and offers a stable environment that stimulates the initiation of innovative processes and a dynamic economy. In this sense, the creation of innovative partnerships and functional linkages is a precondition for the successful implementation of the smart city principles but more important it opens the door for national as well as international cooperation and sharing of experiences and good practices.

3 LISBON ON THE WAY TO BECOME A SMART CITY

Lisbon is currently facing a range of issues that will be significant challenges going into the future. The city is still feeling the effects of the financial crisis, with high unemployment, especially among youth, as well as austerity measures that limit public spending beyond core competencies. Furthermore, demographic changes mean the city’s aging population is going to prove burdensome in terms of effective support through social security in the future. This is not just an issue that is playing out in economic terms but also in terms of the

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spatial and functional design of the city's urban systems. These represent challenges that have no simple short-term solution but can only be solved through long-term strategic development.

At the same time, the city is doing its best to try to maintain its youth, who have tended to leave the city in search of greener pastures, leading to a brain-drain effect where many of the city's best and brightest leave the city contribute to the development of other cities rather than Lisbon's. The city administration has acknowledged these challenges and is trying to position itself as agile and future-proof, able to absorb the coming challenges while developing a liveable, creative and innovative city with many opportunities for its citizens.

In this context Lisbon already participated in various European innovative initiatives, trying to tackle these core problems. For example, the city was elected as one of the three lighthouse cites together with London and Milan for the EU H2020 lighthouse program. One of the main goals of the project is urban regeneration through better energy performance and the development of innovative business models. This shows that the city of Lisbon is working towards establishing itself as one of Europe's most liveable cities while addressing a range of challenges heading into the future.

Nevertheless, not all problems can be solved within such innovation networks or European projects; without a deep understanding of system interdependencies, specific and local challenges cannot be tackled. Therefore, the city decided to apply for the Morgenstadt City Challenge in 2015. The city was selected as a winner city due to its clearly stated sustainability goals, its effective preparation of strategies in the past in a range of sectors, and because of a clear recognition of a need for strategic planning and demonstrated an interest in a holistic approach for its development. The main reward consists of an interdisciplinary city lab investigation performed by the Fraunhofer IAO, assessing the current sustainability status of Lisbon and developing a roadmap to make Lisbon more sustainable and smart.

This paper will outline the key outcomes of this city-lab investigation, starting with a general description of the performed procedure, followed by the analysis results.

4 CITY-LAB LISBON. DESIGN AND PROCESS

Fraunhofer, together with numerous industry and city partners of the Innovation Network "Morgenstadt: City Insights" has developed an action-oriented model for accelerating and strengthening the sustainable development of cities. It is based on six deep-dive analyses and hundreds of case studies to enable other cities to improve their sustainability credentials. Based on an integrated indicator framework and the assessment of over 80 action fields, Morgenstadt experts derive individual city profiles that serve to design and implement individual strategies for city transformation (Fraunhofer 2016). Between March 2015 and May 2016 Prague (CZE), Chemnitz (DEU), Lisbon (PRT) and Tbilisi (GEO), will be supported with this approach by the Morgenstadt Innovation Network. The city lab is structured into five larger phases:

(1) Formal negotiations, team setup, signatory process, communication;

(2) Analysis of existing strategic documents & data assessment by city partners;

(3) 2-weeks assessment and analysis of the city by an interdisciplinary team;

(4) Development / creation of sustainability profile of city;

(5) Development of strategic roadmap for sustainable development.

The in-depth analysis of Lisbon was carried out based on the Morgenstadt assessment framework for sustainable urban development. This framework is structured into three levels of analysis: indicators, action fields and impact factors. They were designed to understand the current sustainability performance of cities and to support development of coherent strategies and an integrated roadmap for development. A mixture of quantitative benchmarks and qualitative data analyses ensures that an objective performance profile of Lisbon can be generated respecting the individual factors of the city (Kalisch et al. 2013).

The City Lab Lisbon began with the Kick-off event in March 2015 and is planned to conclude in May 2016. During the process, a team of 4 Fraunhofer researchers supported by Morgenstadt experts from industry and cities and a local counterpart team from the local administration in Lisbon have assessed a broad range of information and data of the city. This analysis has been the basis for developing integrated measures and projects that are meant to contribute to the sustainable development of Lisbon.

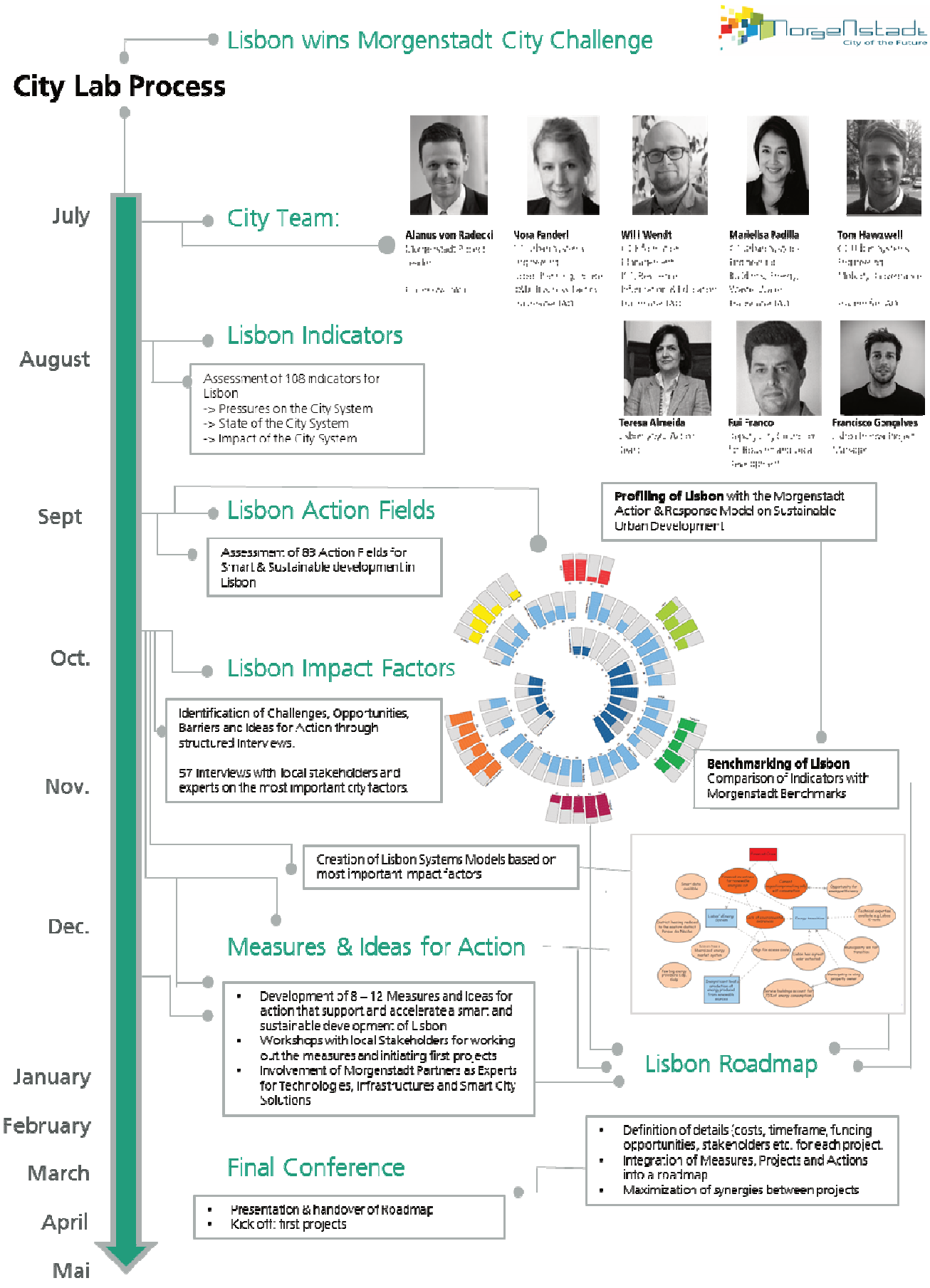

Figure 1: City Lab process Lisbon

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Throughout the analysis the City Team assessed the current status of more than 80 action fields and over 100 indicators that helped to identify the pressures that have an impact on Lisbon (social, economic and environmental pressures), the current state of a range of sectors in the city (mobility system, energy system, socio-economic parameters, security system, water-infrastructure etc.) and the impact that the city has on its society, economy and environment.

The in-depth analysis occurred in the context of an onsite assessment that took place from the 19th until the 27th of October. Together with the on-site mirror team, the University of Lisbon and the local energy and environmental agency, Lisboa E-Nova, the Fraunhofer Morgenstadt team carried out the evaluation in situ, where relevant data was collected and strategic documents were analysed. 57 interviews with local stakeholders from the municipality, local industry, civil society and other institutions that are closely related to the city were conducted, focussing on the identification of current strengths, challenges and opportunities for the development of innovative projects and partnerships within the city. The collected data helped to create a global understanding and to recognize systemic impact factors that allow to identify external pressures, underlying forces, dynamics, socio-cultural and historic implications that are present (often unnoticed) and have an effect on decisions, structures, strategies and measures taken at the city level.

The integration of members of the city hall and Lisboa E-Nova throughout the entire assessment and project development course was part of the capacity development process for the local counterpart team. Knowledge and expertise regarding the methodology, the technologies and the process was gained for enabling a strong sense of local ownership.

5 CITY LAB LISBON. DEVELOPING PROJECT IDEAS

After the analysis of the strategic documents of the city during the preparation phase and the data collected during the evaluation in situ, the Fraunhofer team put together the primary city lab results into a list of more than 15 project ideas, which were then validated by the Lisbon mirror team. From the list a total of 9 projects were prioritized and selected for a more detailed research and further discussion during a project development workshop that took place on the 16th of December 2015. More than 40 participants from the city hall, the private sector as well as Morgenstadt network partners participated and discussed the proposed innovative solutions, such as the creation of a business model for energy transition or the creation of an urban sensor network. The aim of the workshop was to validate the project ideas proposed and to concretize them regarding the needs and demand of all relevant actors, the value that the project creates for the city, the necessary components and the activities that have to be carried out for its implementation. For the discussion, reference projects were taken as examples and inspiration in order to further develop the suggested solutions. The workshop results were the basis for the elaboration of the strategic Roadmap, which shows a series of potential measures for a future sustainable development of the city.

The following Figure 1 visualizes the entire city-lab process, including all process steps from Lisbon's initial application up to the final conference held in May 2016. The next sections of this paper will concentrate on the results of the city lab investigation.

6 CITY LAB LISBON. RESULTS OF THE ANALYSIS

As a result of the city lab, very detailed reports can be derived for each city sector including urban planning, governance, mobility, buildings, energy, resilience, or ICT. In order to gain a better understanding of the interdependencies and interrelations between these sectors, a sensitivity analysis was performed, trying to identify and define systemic key-impact factors that can be identified as:

- DRIVERS - have the potential to drive change and to stay stable over a long time
- LEVERS - are the crucial factors that one needs to get right in order to transform the system in the desired direction.
- INDICATORS - serve to display the change in the system.
- BUFFERS - do not influence many other factors and they are not influenced by many other factors.

The following Figure 2 visualizes the resulting matrix of the sensitivity analysis.

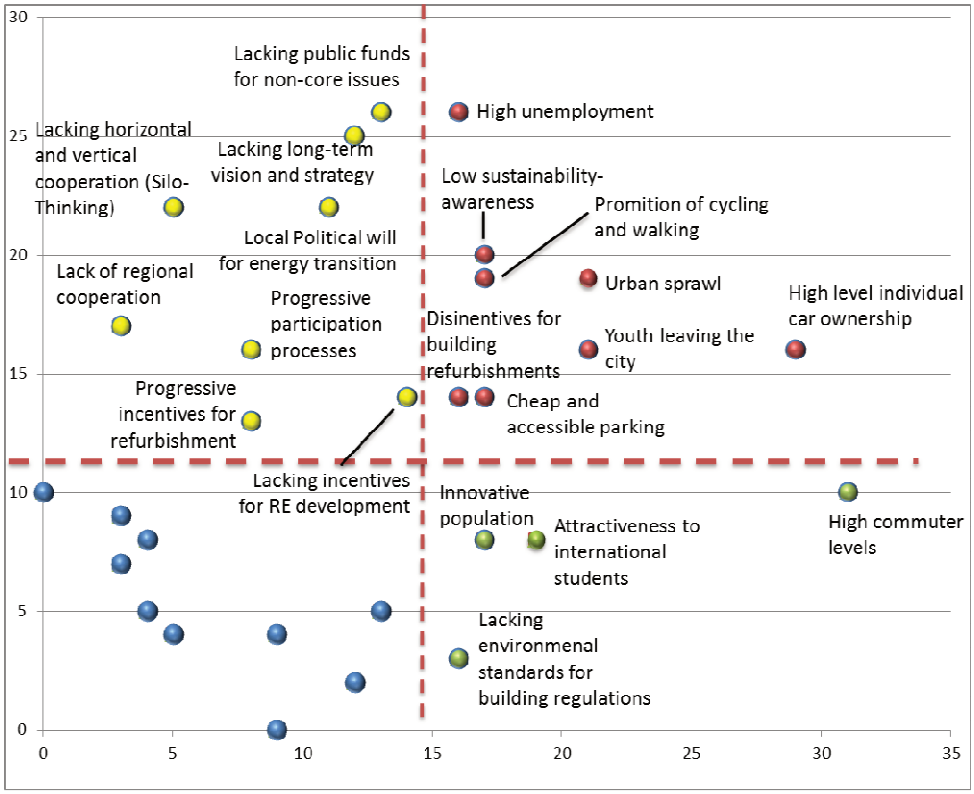

Figure 2: Sensitivity Matrix Lisbon

This result represents a central key outcome of the Lisbon city lab. The main DRIVERS and LEVERS are not limited to specific topics or action fields, rather they address overarching challenges and opportunities such as horizontal/vertical cooperation or long term visions. The sector specific analysis also proves this hypothesis, since almost all sectors carry out innovative and sustainable projects and concepts individually. Exemplary, three best practices from the sectors Water, Mobility and Innovation will be outlined below.

6.1 Intelligent water management for usage optimization

The losses caused by leaks, thefts, metering inaccuracies of Portugal are 7%, which makes Lisbon one of the world leaders in water sector. This optimization has been achieved by various measures and awareness programs, in particular smart initiatives like the online water management system called Aquamatrix (EPAL 2016 a), an commercial management system designed and used by the water provider company EPAL. Besides the Waterbeep (EPAL 2016 b), which is an innovative service offered as a smart app in Lisbon providing customers information about their water consumption. The app sends alerts and warns about abnormal water consumption and even possible bursts, therefore allowing the customer to minimise losses and unnecessary use of water.

These programs also provide information over water consumption breakups from various sources, e.g. municipal water, treated water, rain water etc. They are available as smartphone apps and can be used by individual households and industries. All these initiatives are part of EPALs long term vision to reduce the water consumption and make the overall water sector of the city more efficient.

6.2 Innovation and Creativity Hubs

Lisbon has the vision to become one of Europe's most competitive, innovative and creative cities, utilizing the outlined opportunity of a lively innovation landscape. In order to achieve this vision, the following goals were set, addressing a creative and innovative target group:

- Creating, attracting and retaining talents, companies, investment and strategic clusters;
- Stimulating the innovation, creativity and entrepreneurship spirit in the city;

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- Making Lisbon a space open to the exploitation of new motivations, experiences, concepts and innovations.

Following these goals, a multitude of hubs have been installed, supporting the creative and innovative citizens of Lisbon in the development of their ideas. Innovators get support on all stages of the development process, be that the early product experimentation stage (e.g. at fab lab lisboa or Mouraria Innovation Hub), the stage of making products marketable (Startup Lisboa) or the final stage of finding business investors for market entrance (Invest Lisboa). Under financing of the city council all those hubs provide expertise for local entrepreneurs, making Lisbon on of the most innovative and creative city of the world with more than 100 companies established by to Start-Up Lisboa and over 800 supported businesses so far by InvestLisboa (Fraunhofer IAO 2016).

6.3 Integrated Mobility Strategy

As a major source of local air pollution, noise pollution, GHG emissions, injury and death, as well as valuable time lost spent in traffic, Lisbon has identified urban mobility as a key challenge going into the future. Smart development doesn't always require the addition of new infrastructure or the integration of new technologies, but can simply mean taking stock of what is already available to gain a more comprehensive understanding of the state of urban systems. This allows planners to highlight weaknesses as well as opportunities for more effective intervention. Lisbon has demonstrated this through the development of its integrated mobility strategy. The city has identified ten "layers", each demonstrating an important perspective on the city's mobility system. In addition, the city has identified five key intervention mechanisms that can be utilised to steer mobility behaviour on the respective layers. Finally, the strategy includes a set of goals that help guide interventions, communicate objectives to the public and justify any impositions on the public that might result from induced change in mobility behaviour.

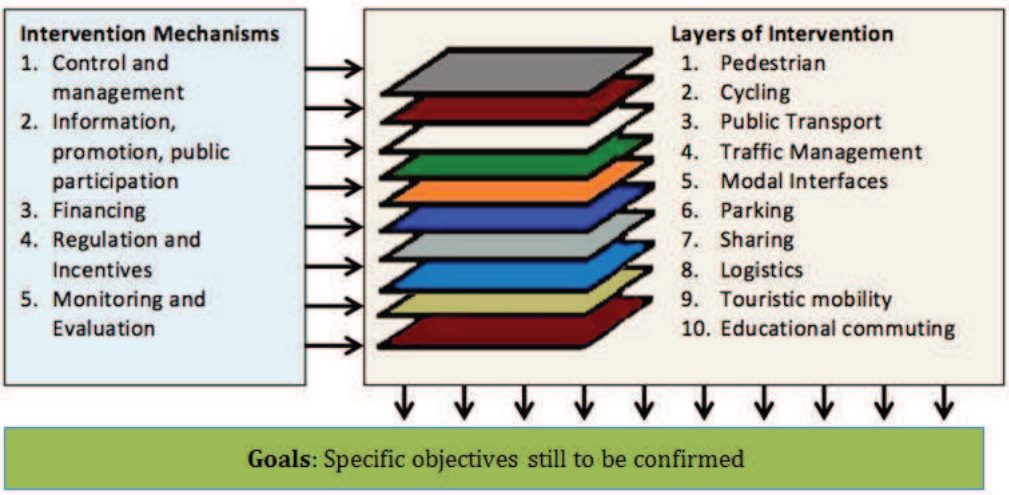

Figure 3: Lisbon's Integrated Mobility Strategy (Fraunhofer 2016)

Taking stock of all of these dimensions of the city's mobility system forced the strategic developers to gather information about influencing factors that previously remained hidden in the periphery. Furthermore, the process encouraged contact with stakeholders whose perspectives too would not have been considered, encouraging a more participative planning approach. By attempting to get a holistic understanding of the system and making the data gathered usable, the city is better able to target planning in an integrated way to maximise positive outcomes. This approach demonstrates that the first step towards smart development is to better understand the state of urban systems in a holistic way to allow for more effective intervention.

These three examples demonstrate the capacity for sustainable innovation among the different sectors in Lisbon. Falling back on the sensitivity analysis it can therefore be stated, that Lisbon´s core need is located in between the innovative sectors and all the implemented best practices, requiring strong support in solutions that strengthen the cooperation among departments and stakeholders. This would allow Lisbon to make better use of the multitude of the already explored opportunities, stepping toward a more holistic integrated system.

7 CITY LAB LISBON. PROPOSED PROJECT IDEAS

Based on the outlined results, the city-lab team proposed a set of project ideas in order to make Lisbon more sustainable and smart. Even though a few of the projects are oriented towards specific topics (compare table 1), the proposed solutions had a very strong interdisciplinary focus, concentrating on a better cooperation among all stakeholders, departments and administrative areas. The following three key-projects were proposed:

(1) A strong Sustainability Action Team with clear authority - the limited capacity of the existing Lisbon 2020 Action Team illustrated the need for clear competences and cross-department authorities for such a team. To allow the body to effectively coordinate activities, it further requires more resources to conduct activities.

(2) The Lisbon Forum - A second key finding was a lack of on-going coordination going into the future. The city itself is constantly changing and is faced with constantly modifying conditions and new challenges. In this context, a more formalised body to facilitate integrated urban development could help to address this. The difficulty with formalising such bodies is that they can often become bogged down in bureaucratic processes, losing their dynamism and agility. Thus, the developed proposal resembled a "Sustainability Forum", rather than a new municipal department or working group. The general idea is that the Forum would comprise of sustainability representatives from the municipal departments and coordinated by the Lisbon 2020 Action Team. Depending on the topic in discussion, different actors from within the municipality, universities and research institutes, NGOs, civil society, private sector, innovation hubs, or any other actors deemed relevant for the topic, would be called upon to build topic-specific think tanks. The integration of other representatives from other municipalities or regional organizations could potentially assist with improving regional coordination, another major issue in the Lisbon Metropolitan region.

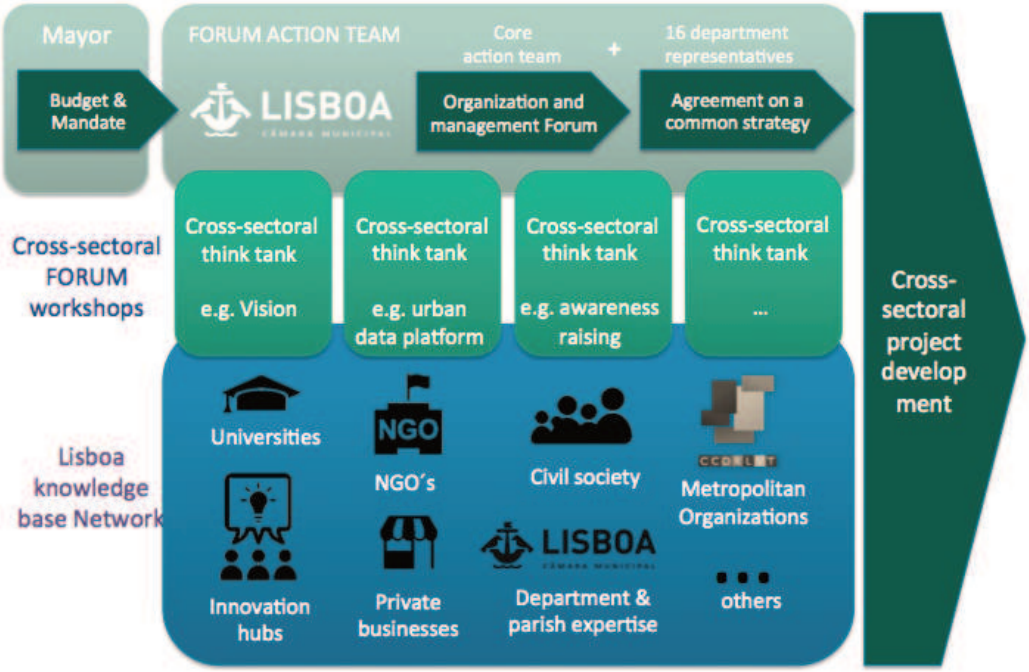

Figure 4: Concept of the Lisbon sustainability Forum (Fraunhofer IAO 2016)

(3) A measurable vision for Lisbon - A third important finding is related to the lack of a vision to help unify actors and guide towards more sustainable development processes across all departments. This too is a process that the city must develop independently, but it is suggested that the proposed Sustainability Forum would be a logical vehicle to create such a vision. Such a vision must be developed in an inclusive and integrated way and be linked to SMART (specific, measurable, achievable, results-focused and time bound) principles, which act as a means of measuring success. Measurable goals allow for transparent communication processes towards the society, reasoning for specific activities and projects and achieving a higher acceptance for these projects.

Further there is a great need for a smart data platform that combines and disseminates all knowledge among all city departments as well as local stakeholders. By developing the Integrated Operational Centre (COI) the

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city already targets this issue. Therefore this core need seems to be taken care of and the city should concentrate on other open issues.

Additionally a set of specific key- measures was developed in cooperation of all city-lab partners, targeting the analysed sectors and identified gaps.

Sector	Project	Short- Description
Energy & Buildings	Extended Solar Potential Map & development of a business model for energy transition	Connecting the existing solar potential map to the energy demand to make it a useful tool for decision making. Implementing a lighthouse project with 8 municipal buildings as a demonstrator to trigger and scale-up the energy transition in Lisbon.
Water & Buildings	Closing the urban water cycle	Designing projects for the use of treated waste water & using prototypes to expand the current regulation for the use of rain water and grey water in new building projects.
Education, Waste & Energy	Sustainability contests	Sustainability awareness campaigns using new technologies and participatory methods to increase energy efficiency and waste reduction and public environmental awareness
Education, Waste & Energy	Smart Waste management solutions: GPS sensors & waste bins sensors together with a waste/recycling app	. The information provided is used to: - Adapt the routes to avoid unnecessary trips (half full bins) and traffic jams in the city. - Provide real-time information to the users about the actual collection time at their street and houses - Apply the polluter pays principle in the taxation
Mobility & Logistics	Upgrade of public lighting network with potentials for inclusion of sensor network	City-wide process of upgrading street lighting by integrating the development a sensor network into this process, this could leverage a range of benefits for all other sectors
Business Tactics	Lisbon Social Innovation Hub	Development of a social innovation hub that offers advanced facilities for social innovation, co-working and micro production.
ICT	ICT Cooperation Strategy	Establishment of a constant cooperation strategy between the city administration, local IT-research institutes, the society and local ICT-companies in order to cooperatively develop bottom-up innovations for the city.
Resilience	Tool-catalogue for civil protection solutions and applications	Development and implementation of a tool-catalogue, including a usage- guideline that allows crisis management professionals to identify relevant tools and solutions.

Table 1: Proposed topic-specific key measures (Fraunhofer IAO 2016)

8 CONCLUSION & OUTLOOK

Lisbon presents the necessary conditions to promote smarter urban development. There was a clear demonstration of political will, reflected in the initiation of integrated planning processes and the encouragement of dialogue between key actors in a range of sectors. However, the city lab process highlighted a range of overarching issues that could not be addressed alone through interventions in specific sectors. Many of these areas are characterized by high complexity and cannot be addressed in the short term through projects that simply integrate new technologies, which is an approach often associated with “smart” development. Therefore, the key proposed solutions for Lisbon relate to overarching interventions that create a dialogue, encourage cooperation between key actors in different sectors, and set meta level objectives. Part of this process is the reinforcement of the capacities of the action team to promote intersectoral cooperation,

the establishment of a forum to create a dialogue between key actors in the city, and the integrated development of a set of clear goals to act as a "guiding star" for future city activities. These overarching interventions need to be complemented by specific projects "on the ground" in the different sectors. Consequently a part of the road map developed together with the city, a range of projects are already on track, including the a lighthouse project for energetic refurbishment in public buildings, including the extension of the solar potential map as a tool for the development of business model for energy transition, and the smartification of the waste management services though the installation of GPS sensors in the collection trucks and filling level sensors in the waste bins. Furthermore the Lisbon 2020 action team is currently under a restructuring process, where its duties and competencies are being redefined.

The City Labs process has demonstrated that „smart" urbanism isn't just about high-tech solutions, but also relates to striving for a more holistic understanding, as well as appreciating the complexity of urban systems. A key first step to achieving this is to create the channels of dialogue between key actors in the city, and create overarching objectives to promote intersectoral communication and cooperation.

Even if a smart city is described as one that operates with intelligent systems and modern technologies, particularly in the form of digital information and communication technologies, it needs to be supported by strong institutional bodies and partnerships able to create the right framework that allows for changes and adaptations, addressing the new challenges and opportunities. These forms of intelligent collaboration together with a clear vision and strategy constitute the basis and at the same time the precondition for becoming a smart city.

9 REFERENCES

EPAL a: AQUAmatrix, http://www.epal.pt/EPAL/en/menu/products-and-services/aquamatrix, accessed 29.11.2015

EPAL b: WATERBEEP, http://www.epal.pt/EPAL/en/menu/products-and-services/waterbeep, accessed 29.11.2015

FRAUNHOFER IAO: City Lab Report Lisbon. Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO (ed.), Stuttgart, 2016.

KALISCH, D.; SCHATZINGER, S.; BRAUN, S.; RADECKI, A.: Morgenstadt: CityInsights. A Research Approach for Systems Research in Urban Development. In: Proceedings REAL CORP 2013 Tagungsband, pp. 571-578. Vienna, 2013.

WENDT, W; KALISCH, D; VANDIEKEN, T; ENGELBACH, W: Smart Cities and ICT – Insights from the Morgenstadt project, In: Proceeding REAL CORP 2014 Tagungsband, pp. 533-541, Vienna 2014

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