MAtchUP

D6.1: Review of business models and financial instrument

WP 6, T 6.1

Date of document

March, 2019, (M18)

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MAtchUP - SCC-1-2016-2017

Innovation Action – GRANT AGREEMENT No. 774477

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N°774477

Technical References

Project Acronym	**MAtchUP**	
Project Title	MAximizing the UPscaling and replication potential of high-level urban transformation strategies - MAtchUP	
Project Coordinator	Ernesto Faubel Ayuntamiento de Valencia efaubel@valencia.es	D6.1
Project Duration	1 October 2017 – 30 September 2022 (60 Months)	
Deliverable No.		
Dissemination Level		PU[1]
Work Package		WP6-WP Exploitation and Market Deployment – Innovative Business Models
Task		T 6.1- Definition of business model evaluation framework
Lead beneficiary		22 (UBIEFE)
Contributing beneficiary(ies)		22 (UBIEFE), 1 (VAL), 23 (ICE)

1 PU = Public
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Due date of deliverable	31 March 2019
Actual submission date	31 March 2019
Estimated person-month for deliverable	16.25

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N°774477

Version	Person	Partner	Date
ToC	Edoardo Croci, Tania Molteni	UBIEFE	13 February 2018
v1	Edoardo Croci, Tania Molteni	UBIEFE	19 June 2018
V2	Edoardo Croci, Tania Molteni	UBIEFE	5 March 2019
V2.1	Giuliana Folco	ICE	22 March 2019
V2.2	Ernesto Faubel	VAL	25 March 2019
V3	Edoardo Croci, Tania Molteni	UBIEFE	27 March 2019

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1 Abstract

The implementation and uptake of smart city solutions needed for a smart and sustainable transformation of urban systems will require new investments, which however are difficult to retrieve from public sources because of the tightness of public budgets. The design, testing and validation of new and innovative business models, as well as new strategies of cooperation between the public and private sector, will play a fundamental role in financing the implementation of smart city solutions, to support this transformation.

There is a wide literature on smart city business models and on the approaches that can be deployed to assess their performances. This report aims to summarize this literature, providing an overview of the current definitions available of smart city business models and main evaluation methodologies which can be applied. The purpose is to identify the necessary elements which form MAtchUP business model evaluation framework. The report starts from the recognition that smart city solutions are expected to deliver not only a private, financial value, but should contribute to the creation of a wider public value, in economic, social and environmental terms. A comprehensive smart city business model evaluation framework should integrate also this perspective.

The report is structured as follows:

Chapter 2 defines the concept of "smart city business model" and the typologies of business models specifically applied to smart city solutions already defined in literature, providing also examples of existing business models categorizations. Typologies of financial instruments used to support smart city projects are described, as key supporting element of any business model. The chapter also provides an overview of evaluation approaches currently applied, in order to identify the key dimensions that should be included in MAtchUP framework.

Chapter 3 presents the main approaches to the economic evaluation of projects, and related valuation/monetization techniques, to consider their possible applicability to smart city projects. Benefits expected from smart city solutions, in particular MAtchUP ones, are identified and described.

Chapter 4 describes the business model evaluation framework proposed for the MAtchUP project, its main building blocks as well as the units of analysis it will be applied to. Connections with WP5 economic evaluation framework are also described.

The business model evaluation framework defined in Task 6.1. and described in this report will be applied in the following tasks of the project, to MAtchUP business models. Furthermore, external case studies will be analysed, in order to provide relevant insights into the most innovative business models supporting smart city projects and provide a meaningful characterization.

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2 Introduction

2.1 Purpose and target groups

WP6 of MAtchUP project is focused on exploitation and market deployment as well as on the identification and analysis of innovative business models defined and tested within the project. Specifically, Task 6.1. aims to define an evaluation framework, to review the business models developed within the project and identify innovative business models and financial mechanisms to foster the implementation of smart city solutions. This deliverable (6.1) describes:

- the outcomes of the desk research on relevant projects and publications on smart city business models and possible financial instruments, as well as on the key dimensions and criteria to be considered in smart city business models evaluation, and of the literature review on co-benefits evaluation methodologies;
- the overall business model evaluation framework proposed for the MAtchUP project, including the main buildings blocks and criteria that will be considered in the analysis.

The business model evaluation framework described in this report will be applied in the following tasks of the project, to analyse business models tested by MAtchUP lighthouse cities. Furthermore, interesting external case studies will be identified and their business models analysed, in order to provide relevant insights into the most innovative business models supporting smart city projects and provide a meaningful characterization.

The main target groups of this deliverable are the partners of the MAtchUP project, in particular the lighthouse cities that will be engaged in the business models evaluation, and their local partners which are involved in the design, implementation and testing of these business models. The deliverable can also be of interest for other cities, their technical and business partners, who wish to acquire information on evaluation approaches for smart city business models evaluation and on MAtchUP specific approach on this.

There is a strong link between WP6 and WP5 “economic evaluation framework”. WP6 will perform in-depth analysis of business models associated with the interventions implemented in the demo-cases by the MAtchUP lighthouse cities, focusing on their key elements, their strengths and weaknesses, success and failure factors. T5.2. will provide the measurement and the evaluation of the business model performances.

Jointly, these activities will enable to provide insights into the benefits and efficiency of the different solutions and their associated business models, as the basis to produce high level upscaling and replication plans and also to give recommendations at local, regional, national and European level.

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2.2 Table of acronyms

Acronym	Definition
BM	Business Model
BOM	Build Operate Manage
BOO	Build Own Operate
BOT	Build Operate Transfer
CBA	Cost-Benefit Analysis
CCTV	Closed-Circuit Television
CDP	Cassa Depositi e Prestiti
CEA	Cost-Effectiveness Analysis
CEF	Connecting Europe Facility
COSME	Competitiveness of Enterprises and Small and Medium-sized Enterprises
DH&C	District Heating and Cooling
EC	European Commission
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
ELENA	European Local ENergy Assistance
EP	European Parliament
EPC	Energy Performance Contracting
ERDF	European Regional Development Fund
ESA	Ecosystem Services Assessment
ESF	European Social Fund
ESIF	European Structural and Investment Funds
EU	European Union
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ICT	Information and Communication Technology
ITS	Intelligent Transport System
JPI	Joint Programming Initiatives
LED	Light-Emitting Diode
LH	Lighthouse (project, city)
MCA	Multi-Criteria Analysis
OECD	Organisation for Economic Co-operation and Development
OPM	Open Business Model
PPP	Public Private Partnership
RES	Renewable Energy Sources
R&I	Research and Innovation
ROI	Return on Investment
SCC	Smart Cities and Communities
SCIS	Smart Cities Information System
SCTP	Smart City Technology Package
SME	Small and Medium Enterprise
TIF	Tax Increment Financing
V2G	Vehicle-to-grid
WP	Work Package

Table 1: Table of acronyms

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2.3 Contribution from partners

The following Table depicts the main contributions from participant partners in the development of this deliverable.

Partner	Task	Contribution
UBIEFE	6.1	Research activities on smart city projects, criteria & dimensions for business model evaluation, co-benefits evaluation methodologies Elaboration of research grid to analyse business models Overall D6.1 coordination and writing
1-VAL 2-LNV 3-WIT 4-UPV 5-ETRA 6-ITE 7-KVEL 8-DRE 9-DWG 10-DVB 11-VON 12-FHG 13-TUD 14-ANT 15-SAM 16-DEM 17-ANP 18-TAY 19-AKD 20-VTT 21-CAR 23-ICE 24-TEC 25-HER 26-OST 27-SKOP 28-KER	6.1.	Suggestions on relevant literature on smart city business models and innovative business model examples. Feedbacks on elaborated research grid and draft D6.1.

Table 2: Contribution from partners

2.4 Relation to other project activities

The following Table depicts the main relationship of this deliverable to other activities (or deliverables) developed within the MATCHUP Project and that should be considered along with this document for further understanding of its contents.

Partner	Task	Relation to other project activities
UBIEFE	5.2.	Task 6.1. defined the business model evaluation framework and Task 6.2. will apply it to the business models implemented in the project. WP6 will perform in-depth analysis of business models associated with the interventions implemented in the demo-cases by the MAtchUP lighthouse cities, focusing on their key elements, their strengths and weaknesses, success and failure factors. WP5 will provide the measurement and the evaluation of the business model performances, according to the framework defined in Deliverable 5.2.
CAR, UBIEFE	1.3.1	Sub-task 1.3.1 defined an approach to characterize the business models associated with SCTPs (Smart City Technology Packages) to be demonstrated in MAtchUP Lighthouse cities and address their bankability.
VAL, DRE, ANT	2.1.2, 3.1.2, 4.1.2	As part of WP2-3-4, these tasks design the financial and business models of LH cities interventions, which will be analysed within WP6 activities.

Table 3: Relation to other project activities

Given the relevant relations between activities in WP1, WP5 and WP6, specific audio calls between WP leaders were held (CAR, VTT and UBIEFE) to coordinate in the best way.

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3 Evaluation of smart city business models

According to the Strategic Implementation Plan of the European Innovation Partnership on Smart Cities and Communities, *“Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and financing to catalyse sustainable economic development, resilience, and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society”* (EIP-SCC, 2013). The implementation and uptake of smart city solutions that can enable this transformation of urban systems will require new investments, which however are difficult to retrieve from public sources because of the tightness of public budgets. This demands new strategies of cooperation between public and private sectors to mobilize external investments, as well as new business models (EIP-SCC, 2013).

The aim of the following chapter is to define the concept of “smart city business model” and the typologies of business models specifically applied to smart city solutions already defined in literature, providing also examples of existing business models categorizations. Typologies of financial instruments used to support smart city projects are described, since the funding/financial model is a key element of any business model. Since the aim of this Deliverable 6.1. is to describe the business model evaluation framework proposed for the MAtchUP project, the chapter also provides an overview of evaluation approaches currently applied, in order to identify the key dimensions that should be considered in such analyses.

3.1 Defining smart city business models

The concept of “business model” was developed in the ‘60s and it has been increasingly used in the ‘90s in different domains (Diaz-Diaz et al., 2017). Several definitions of business models are available. One of the most diffused definitions state that “business models describe the rationale of how an organization creates, delivers and captures value” (Osterwalder and Pigneur, 2010). In the corporate world, “value” is generally conceived in economic terms and referred to economic/financial performances (Tokoro, 2016). The concept of value has however evolved over time until the theorization by Porter of “creating shared value” (CSV): companies are increasingly required by society to contribute also to the creation of social value (ibid). This is particularly true for smart city projects, since these kinds of city transformations and solutions are expected to contribute to better, more sustainable and low-carbon lifestyles and society and ultimately to create public value for people (Tokoro, 2016; Dameri, Rosenthal, 2014).

In this context, the concept of smart city business model can be interpreted as the mechanisms through which a specific smart city solution (or a combination of interrelated solutions) is able to “create, deliver and capture” private and public (economic, social, environmental) value to society, consistently with the smart city strategy and sustainability goals of the local government. A specific feature of the smart city business model is that the city government has a role in the value network, which

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can be direct (e.g. involvement in the design/provision/delivery of the solution), or indirect (e.g. setting the regulatory framework for the solution). In fact, a smart city solution can be initiated/governed/managed by the city authority itself, or by a different actor (e.g. public or private company).

Other definitions of smart city business models are available and can be adopted. For example, the REPLICATE project focuses on the smart city government perspective, and considers a City Business Model as "*the logic of how a city can create and deliver value through the development of smart services that are economically and socially viable, while reducing the city's overall environmental footprint*" (Timeus et al, 2017). However, a common aspect of smart city business models definitions is the key role assigned to public value from a triple-bottom line perspective.

The concept of public value from smart city projects is multi-faceted since it comprises different types of values, which may not be compatible among them; this value can benefit different stakeholders, each one with their specific interests and motivations; and this value can be delivered over different periods of time (Dameri, Rosenthal, 2014; EIP-SCC, 2018). Therefore, the assessment and evaluation of public value created from smart city projects is a particularly complex task. Current mechanisms of accounting and budgeting are not able to represent the wide range of benefits deriving from smart city solutions (EIP-SCC, 2018). There is a need of new methodologies and approaches to evaluate, quantify and communicate this generated value (ibid, and Dameri, Rosenthal, 2014).

The following table summarizes the main objectives and motivations that drive different stakeholder categories in the pursuit of value from smart city initiatives:

Stakeholders	Economic and social value
Public sector	• Economic development (GDP growth, employment, exports, foreign direct investment) • City attractiveness (ability to attract start-ups, ability to attract citizens • Quality of life • Cost-to-serve the citizen • Environmental sustainability (less emissions) • Social sustainability (less divides) • Mechanisms to internalize externalities
Firms	• New markets and new revenue opportunities • Creation of new companies • Productivity growth • Ability to improve their services and customers' satisfaction while reducing churn
Citizens	• Cost savings (in energy, transportations, etc.) • Higher productivity (savings in time) • Well-being • Empowerment • Inclusion

Table 4: Value creation in Smart Cities (Source: adapted from CDP, 2013)

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EC (2016a) provides an overview of the value that can be generated by smart city solutions, according to their sector and types of solution:

Type		Value proposition
Sustainable urban mobility	*Real-time road user information*	Enable people to take informed decisions about their mobility, saving time and energy.
	ITS-based enhancements of public transport	Reduce waiting time as well as emissions, and facilitate intermodal commuting
	ITS for traffic monitoring, management and enforcement	Optimise fleet management and route scheduling.
Sustainable Districts & Built Environment	*Smart technologies for the built environment*	Pursue better living, resource efficiency and waste reduction.
	Sustainable districts	Reduce emissions and resource consumption by embedding integrated energy efficiency technologies.
	Place making	Create communities of interest that can be key to support integrated SCC solutions.
Integrated Infrastructure & Processes	*Smart City Platforms*	Allows real time monitoring and preventive steering of cities.
	Intelligent City Services	Co-ownership of local matters and outcomes. Efficiency savings for city administrations. Stimulate involvement at local level.
	Smart grids	Collected information and insights may serve planners and managers, but are often also shared with users, who can take more informed decisions and can also become prosumers, i.e. users that can switch from being energy consumers to becoming producers based on the circumstances.

Table 5: Value created to communities by different types of Smart City solutions (EC, 2016a)

These new evaluation approaches should be able to capture the benefits that Smart City solutions are able to produce at different levels. The individual Smart City solution generates direct benefits, such as the direct impact of its investments (EP, 2014). The linkages between Smart City projects enable economies of scale/scope and related efficiency gains, thanks to (for example) the common use of infrastructure. Furthermore, these solutions entail wider positive externalities that include for example the activation of further economic activities/business models, such as those enabled by generated data (ibid).

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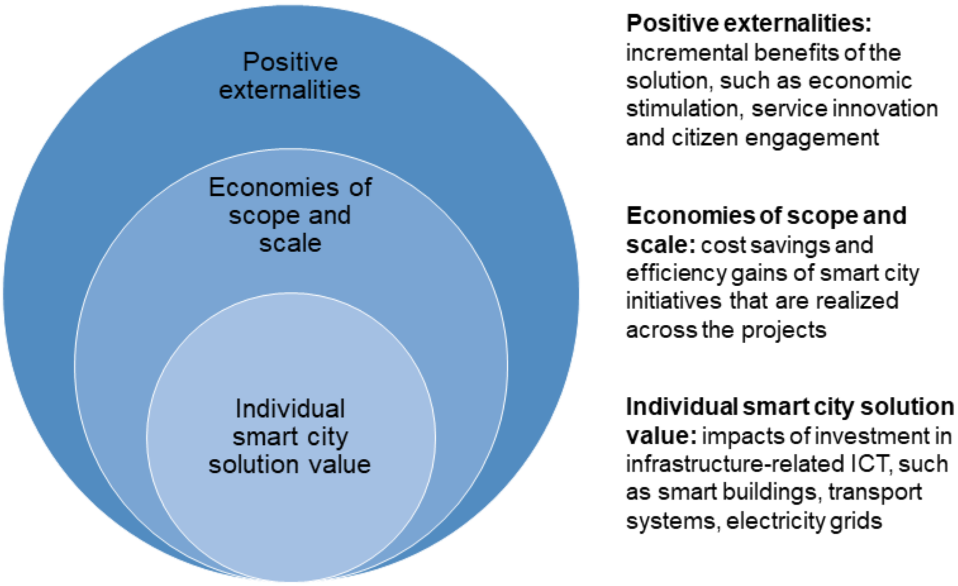

Figure 1: Different levels of benefit of a Smart City solution (EP, 2014)

In business models of Smart City solutions, city governments become active actors in the value network, since they are directly involved in the design/provision/delivery of the service, or because they enable them (e.g. through regulation). Therefore, it is important to consider - alongside the financial value and the business opportunities - also the impact on the public value (Walraven, 2015). Central issues are how and by whom (citizens, users, private and public companies, government) the value produced by smart city solutions is appropriated, and how it can be evaluated and translated into monetary values or utility gains for stakeholders (Vassallo, 2017).

To enable the success of a smart city business model, a mechanism to “capture value” should be defined and implemented (Vassallo, 2017). If the benefit is clearly perceived by the user, the business model can rely on setting a fee and make users pay for this benefit. In other cases, the benefit can take the form of budget savings for municipalities or costs savings for public/private companies. Value can also be captured through taxes aimed to monetize positive externalities (ibid).

Depending on how and to what extent it is possible to capture the generated value, the smart city business model can be different. According to CDP (2013), it is necessary to differentiate smart city business models that are financially unsustainable, and therefore require a public support; mature smart city projects, where market competition is possible; financially sustainable business models, characterized by a low risk and predictable revenue/saving streams. This is the case for example of energy efficiency interventions in buildings, where the energy and monetary savings are accountable. However, the public sector can decide to introduce policy mechanisms aimed to internalize positive externalities which are not monetized in the market, such as environmental benefits. This can be done through (ibid):

- ex-ante mechanisms like incentives, which reduce the investment effort;
- ex-post mechanisms like market instruments (e.g. white certificates), which monetize the positive effects produced by the project.

3.2 Financial instruments to implement smart city solutions

As highlighted also in Deliverable 1.2 of MAtchUP, a provision of adequate funding and financing[2] for smart city solutions is needed to support the large-scale transformation to make cities smarter and more sustainable across several energy-related dimensions. The tightness and current limits imposed to public budgets require the identification and mobilization of private financing sources and new forms of collaborations between the public and the private sectors to foster the deployment of smart city solutions (EC, 2016b).

Several funding programmes for Smart city solutions supported by EU institutions and governments at national and regional are available, which focus on different areas and priorities and are targeted to different actors. EC (2016b) identifies the main following ones at EU level:

Name		Focus
ESIF (European Structural and Investment Funds)	ERDF (European Regional Development Fund)	Social cohesion improvement
	ESF (European Social Fund)	Employment and social inclusion
	Cohesion	Several areas, focus on Member States with low income
EU programmes	Horizon 2020	Support to R&I and cooperation between public and private actors.
	JPI (Joint Programming Initiatives)	Coordination of research and public funds
	CEF (Connecting Europe Facility)	Development of infrastructure
	Life	Environment protection, nature conservation and climate action
	COSME (Competitiveness of Enterprises and Small and Medium-sized Enterprises)	Support to SMEs and entrepreneurs
	ELENA (European Local ENergy Assistance)	Technical support to local and regional authorities to prepare, implement and finance energy efficiency projects.

Table 6: Funding opportunities for smart city solutions at EU level (Source: based on EC, 2016b)

2 According to EC (2016b), funding is a long-term cash inflow to pay for the implementation of a project, and does not foresee a repayment, whereas financing is temporary and is expected to be paid back.

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Finance for smart city projects can be originated from public as well as from private sources, through specific financial products, programmes or instruments. It can take be delivered through debt, equity or guarantees, or through alternative mechanisms (ibid). Several categorizations of these financing opportunities are available across the literature, such as (EC, 2013):

Equity and debt financing	Senior debt instruments Subordinated debt and mezzanine financing Equity financing
Public finance mechanisms	Grants Soft loans Revolving funds Financial instruments
New funding mechanisms	Models for early demonstration and deployment of innovative solutions (grant, guarantee and loan blending mechanism) Project financing Spread shareholding Smart bonds Crowdfinance Energy Performance Contracting (EPC) for energy efficiency

Table 7: Traditional and innovative financing mechanisms for smart cities (Source: based on EC, 2013)

Deliverable 1.2. provides a detailed description of four specific innovative financing schemes, which could be used to ensure the bankability of the smart city strategy defined in the MAtchUP project: Public Private Partnerships, TIF (Tax Increment Financing), Green Bonds and Energy Performance Contracting.

Innovative business models can stimulate the private sector and attract financing to support smart city projects.

3.3 Existing evaluation approaches for smart city business models

Several evaluation approaches have been defined over time to develop new business models or analyzing existing ones, with the aim to support private and public organizations to enhance their mechanisms to deliver value. These approaches vary according to the context in which they were developed, the specific objectives of the

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analysis, the types of solutions/technologies/business sectors they are applied to, as well as the type of users of evaluation results.

Evaluation approaches applied to smart city business models are characterized by the fact that they consider also the public value and the societal benefits deriving from the implementation of smart city solutions. Furthermore, they incorporate and consider the specific role of the city government along the value creation chain. In the following paragraphs, several evaluation approaches will be described, in order to identify the main dimensions that should be considered to design the MAtchUP business model evaluation framework.

To analyse and categorize business models it is necessary to identify a set of key parameters, which in the business model literature are usually named as ‘‘business model dimensions’’, ‘‘business model building blocks’’, or ‘‘business model elements’’ (Ballon, 2007). The number of parameters used can vary from two to several dimensions, and these diverse classification systems lead to several different typologies and taxonomies of business models, which can amount to a few until over 30 (ibid).

One of the most diffused business model evaluation frameworks in the literature is the Business Model Canvas developed by Osterwalder and Pigneur (2010), which identifies the following main building blocks that should be considered when analysing a business model:

- value proposition
- target customer
- distribution channel
- customer relationship
- value configuration
- capabilities
- partnership
- cost structure
- revenue model

The canvas has also been implemented for Non-Profit business models, by including social and environmental costs as well as social and environmental benefits linked to the business model, with the aim to take into account also “not purely economic values that are important when making decisions that affect the society” (Diaz-Diaz et al., 2017). The Non-profit canvas has been specifically applied to smart city business models by Diaz-Diaz and colleagues (ibid). A visualization of the Non-Profit Business Model Canvas is provided below:

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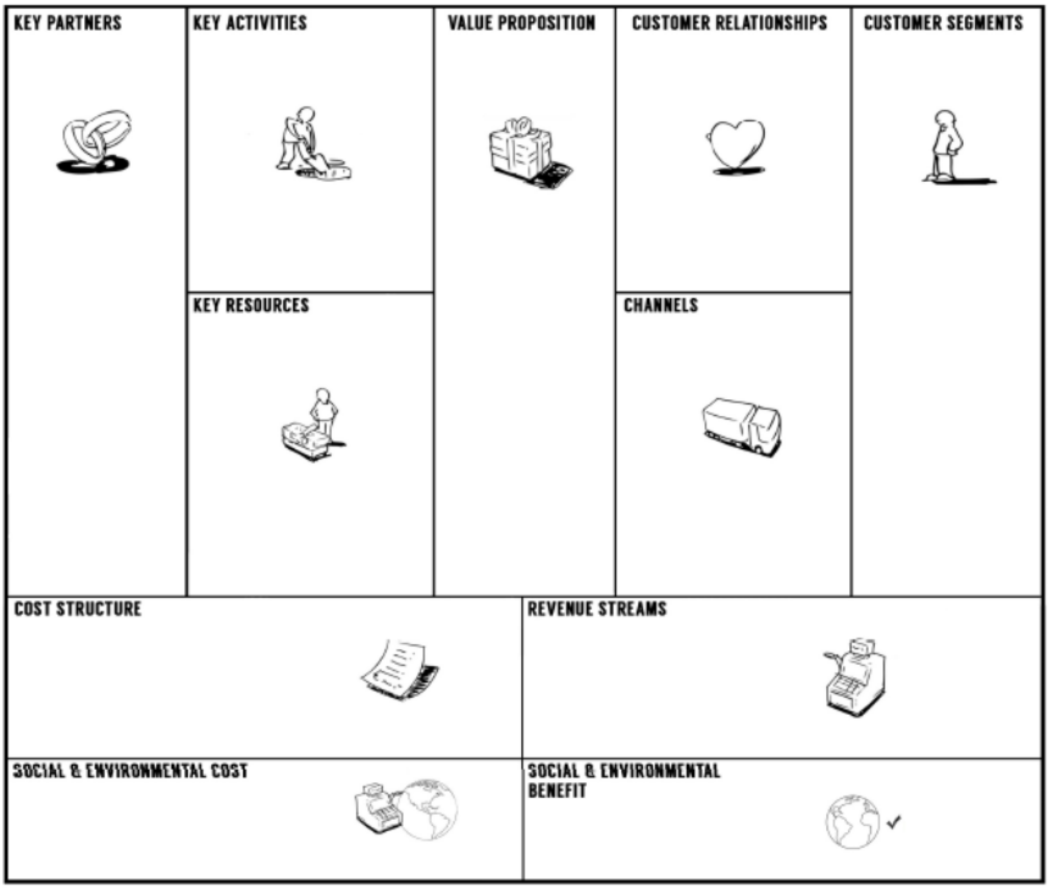

Figure 2: Non-Profit Business Model canvas (Osterwalder, Pigneur, 2010)

A similar approach has been adopted in the REPLICATE project, which developed a framework named “Smart City Model Canvas” based on the original business model canvas. This framework allows municipal authorities to assess their business models, and incorporates the consideration of environmental/social costs and benefits associated with a smart city service (Timeus et al., 2017).

Other frameworks have been developed for the analysis of business models involving city governments in relation to smart city projects.

Walraven (2015) elaborates a theoretical framework for the analysis of smart city business models, where city governments are involved at various degrees in the value network. The framework comprises a set of qualitative indicators to capture and define the dimensions of governments’ involvement in the business model and the type of public value generated by the smart city solutions. Specifically, he applies the framework to mobile city services, mapping a set of case studies. The framework can be used to compare different cases and their underlying strategies.

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	Value network	Technical architecture	Financial architecture	Value proposition
Business design parameters	Control parameters		Value parameters	
	Control over assets	Modularity	Investment structure	User involvement
	Ownership vs Consortium Exclusive vs other Influence	Modular v integrated	Concentrated v distributed	Enabled, Encouraged, Dissuaded or Blocked
	Vertical integration	Distribution of intelligence	Revenue model	Intended Value
	Integrated v disintegrated	Centralised v distributed	Direct v indirect	Price/Quality Lock-in effects
	Control over customers	Interoperability	Revenue sharing	Positioning
	Direct v mediated Profile & identity management	Enabled, Encouraged, Dissuaded or Blocked	Yes or no	Complements v substitutes Branding
Public design parameters	Governance parameters		Public value parameters	
Policy goals	Good governance	Technology governance	ROPI	Public value creation
	Harmonising existing policy goals & regulation Accountability & trust	Inclusive v exclusive Open v closed data	Expectations on financial returns Multiplier effects	Public value justification Market failure motivation
Organisational	Stakeholder management	Public data ownership	Public partnership model	Public value evaluation
	Choices in (public) stakeholder involvement	Definition of conditions under which and with whom data is shared	PPP, PFI, PC...	Yes or no Public value testing

Figure 3: Expanded business model matrix (Walraven, 2015)

Furthermore, templates to analyse business models of smart city solutions have been elaborated within the packaging activity of the SCC01 lighthouse projects, an initiative which is developing common tools to describe and document the solutions implemented in these projects to bring greater consistency and support an aggregated demand of SCC solutions within the market.

An example of the business model template of the packaging activity is provided below.

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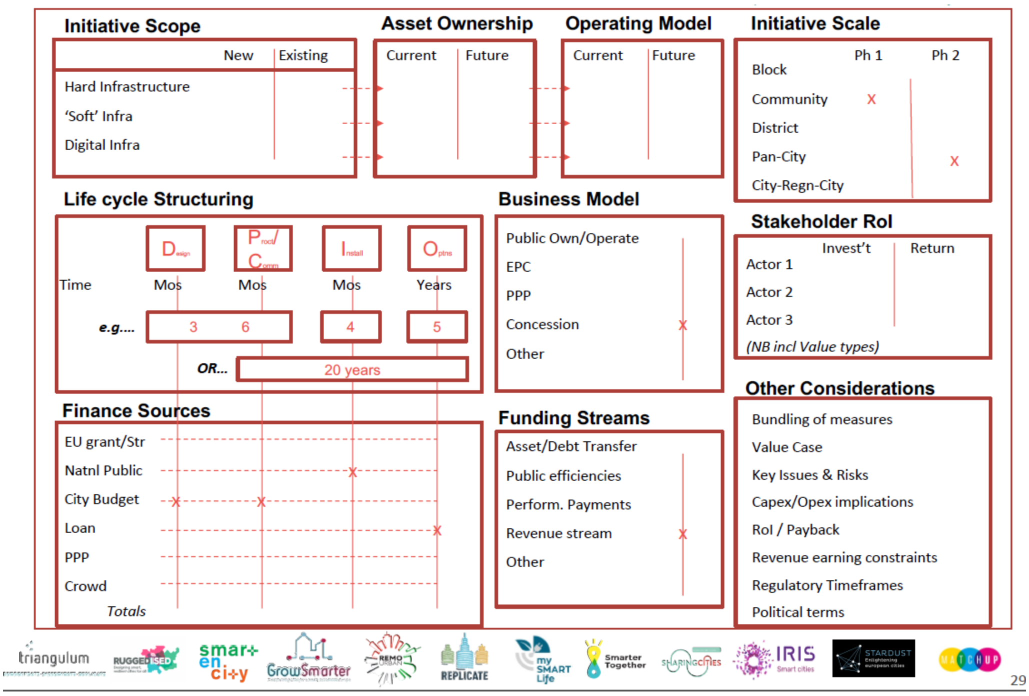

Figure 4: City Business Model & Financing template (Source: Cross-SCC01 Packaging Strategy, 2018)

All these frameworks have been taken into account for the development of the business model evaluation framework of the MAtchUP project (see Chapter 4).

3.4 Existing categorizations of Smart City business models

Taking into account different criteria and dimensions, several categorizations/taxonomies of smart city business models are currently available in the academic and non-academic literature. Most of them have been defined in the context of IT or telecommunication services. Some examples of these taxonomies are described below. They differentiate the business models of smart city solutions based on the following elements:

- the role/responsibilities of the city governments and other stakeholders in designing/building/operating a specific smart service or infrastructure;
- the funding/revenue model, depending on the source/mechanism through which funding is provided to or are generated from a specific smart initiative, and the role of stakeholders in these models;
- the objectives/impacts that the smart solution aims to achieve.

Based on the roles and responsibilities that the city government and its partners have in building the city infrastructure and providing the services, four main smart city business models can be identified (Frost & Sullivan, 2017):

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- **Build Own Operate (BOO)** – The smart city planner independently builds the city infrastructure and delivers smart city services. The operation and maintenance of the services are fully under the planner's control.
- **Build Operate Transfer (BOT)** – The smart city planner appoints a trusted partner to build the city infrastructure and provide smart city services for a particular area within a period. After completion, the operation is handover to the smart city planner.
- **Open Business Model (OPM)** – The city planner allows any qualified company or business organization to build city infrastructure and provide city services. The city planner, however, will impose some regulatory obligations.
- **Build Operate Manage (BOM)** – The smart city planner appoints a trusted partner to develop city infrastructure and services. The partner operates and manages the smart city services. The city planner has no role further. Most of the public-private partnerships are built on this model.

Based on the funding/revenue model, several typologies of business models can be defined, which comprise traditional funding approaches (i.e. an external investment) to more innovative ones (e.g. data monetization). Bélissent et al. (2010) identify the following engagement models for smart cities, that can provide funding for ICT initiatives.

External investment	Regional banks and investments funds such as the Asian Development Bank, Inter-American Development Bank and the Brazilian Development Bank, provide funding for public-sector IT initiatives.
Revenue-generating (or cost-cutting) initiatives	Revenue-generating and cost-cutting initiatives, such as fee and tax collection or electronic government procurement, can become self-funding and prove appealing both for budgetary and political reasons.
Revenue-sharing and public-private partnerships	Partnerships with a vendor, service provider, systems integrator, or even real estate developer on a revenue-sharing basis can defray upfront costs and risks of a new initiative.
Capacity reselling	Excess capacity from large municipal IT infrastructure or applications deployments can be provided to neighbouring cities or organizations, with the larger city IT department acting as a service provider or through a managed service provider.
Multicity initiatives	Upfront agreements to pool resources and share infrastructure facilitate the launch of large IT initiatives.
Leasing and financing	Traditional financing remains an alternative for the purchase of IT infrastructure, particularly hardware and networking, and provides flexibility in case of budget shortfall or other political contingencies.
Barter or in-kind exchange	Exchange of product testing or customer references for new technologies is a way of overcoming budget shortfalls, particularly for universities or research facilities with skilled developers and users.
Data monetization	The use of primary data generated by instrumented infrastructure provides a potential revenue source for data owners.

Table 8: Alternative engagement models for IT initiatives (Source: Bélissent et al., 2010)

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In addition, smart city business models can be categorized according to the main objective and technical impacts of the solutions. Mulligan and Olsson (2013) apply this approach to business models in the ICT and telecommunications sector:

Category	Example	Technical impact
Environmental improvement	Smart meters, smart grid, air quality monitoring	New devices connected to network
Economic growth	Incubators, smart education, green growth initiatives	Open data, data aggregation
Cost efficiency	Removing data silos between government departments	Cloud computing, open data
Safety	Sensoring firemen, redirecting transport around a collision	New devices, new data sources, data aggregation, open data
Quality of life	Feedback loops in urban planning from data across the city	Data aggregation, information management
Connected citizens	Transport apps for a “connected commute”	Privacy, data aggregation, open data
New business models	Using data from smartphones across a city to create new advertising and revenue streams for local businesses	Privacy, data aggregation, open data, data provenance

Table 9: Categories of smart city business models (source: Mulligan and Olsson, 2013)

3.5 Existing collections of Smart City business models

The **European Innovation Partnership on Smart Cities and Communities** (EIP-SCC) has launched a **Business Models Repository**[3], providing information on business models of projects developing smart city solutions, with the aim to support project development and replicability.

For each project, the following information is provided:

- **City**
- **City population**
- **Type of solution** (sustainable district, Smart technologies for the built environment, Intelligent City Services, Smart grid, ITS for traffic monitoring, management, enforcement)
- **Financial sources** (public funding/private resources/revenue stream)
- **Main technologies involved**
- **Needs addressed**
- **Impact of the solution**

3 https://eu-smartcities.eu/business-models-repository

The platform currently displays 21 cases[4] from a variety of EU Member States covering differing project typologies and sectors.

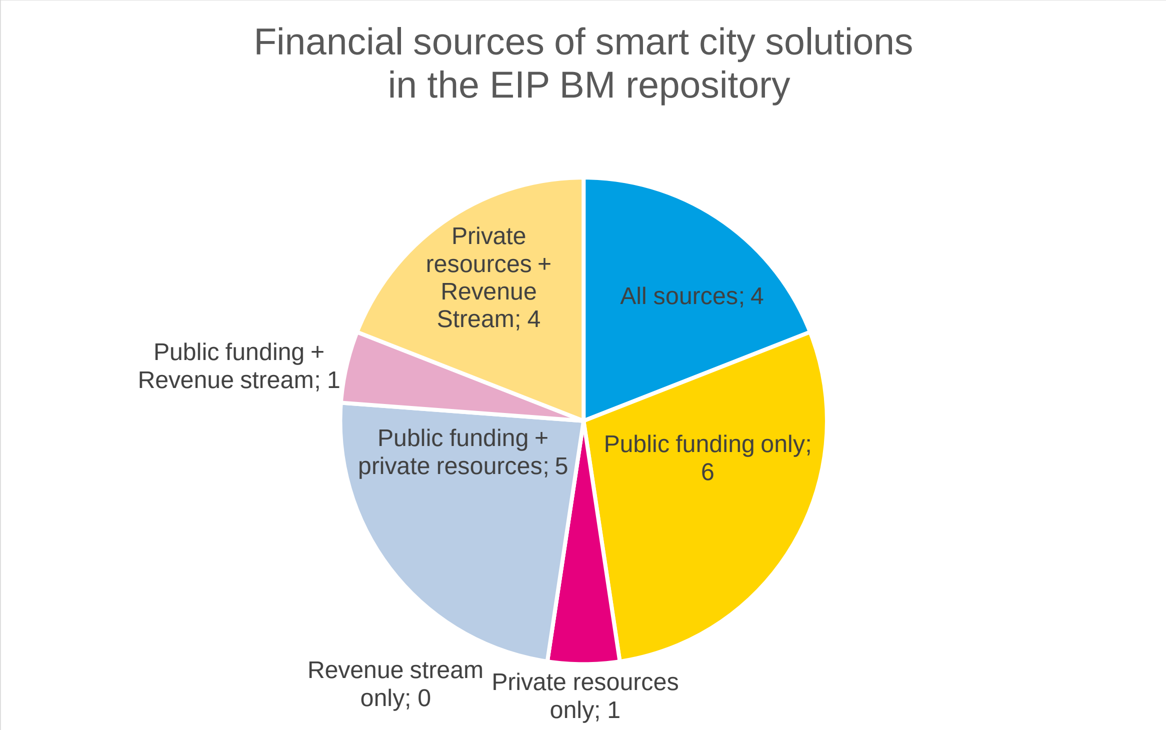

Figure 5: Financial sources of smart city solutions in the EIP Business models repository

Of the 21 smart city solution cases included in the BM repository, the individual financial sources or combination of them which are most frequently used are public funding only (6 cases), public and private resources together (5), private resources and revenue streams together (4) or all three types of sources together (4). The adoption of private resources only or a combination of public funding and revenue stream is seldom present (1 cases each). No cases rely uniquely on revenue streams.

4 As of 11 March 2019.

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4 Review of approaches for the valuation/monetisation of externalities and co-benefits of smart city projects

As described in Chapter 2, there are many definitions of "smart city business models" and different evaluation methodologies to assess their performances. Some methodologies are the adaptation of business model evaluation approaches already applied in the private sector, integrated by additional elements which aim to provide insights about the wider social, economic and environmental effects of smart city projects. A key aspect is the quantification of these effects and their communication to all stakeholders, in order to make them aware of the overall value generated by a project. Valuation/monetization techniques applied for the economic evaluation of projects could be considered as possible tools to translate these effects into monetary values, incorporating existing business model analysis with a public value perspective.

At this purpose, the following chapter aims to provide an overview of approaches to the economic evaluation of projects, and related valuation/monetization techniques, in order to provide useful elements to the definition of MAtchUP business model evaluation framework. Examples of economic evaluation methodologies are provided, together with their application to smart city projects. Their potential applicability in the context of MAtchUP is discussed. A specific smart city project in fact could be analysed from different perspectives: from a purely financial perspective, relevant to the project investor, to a wider economic assessment relevant to society, including also potential external effects which are not usually accounted and valued in markets (i.e. externalities and co-benefits).

A specific focus of the chapter is dedicated to the identification of the multiple benefits deriving from smart city projects, considering the typologies of actions implemented in the MAtchUP project. The main suggestion from the chapter is that a smart city business model evaluation framework should be able to identify, qualify and quantify these effects and the value generated by smart city projects, by applying a combination of different techniques, including qualitative and quantitative indicators.

4.1 Economic evaluation of smart city projects

Economic evaluation/assessment is a broad term adopted in several domains, which refers to the comparative analysis of costs and effects (benefits) deriving from different projects, programmes, interventions or policies. It aims to support decisions in the allocation and use of resources, as well as to assess the efficiency of implemented interventions, by structuring information that is relevant to a decision (Brander, van Beukering, 2016). Different methodologies of economic evaluation are available. The selection of the methodology to be used depends on the specific field and objectives of the project/programme/intervention, on data availability, as well as on the viewpoint adopted in the analysis (private vs. public perspective). Ideally, a combination of tools should be adopted to inform a decision, in order to (OECD, 2018):

- have a broader picture, since each tool provides a different perspective on the same problem;

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- minimize the shortcomings of each methodology, including possible information/evidence gaps;
- represent a plurality of views and beliefs;
- more effectively support participative or deliberative processes;
- account for the level of data availability.

A main distinction should be made between financial and economic analysis (COWI, 2016).

The financial analysis of a project is focused on its profitability for the investor. It compares the project costs with its revenues over the project lifetime, in order to calculate the project return on investment and assess its performance. The financial analysis is based on market prices and does not consider external effects (i.e. externalities) generated by the investment.

Several tools are available to perform project financial analysis, including indicators such as the Return of Investment, Financial Net Present Value and Financial Internal Rate of Return.

The economic analysis aims to evaluate if the project is beneficial to the society. It compares the overall costs and benefits deriving from a project, including its external effects (e.g. environmental or health externalities), by translating them into monetary values by means of different techniques.

Several methodologies are available for economic analyses of alternative options, which are applied to projects, programmes or policies, among which the Cost-Benefit Analysis (CBA), which is widely applied (see Table below for further information).

• **Cost-effectiveness analysis (CEA):** it is applied to decisions where a specific goal can be identified. It evaluates the effectiveness of alternative options in achieving the specific goal, by considering only the costs associated with its implementation (the benefits are not included); it thus enables to rank different options and identify the option that achieves the desired goal with the least cost;
• **Cost-benefit analysis (CBA)**: it compares the value of costs and benefits associated with the implementation of alternative options, by translating them into a common unit (monetary terms), in order to calculate the net benefit (i.e. if benefits exceed costs); it can be carried out from the perspective of society as a whole or from the perspective of an individual person, organization or company;
• **Multi-criteria analysis (MCA)**: it compares costs/benefits of different options, including those which cannot be translated into monetary values but only in other values or qualitatively, by applying a set of criteria, to which different weights and scores are attributed.

Table 10: Most common methodologies for economic evaluation

A key feature of CBA is the valuation process, meaning the attribution of a monetary value to the effects/impacts of a project or a policy, including the monetization of externalities (OECD, 2018). In the economic literature, the concept of externalities is used for “any cost (negative externality) or benefit (positive externality) that spills over

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from the project towards other parties without monetary compensation" (EC, 2014). Since the '90s, also the concept of "co-benefits" and "co-costs" has started to be considered in economic evaluations, originating from the analysis of GHG reduction policies (Davis et al., 2000). They can be understood as the "positive/negative effects arising from a project, both intentional and not, exceeding the intended primary goal" (Bisello, 2016). These effects can comprise both tangible (e.g. increased market value of buildings) and intangible effects (e.g. technological innovation in firms) (ibid).

Different techniques for the monetization of externalities and co-benefits are available (see par. 3.3. for a brief overview). Monetization of benefits and co-benefits is a widely debated approach, also for ethical issues (e.g. in the domain of health). It should be considered that the translation into monetary terms can be understood as a common unit of measure to express value across different domains (Bisello, 2016).

As shown from this brief description, economic evaluation approaches can have different perspectives, purposes, scopes, and they make use of a variety of tools. A specific smart city project could be analysed from different perspectives: financial, economic, including externalities and co-benefits, depending on the specific needs and scope. Since smart city projects are expected to deliver private and public value, a purely financial analysis seems to cover only partially the need for information on a smart city project impact.

CBA studies have been conducted on specific Smart City solutions, for example within the ESPRESSO project (Espresso – systEmic Standardisation apPRoach to Empower Smart citieS and cOmmunities)[5]. Espresso was a Horizon 2020 funded project, focused on the development of a conceptual Smart City Information Framework based on open standards. The framework included the development of a Smart City Platform and a series of data provision and processing services to integrate relevant data, workflows, and processes. Espresso applied a cost-benefit analysis of the project use-cases. The CBA investigated costs, as well as a set of monetized and qualitative benefits (see also par 4.1.3 of Deliverable 5.2. "Economic evaluation framework").

Another example is an economic CBA of implementing public WiFi into a test grid of smart LED street lights in Columbus (US) (Vento et al., 2017). The study aimed to evaluate costs and benefits of a project implementing free public WiFi in a neighbourhood through smart street lighting system, to inform the City of Columbus on the compatibility of the project with its public sustainability policies and goals. The analysis focused on a set of environmental (energy and GHG savings) as well as societal benefits (educational and career development impacts) deriving from the implementation of the smart solution.

Over time, CBA has been harshly critiqued for many reasons, defining it as an "inherently flawed" approach (Ackerman, Heizerling, 2002). For urban transformation projects, in particular for urban regeneration projects, it has been suggested to adopt hybrid approaches, combining different methodologies like CBA and MCA in order to capture a broader variety of aspects and tackle the complexity of urban systems (Bottero, Mondini, 2016). New evaluation frameworks are being implemented which

5 http://espresso-project.eu/

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aim to quantify the overall social and environmental impacts of urban projects, overcoming traditional CBA approaches or financial indicators like the Return on Investment (ROI). An example is the Sustainable Return on Investment (SuROI), which combines an estimation of social value based on the Social ROI and Wellbeing Valuation techniques, and the estimation of the ecological value using the Ecosystem Services Approach (ESA) (Bichard, 2016). This framework has been applied to regeneration project case studies in UK (Dean et al., 2017).

In smart city lighthouse projects like MAtchUP, the solutions and projects to be implemented have already been assessed and selected for implementation. They are part of an integrated urban transformation vision and process defined by participating cities. So, a potential economic evaluation is not targeted to compare different implementation options, as it might be in common economic analyses. A full economic evaluation of solutions is not in the scope of project activities, and specifically of WP6 and WP5 economic evaluation activities. The overview of evaluation and monetization approaches provided here aims to give insights into possible unexplored dimensions and impacts of smart city projects, which could play a role in the innovative business models tested by lighthouse cities. Identifying suitable mechanisms to make this value visible within smart city business models is a key aspect of lighthouse projects, which should be explored through the demo-sites activities.

4.2 Key externalities and co-benefits of smart city projects

As described in Chapter 2, individual smart city projects are not only able to generate a specific type of value and effect, based upon their objectives and value proposition, but they can deliver different typologies of benefits which are distributed across several stakeholders.

Benefits from Smart City solutions regard a variety of aspects and include: improvement in city services, increased efficiency in governance, improvement of environmental conditions (e.g. air pollution reduction, GHG emissions reduction), energy and cost-savings, time savings, increase of safety, health benefits, innovation in the industry sector and in economic activities, promotion of new economic activities/business models, smarter infrastructure (EP, 2014; Lam and Yang, 2017)

These benefits can be further detailed according to the typology of solutions considered. For example, intelligent transportation systems are acknowledged to improve road and pedestrian safety, improve traffic management, increase vehicle connectivity and enable better driver comfort (Galati, 2018).

Ultimately, smart city solutions are expected to contribute to an overall improvement of a city and its citizens' quality of life, delivering social, economic and environmental value. Therefore, a comprehensive overview of the overall effects deriving from their implementation would be desirable, in order to evaluate the overall value and benefit for society. To this purpose, the previous paragraph introduced the economic concepts of "externalities" and "co-benefits". Smart city solutions are able to deliver relevant positive externalities in terms of GHG and pollutant emission reductions, noise reduction, better resource consumption. However, these benefits may not be considered or valorised in their business model (von Radecki, 2016). Furthermore,

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these types of solutions can deliver additional positive externalities, which derive from the connection and integration among different technologies enabled by ICT (ibid).

Regarding co-benefits, if the primary goal of smart city solutions is identified as the reduction of energy consumption and related GHGs, the additional effects generated by the adoption of the solution (e.g. in terms of employment opportunities or better environmental resources management) could be considered as its “co-benefits”. There is a wide literature discussing the differences between externalities, co-benefits and related concepts (e.g. Ürge-Vorsatz et al. 2014).

The identification and evaluation of main externalities and additional benefits derived from the implementation of smart city solutions is useful to capture their contribution to the smart city policies and priorities, as well as their overall social, economic and environmental value. Since smart city solutions are expected to address multiple goals simultaneously, it can be useful to adopt the concept of “multiple benefits” for the analysis of these types of solutions and their related business models.

Benefits and costs of smart city projects can be divided into “direct” and “indirect” ones from the point of view of a public authority and according to the source of investment (public/private) (Lam and Yang, 2017).

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Figure Errore. Solo documento principale.**: Examples of costs of Smart City projects (source: Lam and Yang, 2017)**

Source of Investment	Benefits	
	Direct Benefit	Indirect Benefit
PUBLIC SECTOR ONLY	User Charge (if applicable) as public revenue	Saving of scarce resources (alleviate manpower shortage)
	Time saved due to increased convenience , less travelling time and queuing time	Property value / wage increase due to smart installation
	Increased spending (e.g. online purchases, booking, etc.)	Multiplier effect on local economy
	Life saved from accident reduction/disaster prevention	General happiness of users
	Medical cost saving	More timely treatment of illness (less suffering)
	Higher productivity	More resting time/reduced stress
	Reduced pollution (e.g. noise, air, water) abatement	More family union time
	Increased tourism income	Fame and prestige of city
	Street crime reduction	Reduced penal & rehab cost/crime investigation cost
		Birth rate increase alleviates manpower shortage
PUBLIC BENEFITS IN CASE OF PRIVATE INVOLVEMENT	Private sector skills made available	Technology transfer
	Improved efficiency	Competition leads to improved service quality, better technological innovation development and lower price
	Finance availability	Public funds can be channeled for other uses
	Risk transfer	Increase export opportunities (if systems have market)
	Increase local/foreign investment	
	Reduce public sector establishment size	

Smart City Projects

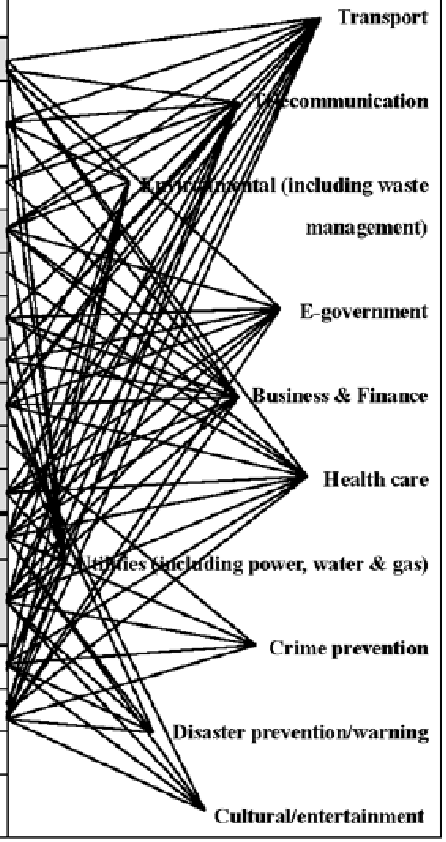

Figure 6: Examples of benefits of Smart City projects (source: Lam and Yang, 2017)

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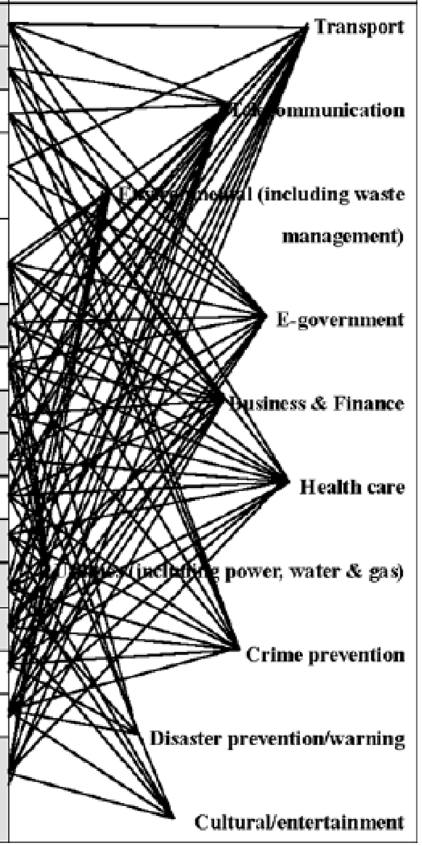
Source of Investment		Costs			Smart City Projects
		Direct Cost		Indirect Cost	
PUBLIC SECTOR ONLY		Prelim study + Public Engagement		Privacy breach	
	Part or all of these costs transferrable to Private Sector in PPPs	Design + Research & Development		Confidentiality breach	
		Installation + Backup system		Cyber Attack	
		Operation	Data collection & management	Downtime loss (including loss of opportunities, loss of market value, etc.)	
			License fees for software		
		Equipment maintenance		Non-availability leads to substitution by manual methods (if still exist)	
		Soft & equipment update/replacement		Chaos caused by network congestion/failure	
		Date center building & maintenance (if needed)		Failed system rectification	
		Help desk services		Unhappiness caused to users due to system failure	
				Widened "Digital Divide" btw. users & non-users	
				Forced redundancy payment to severed manual workers	
				Anti-social behaviours	
PUBLIC COST IN CASE OF PRIVATE INVOLVEMENT		Tender / Output Specifications / Negotiation		Monopoly price-setting	
		Legal fees in contract preparation		Poor service quality	
		Performance monitoring		Delay (forced use of alternative)	
		Loss of user charges as government revenue		Dispute resolution	
		Subsidies / Tax reduction as incentives		Polarity btw. payers (for private good) and non-payers (for public good)/Allegation of favoritism/Gov't image damage	



Overall, the co-benefits of smart city projects have been seldom investigated. An overview and taxonomy of possible co-benefits associated with the implementation of a specific type of smart city projects, the Smart and Sustainable Energy-District Projects (SSEDPs), funded within the CONCERTO initiative and the Smart Cities and Communities programme, is provided by Bisello (2016). These projects involve the energy-optimisation of districts and communities. Their co-benefits can be referred to three types of project activities (intervention on buildings and infrastructures at district level; actions on stakeholders; design and management), and cover all the three pillars of sustainability (economic, environmental, social). As shown in the next image, co-benefits contribute to different dimensions of the smart city transformation:

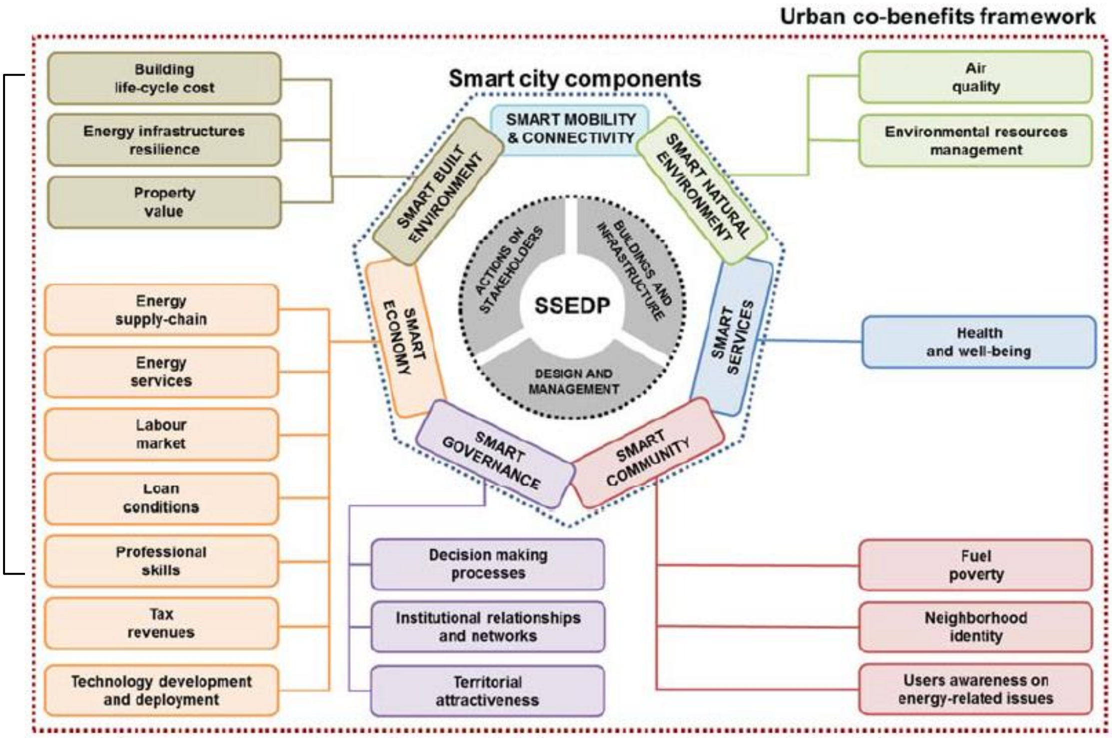


Figure 7: Role of SSEDPs co-benefits towards the achievement of smart-city status (Source: Bisello, 2016).

MAtchUP project will deploy several solutions in the energy, mobility, ICT and non-technical domain in the three lighthouse cities of Valencia, Dresden and Antalya, with the aim to contribute to a smart and sustainable urban transformation.

The following table maps the main benefits associated with solutions to be implemented in MAtchUP demo-sites, based on the descriptions provided in project deliverables and the overview of literature on smart city project benefits analysed in WP6. Reduction of GHGs and energy savings are not mentioned since they are considered as main primary benefits and goals of all solutions. The mapping of benefits is not exhaustive, but may be further integrated and detailed according to the typology of solutions.

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The three evaluation frameworks (technical-environmental, economic, social) developed in WP5 of the MAtchUP project will enable to evaluate a selected number of actions-related benefits, to account for the impact of solutions implemented within the project.

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Table 11: Main benefits linked with MAtchUP solutions

Category	Sub-category	Potential benefits
Buildings and district	*Building integrated RES*	**Stronger dependence on RES:** integration of RES enables a stronger production and reliance on renewable energy sources, benefitting all buildings but especially those with high energy needs. **System flexibility:** it ensures a continuous service in the face of rapid and large swings in supply or demand. **Energy autonomy**: it contributes to the establishment of a local energy supply-chain and (if self-consumption is possible) it enables greater autonomy. **Services availability:** if legally possible, building integrated RES can create local microgrids that can be leveraged for other services (e.g. e-vehicles). **Cost-effectiveness**: integration of renewable energy sources strengthens their cost-effectiveness, with positive impacts on energy bills. **Health improvements due to air pollution reduction:** the production of renewable energy leads to a reduction of air pollution from fossil fuel energy production. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases). **Employment opportunities:** it supports the renewable-energy supply chain and may create new job opportunities in the installation/maintenance sectors.
	Building integrated storage	**Reliability:** storage enables the continuity of service, ensuring security of energy supply by storing excess power for late use. **Increased efficiency:** storage increases the efficiency of building renewable energy systems, strengthening the benefits of their integration, enabling load shifting and improved demand management. **Cost-effectiveness**: increased efficiency of the overall system translates in savings in energy bills. **Energy autonomy**: it contributes to the establishment of a local energy supply-chain and (if self-consumption is possible) it enables greater autonomy. **Health improvements due to air pollution reduction:** storage maximizes the positive impacts of RES with positive impacts on air pollution reduction.
	Domotics & smart controls	**Efficiency:** smart energy controls support energy and facility managers in their energy planning and management activities.

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		Reduction of building's maintenance cost: the deployment of smart controllers can increase the efficiency of building control, identifying more quickly technical problems or issues to be solved and optimizing the monitoring/management of its technical components and maintenance issues. **Reduction of workers' illnesses:** a better indoor environment in the building can create better working conditions for workers involved in maintenance. **Health improvements due to air pollution reduction:** energy savings lead to a reduction of air pollution from fossil fuel energy production. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases). **Wellbeing:** residents can benefit from domotics solutions to improve their indoor quality of life. **Changing behaviors:** the possibility to access data on energy consumption makes residents informed about their habits and drives changing behaviors, enabling a virtuous cycle that accelerates energy savings. **Innovative services, startups and employment opportunities:** domotics can support the development of new applications and foster the birth of new startups offering innovative services. This in turn will create employment opportunities with positive effects on local GDP.
	New buildings	**High-quality indoor environment:** new buildings designed with smart criteria and technologies provide a good management of indoor temperature (heating/cooling) and air quality. **"One stop-shop":** new buildings designed with smart criteria and technologies have the potential to integrate all benefits of integrated RES, integrated storage, domotics and smart controls (as described above), and can be seen as a "one stop-shop" of sustainable energy in smart buildings. **Employment opportunities:** they may create new job opportunities in the smart/sustainable buildings construction sector.
	Retrofitting	**Sustainable environment:** considering the small number of new buildings and the very large stock of aged buildings in EU cities, retrofitting is key to accelerate cities' move to a sustainable environment. **Better indoor environment and wellbeing:** retrofitting improves internal living conditions in relation to humidity/heating/cooling. **Health improvements due to air pollution reduction:** energy savings lead to a reduction of air pollution from fossil fuel energy production. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases). **Technology-driven benefits:** depending on technologies installed, retrofitting benefits from the different positive factors highlighted in this table. **Improved aesthetic:** retrofitting improves the aesthetic of cities and enhances the social image of buildings'

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		residents fostering their satisfaction and sense of belonging. **Employment opportunities:** it may create new job opportunities in retrofitting.
	Building repurposing actions	**Public space savings:** it may avoid the consumption of further public space, enabling a better use and management of urban land.
City infrastructures	*District heating and cooling*	**Increased efficiency:** DH&C is considered more efficient than conventional plants **Health improvements due to air pollution reduction:** depending on how district heating and cooling is alimented, it may lead to a reduction of fossil fuel consumption. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases).
	District thermal storage	**Increased efficiency:** storage can increase the efficiency of the energy system in a specific district.
	District electrical storage	
	Public lighting	**Reduction of public lighting cost:** real time data from smart public lighting enable a more efficient management of on/off switches of the lighting network and sensibly reduces costs, to the benefit of the entire city community. **Reduction of public lighting maintenance cost:** the deployment of smart lighting can increase the efficiency of lighting control, identifying more quickly technical problems or issues to be solved and optimizing the monitoring/management of its technical components and maintenance issues. **Increased road and personal safety:** better lighting of streets make people feel safer at night; **Integration and enablement of new services**: smart public lighting builds upon a platform that can enable and deliver new services such as noise detection, movement detection, air pollution detection, CCTV cameras, traffic sensors, etc. **Health improvements due to air pollution reduction:** energy savings lead to a reduction of air pollution from fossil fuel energy production. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases).
	Smart grids	**Reduction of power interruptions:** smart grids reduce the costs of breakdowns and related maintenance costs, ensuring security of supply in a time energy demand keeps on increasing. **Remote control of consumption**: the possibility of having a smart grid is the first step that allows the management of demand and storage.

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		Grid efficiency: Matching demand and supply minimizes waste and loss in the grid and enables a more efficient management of the grid. **Postponing the need to invest in infrastructure**: thanks to demand management, consumption peaks can be reduced, thus delaying the need to invest in new electricity infrastructure over time. **Other Utilities' benefits**: smart grids help utilities face a long list of other challenges including high power system loading, increasing distance between generation and consumption, increasing cost and regulatory pressures, increased energy trading, utility unbundling, etc. **Transparency:** smart grids enable transparency in the consumption and pricing to the energy end-users/citizens. **New energy consumption models:** smart grids enable new energy consumption models, including e-vehicles, smart buildings, domotics and residents' smart control, etc. **Integration of alternative energy sources:** solar and wind energy sources are intermittent depending on weather conditions. This puts additional strains on existing ageing grids. Their intermittence must be counter-balanced with more intelligence in the grid. **Health improvements due to air pollution reduction:** due to the above, smart grids accelerate the reliance on new consumption models and alternative energy sources with positive impacts on air pollution. **Demand for new skills:** smart grids require new skills and create new jobs. **SMEs, start-ups and employment opportunities:** as enabler of new consumption models, smart grids creates new business opportunities for SMEs and start-ups offering innovative services, thus fostering employment and GDP growth.
	Urban level RES	**"Multiplying" benefits:** urban level RES extends the benefits of RES within buildings to an urban area. Most of benefits presented for building integrated RES apply and are magnified at urban scale. **Utilization of a residual energy**: within MAtchUP, the integration of a sewer retrofitting system which includes an in-sewer heat recovery system allows taking advantage of a type of energy that until now was not used.
Mobility actions	*Charging stations*	**Service availability:** charging stations can provide multiple services to e-vehicles users.
	Demand management	**Increased efficiency in electromobility management:** Demand management-EV to grid and grid to EV ensure effective performances in the management of e-vehicles, potentially enabling car owners to sell energy to the network and utilities to use it as a backstop to face peaks in energy demand. **Costs savings:** this would enable to save costs of both car owners and utility providers.

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		Environmental sustainability: reduced waste of energy through EV to grid and grid to EV strengthens environmental sustainability of e-vehicles. **Intermittence of RES**: EV-to-grid helps mitigating the challenges of intermittence of solar and wind energy, which are dependent on weather conditions. Green energy stored in vehicles feed back into the network, ensuring continuity of the service and grid reliability. **Driver for further energy innovation:** further innovation can follow, including for example Vehicle-to-Home.
	Electric vehicles	**Health improvements due to air pollution reduction**: electric vehicles enable a reduction of local air pollution in the city. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases). **Noise reduction:** electric vehicles are more silent than conventional vehicles. **Storage or regulation function for the grid:** Because of their batteries, electric vehicles can store small amounts of electricity in their batteries and effectively decouple electricity generation from demand (Malmgren, 2016), (Vehicle to Grid - V2G). However this may not be possible for grid limitations.
	Intelligent transport systems	**Increased safety:** ITS are acknowledged for enabling road and pedestrian safety **Increased efficiency/time savings**: ITS enables better traffic management, minimizing traffic problems. Data can be leveraged also for advanced urban traffic planning. **Better drivers' and commuters' comfort** (Galati, 2018): ITS drives comfort thanks to prior information about traffic and real-time running information, but also seat availability, bus timing, bus location, etc. for public transport. **Driver for further innovation**: ITS functionalities can be extended to cover several areas within traffic management, traveller information systems, vehicle control systems, public transportation system, commercial vehicles operations system, etc.
	Multimodality	**Increased efficiency/time savings:** multimodality ensures flexibility in urban travels, tailoring the transport mode use to the current traffic conditions and itineraries. **Health improvements due to air pollution reduction**: multimodality including sustainable transport modes can contribute to reduce personal car use, leading to a reduction of local air pollution in the city. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases).
	Urban freights - logistics	**Increased efficiency/time savings:** some vehicles may be more efficient in last-mile freight due to local traffic conditions (eg. e-bikes).

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		Congestion reduction: some vehicles free road space (e.g. e-bikes). **Health improvements due to air pollution reduction**: the use of e-vehicles for last mile delivery can partially substitute the use of conventionally fueled vehicles, leading to a reduction of local air pollution in the city. At a certain scale, a health improvement effect can be detected (reduction of air pollution-related diseases).
Non-technical actions	*Citizen's engagement*	**Empowerment & inclusion:** the participation into co-design and co-creation processes, as well as the possibility to provide feedback on the effectiveness, usefulness and benefits of the urban transformation will empower citizens and enable the inclusion of vulnerable groups into decision processes. **Education opportunities & sustainability awareness:** the provision of training opportunities as well as of informative materials on the project and the smart solutions to be implemented will increase the knowledge of citizens on these issues, as well as it will sensitize them to change their behaviours into sustainable practices. **Partnership between citizens and public sector:** citizens will play an active role in setting the vision for the smart and sustainable transformation of their cities in the incoming years. **Improved services to citizens:** connecting with citizens drives a better understanding of citizens' needs, requirements and expectations, and enables public authorities to deliver better and tailored services to its citizens.
	Innovative business	**Education & employment opportunities:** Specific employment and training programmes related to innovative business can increase job opportunities in the concerned areas. **Partnership between private and public sector:** new forms of public-private collaborations will be tested in the project as a way to provide alternative financing models for smart city solutions. **Development of new business models:** Smart city solutions provide the opportunity to develop and test innovative business models (e.g. which rely on self-consumption models, the combination of different technologies, the use of urban data).
	Policy improvement	**Increased efficiency:** Overall, the results from the actions implemented in the project across different fields will enable to revise, improve and integrate policies in several sectors, in the view to achieve greater efficiency and overall greater public value.
	Staff exchange	**Knowledge sharing & education opportunities:** Staff exchanges are important opportunities to share the different types of knowledge available in city departments and among different cities, and contribute to spread good practices, tools, break silos and stimulate innovation in public administrations.
	Urban planning	**Upscaling & replication opportunities:** The development of specific upscaling and replication plans will contribute to a greater diffusion of smart city solutions tested within the project.

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		Increased efficiency: The monitoring will enable to revise, improve and update city plans in the sustainable energy, mobility, ICT and other fields, in view of achieving greater efficiency and sharing the achieved results and lessons learnt with other cities (e.g. within the Covenant of Mayors initiative).
Urban platform and ICT developments	*IoT* *Urban platform*	**Smart city enabler:** ICT urban platforms are the key enabler of the smart services cities deliver to their citizens. IoT leverages open standards, which allow overcoming the barriers of using proprietary technologies in data monitoring and management. This in turn drives the proliferations of sensors in city contexts. An integrated approach to data management within the ICT urban platform allows effective planning and fast and accurate decision making responding to citizens' needs. **Increased efficiency and improved citizens' services:** urban platforms collect data that can be leveraged for urban planning and services' delivery. This drives efficiencies in the daily work of cities' authorities and enables the provisioning of better citizens' services tailored to their needs and demand. **Employment opportunities:** the proliferation of sensors, the availability of an adequate networking and telecom infrastructure, the reliance on cloud and big data solutions enable commercial players to capitalize on new business opportunities. Start-ups delivering innovative services are also expected to benefit from smart cities' technologies. At the same, new skills' need drives demand for innovative jobs. **Increased city attractiveness**: the increased quality of services enabled by the smart city ICT infrastructure coupled with a favorable technological environment for business development increases the level of cities' attractiveness towards students, potential new residents, commercial companies, startups, and tech-skilled workers.

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4.3 Valuation/monetisation approaches applied to smart city projects

Projects can generate a variety of impacts on different domains, which may be directly measured in monetary terms through their market prices (market goods), or otherwise need to be estimated through a range of techniques (non-market goods). Valuation methods are used to quantify externalities and express them in monetary terms (Schleisner, 1999). Also co-benefits may be quantifiable or need to be priced through monetization approaches.

OECD (2018) identifies the following main methods for environmental valuation: **Revealed preference methods:** they value non-market impacts through the observation of actual behaviours (i.e. purchases in real markets). Behaviours are expected to reveal the implicit price of a linked non-market good; **Stated preference methods**: they analyse answers provided by individuals to derive their preferences; these include **contingent valuation**, which asks directly to individuals for their Willingness to Pay (or Willingness to Accept compensation) for a change in the provision of a non-market good; **Value (or benefit) transfer:** it applies a unit value of a non-market good estimated in another context to value benefits/costs of a different policy or project; **Subjective well-being valuation**: the value is estimated according to how non-market goods affect self-reported measures of well-being, such as life satisfaction.

Table 12: Most common methods for environmental valuation

The application of these methods depends on the specific objectives of the analysis, on data availability, as well as on the methodological approach adopted. Monetization of a project impacts can be incorporated into several methodological and practical tools for evaluation.

Some Smart City lighthouse projects are developing analyses which aim to quantify and monetize the external impacts of smart city technologies, as means to support innovative business models and financing approaches which foresee co-investment strategies by different stakeholders (e.g. in the Triangulum project - Von Radecki, 2016).

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5 Definition of business model evaluation framework for MAtchUP

This chapter aims to define the business model evaluation framework that will be implemented in the MAtchUP project. It defines the relevant units of analysis for evaluation and the approach to identify meaningful business models within the project. It presents the research grid that will be applied to identify the building blocks and assess the main strengths and weaknesses of business models. It finally connects this deliverable with WP5 economic evaluation framework to set the Key Performance Indicators for the business model evaluation.

5.1 Unit of analysis for the business model evaluation

A relevant issue in performing the business model evaluation is defining the boundaries and identifying the different smart solutions which form a specific business model. As highlighted also in Deliverable 5.2. “Economic evaluation framework”, several actions implemented in MAtchUP are related among them from a financing point of view (e.g. they are financed under the same programme or funding sources, or one action is able to finance other actions) or because they are jointly interlinked by a specific business model.

WP5 economic evaluation and WP6 business model evaluation form an integrated and complementary approach, which investigates the same unit of analysis: the innovative business models tested by MAtchUP lighthouse cities within the demos. WP6 will explore the main building blocks of these business models, including their financial instruments, with the aim to analyse their strengths and weaknesses, as well as the stakeholders involved and their roles. WP5 will assess the performances of the business models across all the project duration, by targeting a set of environmental, social and economic impacts.

In order to perform this integrated analysis, LH cities have identified the meaningful business models to be investigated in the project, by defining bundles of smart city actions supported by a specific business model (from now on in the text: “action bundles”). A preliminary list of these action bundles is included as Annex to this report.

5.2 Research grid

Based on the results of the literature review on smart city business models and on the feedback of project partners, a research grid has been developed as a main tool of the proposed business model evaluation framework for MAtchUP. It is structured in two parts, the first dedicated to present key information on the action bundle and the second one which specifically describes the main elements of the associated business model.

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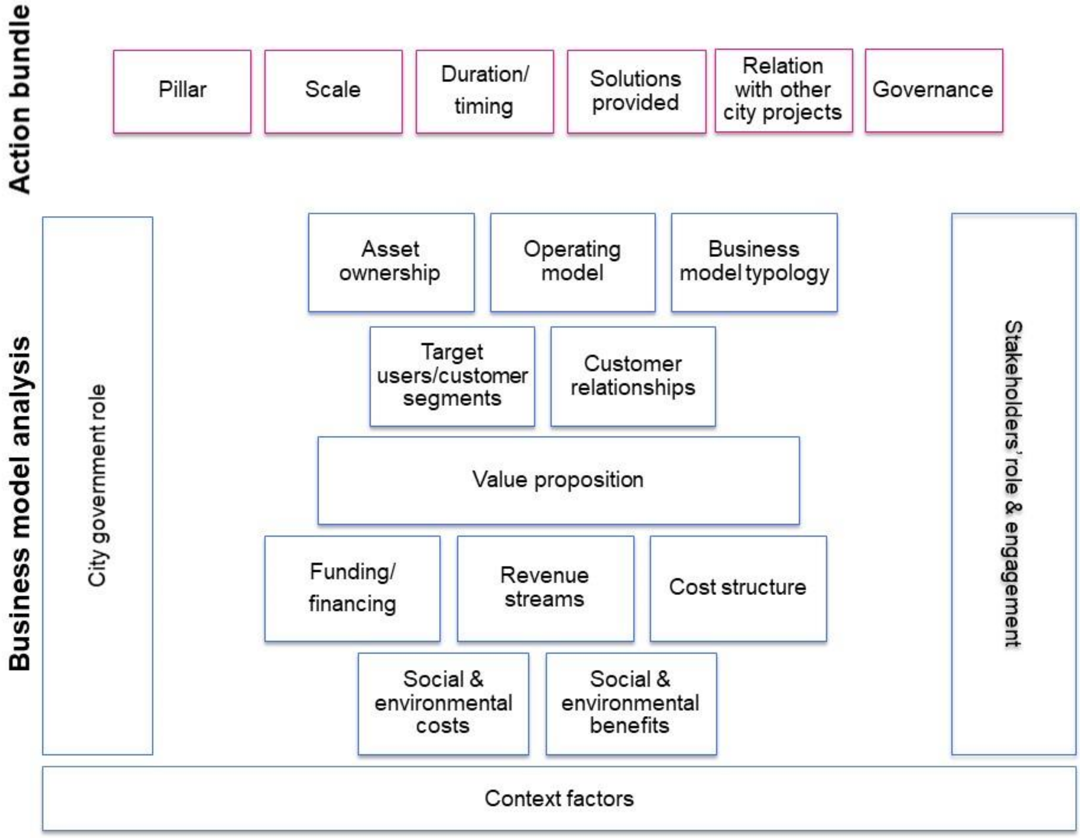

Figure 8: Main elements of MAtchUP business model evaluation framework

The building blocks analysed are described in the table below:

Key information on the action bundle and its business model

Business model name/ID	
City	
Country	
Pillar	energy/mobility/ICT/Non-Technical Action
Actions included in the bundle	List of actions included in the bundle and their category
Action bundle scale	building/block/community/district/city/region/country/other
Action bundle duration/timing (Life cycle)	Number of months/years for: • Design • Procurement/Commercialization • Installation • Operation In alternative:

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	Overall lifecycle duration (number of years)

Overview of the solution provided	• Summary/description of the "smart city" solutions (product/service) provided within the action bundle, differences compared to "traditional" products/services, innovative aspects of the solutions.
	• Market maturity
	  ○ Status - within the city: experimental/pilot/in-city roll out/market scale
	  ○ Status - supply market: TRL, competitiveness, regional factors.
	• Investor interest: who and level

Relationship with other actions/city projects	• Description of the relationship of the solutions with other city projects, how they are related with each other (i.a. value information, dependency…).
Governance	• Type of governance model adopted to design, implement and carry out the action bundle • Role of public/private stakeholders • Presence of mechanisms for coordination and decision-making.

Business model analysis

Asset ownership	Description of actors that own the assets used by the actions (if assets are present).
Operating model	Description of how the action bundle is operated
Business model	Description of the main business model typology which supports the action bundle: • Public own/operate • Energy Performance Contracting (EPC) • Public Private Partnership (PPP) • Concession • Other
Target users/customer segments	Identification and description of key target users/customers of the product/service (For whom does the action create value? Who are the most important customers?)
City government role	Description of the control that the city government has on the action: • Finance • Design • Management • Regulation • Economic incentive

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	• Monitoring • Communication • Diffusion • Other
Customer relationships	Description of the relationships between customers of the product/service and the stakeholders involved in the business model (owner/operator…).
Value proposition	Description of the value that the action intends to create for citizens/city-users/local government/other stakeholders and of the needs that the action aims to address and satisfy.
Revenue streams	Identification (and quantification) of the revenue streams associated with the action bundle: • asset transfer • economic efficiencies (cost savings) • payments/tariffs for the use of the service • other
Funding/financing	Identification (and quantification) of resources needed to implement the action: • National funding • Regional/state funding • EU funding • Purpose taxes or charges • Loans • Bonds • Local tariffs for public services • Construction rights • Private funding • Crowdfunding • Third party financing • Sponsorships • Advertising • Others • Staff involved
Cost structure	• capital expenses of the action bundle (€) • operational expenses (€) (annual average) (including fees and levies)
Social & environmental costs	non-financial aspects of the business model that are harmful to the smart city (Diaz-Diaz et al., 2017), such as: • job reduction • increase of energy consumption/related GHG emissions compared to traditional solutions • increase of other resources consumption

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	• other social/environmental impacts
Social & environmental benefits	non-financial aspects of the business model that are beneficial for the smart city (Diaz-Diaz et al., 2017), such as: • job creation • business generation (e.g. activation of start ups or innovative businesses) • social inclusion • energy/GHG emissions saved • resource efficiency • contribution to vulnerability reduction and resilience other social/environmental benefits (please specify…)

Stakeholder engagement	• Number, typologies and roles of stakeholders involved in the business model
	• Methods/processes for stakeholder engagement
	• stages involved:
	  o design
	  o construction
	  o management
	• Monitoring processes
	• Reporting and KPIs adopted Communication channels and activities

Context factors	Identification and description of the technological, political-institutional, socio-cultural, economic-business factors needed for a successful application of the business model

The elements needed to fill in this evaluation framework for the business models tested in the MAtchUP project will be collected by means of a dedicated questionnaire.

5.3 Selected KPIs for the business model evaluation

As anticipated in previous sections, WP5 economic evaluation and WP6 business model evaluation form an integrated and complementary approach, which investigates the same unit of analysis: the innovative business models tested by MAtchUP lighthouse cities within the demos. WP6 will explore the main building blocks of these business models, by means of a dedicated questionnaire and a SWOT analysis. WP5 will assess the performances of the business models across all the project duration, by targeting a set of environmental, social and economic impacts.

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As described in Deliverable 5.2., a set of core and complementary indicators have been selected with the purpose to evaluate the performances of the business models. These are connected also to the benefits mapped in par 3.2.

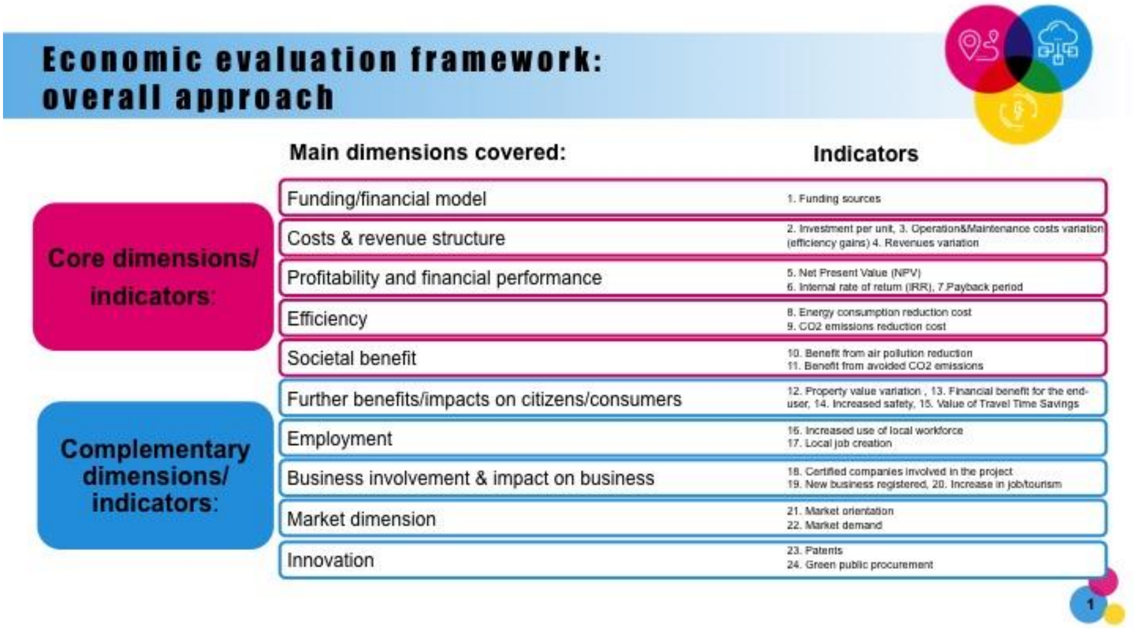

Figure 9: Economic evaluation indicators selected in WP5

The application of the selected indicators will depend on data availability and will aim to quantify selected aspects of smart city solutions impacts and benefits, to broaden the evaluation of the underlying business model.

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6 Conclusions

The implementation and uptake of smart city solutions that can enable this transformation of urban systems will require new investments, which however are difficult to retrieve from public sources because of the tightness of public budgets. As highlighted in many documents, new financing sources, strategies of cooperation between public and private actors, as well as new business models will play a key role in supporting this transformation.

The review of literature on smart city business models provided in the deliverable has highlighted that a common definition of smart city business models is currently not available, and several methodologies of evaluation of their performances are applied. These methodologies incorporate tools to estimate the multi-dimensional impact of smart city projects on several stakeholders, through quantitative as well as qualitative indicators. The diversity of evaluation approaches currently available is explained by the complexity of impacts deriving from smart cities, which regards not only the private but also the public sphere, with tangible and non-tangible effects across several domains. Such impacts are not often quantified and they are not valorised in the business models. Some projects are testing methodologies to express this value and communicate it to all stakeholders involved, also in the view to test new investment strategies and leverage different financing opportunities.

The business model evaluation framework proposed for the MAtchUP project builds on this context and aims to provide a comprehensive description of the main elements that form a smart city business model, which can serve as a basis to evaluate its performance from a private but also a wider public perspective. The business model evaluation framework will be implemented and applied in the next steps of the project through the delivery of a specific questionnaire, which will collect the necessary information to perform the analysis from the lighthouse cities.

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7 References

Anfosso A. et al. (2015), “Business models”, Deliverable 1.2. of the project CITYOPT - Holistic simulation and optimisation of energy systems in Smart Cities, Co-funded by the European Commission within the 7th Framework Programme.

Bélissent J. (2010), “Getting Clever about Smart Cities: New Opportunities Require New Business Models”, Forrester research.

Bichard E. (2016), “Sustainable return on investment: towards a method of valuing social and environmental change in the built environment”. University of Salford. Manchester.

Bisello A. (2016), “Smart and Sustainable projects at the energy-district level. How to assess them based on the co-benefits paradigm”.

Bottero M., Mondini G. (2016), “Assessing Socio-Economic Sustainability of Urban Regeneration Programs: An Integrated Approach”, In: Bisello A., Vettorato D., Stephens R., Elisei P. (eds) Smart and Sustainable Planning for Cities and Regions. SSPCR 2015. Green Energy and Technology. Springer, Cham

Brander, L.M. and van Beukering, P. (2016). “Economic assessment methods and applications”. Deliverable D4.2 EU Horizon 2020 ESMERALDA Project, Grant agreement No. 642007.

CDP (Cassa Depositi e Prestiti) (2013), “Smart City. Progetti di sviluppo e strumenti di finanziamento”. Report monografico.

Dameri R.P., Rosenthal-Sabroux C. (eds.) (2014), “Smart City. How to create public and economic value with high technology in urban space.” Progress in IS. Springer International Publishing. Switzerland.

Dean K., Trillo C., Bichard E., (2017), “Assessing the Value of Housing Schemes through Sustainable Return on Investment: A Path towards Sustainability-Led Evaluations?”, *Sustainability*, 9, 2264; doi:10.3390/su9122264

Díaz-Díaz R. et al. (2017), “The Business Model Evaluation Tool for Smart Cities: Application to SmartSantander Use Cases”, *Energies*, 10, 262; doi:10.3390/en10030262

EC (2014), “Guide to Cost-Benefit Analysis of Investment Projects Economic appraisal tool for Cohesion Policy 2014-2020”. European Commission Directorate-General for Regional and Urban policy.

EC (2016a), “Analysing the potential for wide scale roll out of integrated Smart Cities and Communities solutions - Final Report”, Report written for DG ENERGY by PWC, Danish Technological Institute, ISIS, Sigmaorionis.

EC (2016b), “Analysing the potential for wide scale roll out of integrated Smart Cities and Communities solutions – Funding/financing schemes for SCC solutions”, Report D8.1, written for DG ENERGY by PWC, Danish Technological Institute, ISIS, Sigmaorionis.

EIP-SCC (2013), “European Innovation Partnership on Smart Cities and Communities - Strategic Implementation Plan”.

EIP-SCC (2018), “Marketplace of the European Innovation Partnership on Smart Cities and Communities. Towards a joint investment programme for European smart cities. A Consultation Paper to Stimulate Action.”

EP (2014), “Mapping Smart Cities in the EU”, Directorate General for Internal Policies, Policy Department A: Economic and Scientific Policy.

Frost & Sullivan (2017), “Global Smart City market”.

Lam P.T. I., Yang W. (2017), “A Study of the Costs and Benefits of Smart City Projects Including the Scenario of Public-Private Partnerships”, World Academy of Science, Engineering and Technology, *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering,* Vol:11, No:5, 507-512.

Mulligan C., Olsson M. (2013), “Architectural Implications of Smart City Business Models: An Evolutionary Perspective”, IEEE Communications Magazine.

Osterwalder, A., Pigneur, Y. (2010), “*Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers”*, Self Published: Amsterdam, The Netherlands.

Timeus, K. Vinaixa, J., Pardo, F. and Ysa, T. (2017), “Report on the Business Models of the Lighthouse Cities” (Horizon 2020: REPLICATE Project Reports No. 2.2). Barcelona: ESADE Business School.

Tokoro N. (2016), “The Smart City and the Co-creation of Value. A Source of New Competitiveness in a Low-Carbon Society”, Springer.

Ürge-Vorsatz, D., Herrero, S.T., Dubash, N.K., Lecocq, F. (2014), “Measuring the Co-Benefits of Climate Change Mitigation”. *Annual Review of Environment and Resources* 39, 549–582.

Vassallo J. (2017), “Business Models for Smart Cities”, Discussion Paper 1/2017, Smart Transportation Alliance.

Vento C., Kitchen D., Collinson E., Bilinski K., and Fuerst M. (2017), “Economic Cost-Benefit Analysis of Smart LED Street Lights:Providing Free Public WiFi to the Linden Neighborhood”. AEDE 4567 Capstone Final Report.

Von Radecki (2016), “D6.2 Smart City Replication Framework”, Deliverable 6.2. of H2020 project “Triangulum”.

Walravens, N. (2015), “Qualitative indicators for smart city business models: The case of mobile services and applications”. *Telecommunications Policy*, 39, 218–240.

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Annex A1. Preliminary economic & business model evaluation action bundles identified for the three Lighthouse Cities

Economic & business model evaluation action bundles for Valencia

Zone	Business Model ID	Business Model Name	MAtchUP Pillar	Actions	Lead
Cabanyal	VAL_BM-01	Reconstruction of private residential building	Energy	V1 (Reconstruction of 16 houses (13 private + 3 public) V2 (223 kW PV integration), V3 (1100 kWh electrical storage for self-consumption model integration), V4 (400 Smart meters for buildings), V5 (Next generation of 150 smart controllers at the building level), V12 (Solar thermal integration), V28 (Smart home energy management system (SHEMS)	ITE
Cabanyal	VAL_BM-02	Retrofitting of private residential buildings	Energy	V6 (Retrofitting of 548 private houses (536 private + 12 public), V4 (400 Smart meters for buildings), V5 (Next generation of 150 smart controllers at the building level) V12 (Solar thermal integration), V28 (Smart home energy management system (SHEMS),	ITE
Cabanyal	VAL_BM-03	Reconstruction of public tertiary buildings	Energy	V9 (Civic centre for the district “Centro Cívico), V2 (223 kW PV integration), V4 (400 Smart meters for buildings), V5 (Next generation of 150 smart controllers at the building level), V29 (Smart District energy management system (SDEMS)	VAL

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Cabanyal	VAL_BM-04	Retrofitting of public tertiary buildings	Energy	V10 (Retrofitting of “Mercado del Cabanyal), V11 (Retrofitting of local agency of Urban development (*Agencia local de desarollo urbano*) V2 (223 kW PV integration) V4 (400 Smart meters for buildings), V5 (Next generation of 150 smart controllers at the building level), V29 (Smart District energy management system (SDEMS)	VAL
District P. Maritims	VAL_BM-05	Building integrated RES in a tertiary building (Nazaret Sport Centre)	Energy	V8 (Geothermal energy), V2 (223 kW PV integration), V14 (Sewerage energy recovery system), V29 (Smart District energy management system (SDEMS)	ITE
District P. Maritims	VAL_BM-06	Urban RES	Energy	V13 (Pilot of Wave Energy Converter (WEC) to supply public lighting)	LNV
District P. Maritims	VAL_BM-07	Smart lighting	Energy	V27 (Smart lighting – 4000 street lamps)	VAL
District P. Maritims	VAL_BM-08	Humble lampposts	Energy	V26 (10 humble lampposts)	ETRA
City level	VAL_BM-09	EV (public sector)	Mobility	V15 (101 local government eVehicles), V16 (10 fully eBuses + 8 hybrid buses), V21 (Demand management and operation of charging systems for the eBus fleet), V24 (Eco-driving patterns to optimize the performance of electric buses)	VAL, EMT
City level	VAL_BM-10	EV (private sector)	Mobility	V18 (72 EV charging points), V20 (Public charging system management),	VAL, ETRA
City level	VAL_BM-11	Demand management	Mobility	V19 (3 V2G pilots)	LNV

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District P. Maritims	VAL_BM-12	Logistics	Mobility	V17 (2 e-bikes for disabled mobility and 3 e-bikes last mile logistics), V22 (Last mile logistics based on eBikes)	LNV, VAL
City level	VAL_BM-13	Multimodality	Mobility	V23 (2 multimodal hubs)	VAL
City level	VAL_BM-14	ITS for parking management	Mobility	V25 (Management of EV parking places)	ETRA
City level	VAL_BM-15	Use of open data for new business	ICT	V30 (Open Data management), V31 (Open APIs)	UPV
City level	VAL_BM-16	Inputs and Outputs of Urban platform	ICT	V32 (IoT devices integration with the VLCi smart city platform), V33 (IoT & Big Data analysis (KPI dashboard)	UPV
District P. Maritims	VAL_BM-17	Employment initiatives	Non-Technical Actions	V35 (MAtchUP employment initiative), V37 (Social and local entrepreneurship program), V38 (Promote business opportunities for district inhabitants),	KVEL
District P. Maritims	VAL_BM-18	50/50 Programmes	Non-Technical Actions	V36 (50/50 Programmes)	LNV
City level	VAL_BM-19	Shared private-public investment models for sustainable energy consumption and circular economy	Non-Technical Actions	V39 (Shared private-public investment models for sustainable energy consumption and circular economy)	KVEL
District P. Maritims	VAL_BM-20	Prosumer Energy Cooperatives	Non-Technical Actions	V40 (Prosumer Energy Cooperatives)	LNV
District P. Maritims	VAL_BM-21	District refurbishment local investment fund (financial instrument)	Non-Technical Actions	V41 (District refurbishment local investment fund (financial instrument)	LNV

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Economic & business model evaluation action bundles for Dresden

Zone	Business Model ID	Business Model Name	MAtchUP Pillar	Actions	Lead
District Johannstadt	DRE_BM-01	Smart tenant existing building	Energy	A1 (Smart tenant), A4 (PV on existing building)	DWG
District Johannstadt	DRE_BM-02	Smart tenant new building (District Future House)	Energy	A9 (District future house), A41 (8.7 kWp PV system), A42 (Power storage)	DWG
District Johannstadt	DRE_BM-03	Energetic transformation of the real estate	Energy	A7 (Retrofitting project Pfotenhauer Str.), A38 (Energy-efficient design real estate)	VON
District Johannstadt	DRE_BM-05	Smart controls (Building control center)	Energy	A2 (Building control center)	DRE
District Johannstadt	DRE_BM-07	Smart public lighting	Energy	A15 (Optimization actions in public lighting)	DRE
City level	DRE_BM-08	EV for the public sector	Mobility	A19 (public sector)	FHG
District Johannstadt	DRE_BM-09	EV for housing sector	Mobility	A40 (housing sector)	DWG
District Johannstadt	DRE_BM-10	Expansion charging infrastructure	Mobility	A22 (Charging points + fast-chargers)	DWG
District Johannstadt	DRE_BM-11	Intermodal mobility hub	Mobility	A26 (1 IMMH)	DVB
City level	DRE_BM-12	Smart charging	Mobility	A11 (Smart meters), A24 (Smart management e-mobility), A37 (Business model for charging stations)	DWG
				A23 (Optimal use charging infrastructure), A54 (Reducing impact of charging stations on the grid)	FHG

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Economic & business model evaluation action bundles for Antalya

Zone	Business Model ID	Business Model Name	MAtchUP Pillar	Actions	Lead
Kepez Satral	ANT_BM-01	New construction of residential building	Energy	A1: Residential blocks (B Energy Rating) A4: Solar thermal collectors installation for residential building A6: Smart control and domotics	ANP
Kepez Satral	ANT_BM-02	New construction of high performance public building	Energy	A2: New construction of public tertiary buildings A3: PV installation for public building A5: Electrical storage for building and charging station	ANP
Kepez Satral	ANT_BM-03	Smart public lighting	Energy	A8: Led public lighting A9: Smart control of public lighting	ANP
City Level	ANT_BM-04	Solar power plant with storage	Energy	A10: PV system with a total capacity 5MWp A12: Integration of district electricity storage	ANT
City Level	ANT_BM-05	LFG Utilization	Energy	A11: LFG and electricity generation	ANT
City Level	ANT_BM-06	E-bus	Mobility	A13: 2 e-bus A23: 2 e-buscharg ing stations A22: Management of e-fleet	ANT
City Level	ANT_BM-07	E-car	Mobility	A14: 20 e-vehicle for municipality fleet A6: 5 e-vehicle charging points	ANT
City Level	ANT_BM-08	E-bike	Mobility	A15: 30 e-bike A17: 5 e-bike charging stations	ANT
City Level	ANT_BM-09	Multimodal hubs	Mobility	A19: 2 multimodal hubs	ANT
City Level	ANT_BM-10	Intelegant transport system	Mobility	A20: Integrating existing light rail with ebike station and bus terminal A21: Applying last mile mobility for citizens via integration of e-bike station with the light rail stations.	ANT

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