Project no. 691735

REPLICATE PROJECT

Renaissance of Places with Innovative Citizenship And Technology

This Project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° 691735

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Project no. 691735

H2020-SCC-2015 Smart Cities and Communities

Innovation Action (IA)

D2.4 Report on the Replication Potential of City Business Models

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1. Executive Summary

The challenge set out by the European Innovation Partnership on Smart Cities and Communities (2016) required Municipalities to find the means of bridging the gap between the investment required to meet climate targets and ready sources of capital. The instrumental means to achieve this was the notion of the replicable business model and hence this report into the replication potential of city business models. Supported by the empirical evidence provided by the municipalities about the REPLICATE project interventions, rounds of data collection from the REPLICATE cities, and an extensive literature search, this Work Package has found that replicable business models, as interpreted in a narrow firm-oriented sense as exemplified by much of the Business Model Innovation (BMI) literature, are not by themselves a sufficient means of bridging this financing gap.

The emergent logic from the data collection and analysis is that for any city there exists a notional financial need that reflects the total inward capital investment required to pay for all the interventions required to achieve climate change targets. A 'Direct Model' highlights the fact that not all of this capital investment is, or should be, in the "gift of the municipality". However, the difference between the overall need and that which can be achieved through this direct means is the target amount of capital finance that the municipality itself needs to raise. What is not provided through the 'Funding Model' and its many variants therefore remains the scope of either trivial business cases or a limited number of Value Creation Ecosystem (VCE) Models identified in this work.

These 'leading contender' VCE Models for raising the finance required are the 'EU SPV Model', the 'ESCO Model', and the 'USA SPV Model'. It is clear that a considerable burden will be placed on these Models to achieve the requisite *value engineering* for a Municipality to achieve its targets; they have some heavy financial lifting to do. Also, despite the clear viability of the 'EU Municipal Green Bond Model', it was largely rejected by the REPLICATE partners for possible use in the 2021-2025 and 2025+ timeframes. Therefore, whilst we believe the EIP-SCC challenge has been solved, it has only been done so by the reinterpretation of the instrumental replicable business model at a different, much larger, scale. There is also a sense that whilst the 'EU SPV Model' and the 'ESCO Model' could be used to address the totality of the remaining financing gap that a Municipality is facing, they also seem potentially fragile, either resulting in exit (i.e., examples of the demise of the 'ESCO Model' in the UK) or the possible migration to the 'USA SPV Model'. Whilst these 'leading contender' Models represent immediate ways forward for securing access to the capital investment that cities require and can be implemented today, they perhaps come at the risk of storing up problems for later. The

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findings reported here should be interpreted in the context of a rapidly developing movement towards 'green finance' and the current effects of the Covid-19 pandemic. The likely impact of new initiatives such as the EU's Green New Deal and similar national-level endeavours remain uncertain.

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2. REPLICATE

The main objective of REPLICATE project is the development and validation in three lighthouse cities (**San Sebastián** – Spain, **Florence** – Italy and **Bristol** – UK) of a comprehensive and sustainable City Business Model to enhance the transition process to a smart city in the areas of the energy efficiency, sustainable mobility and ICT/Infrastructure. This will accelerate the deployment of innovative technologies, organizational and economic solutions to significantly increase resource and energy efficiency improve the sustainability of urban transport and drastically reduce greenhouse gas emissions in urban areas.

REPLICATE project aims to increase the quality of life for citizens across Europe by demonstrating the impact of innovative technologies used to co-create smart city services with citizens, and prove the optimal process for replicating successes within cities and across cities.

The Business Models that are being tested through large scale demonstrators at the three cities are approached with an integrated planning through a co-productive vision, involving citizens and cities' stakeholders, providing integrated viable solutions to existing challenges in urban areas and to procure sustainable services. Sustainability of the solutions is fostered in three areas: economic and environmental and finally, fostering transparency in the public management.

In addition, the Model features the replicability of the solutions and their scale up in the entire city and in follower cities, particularly in three follower cities (**Essen** – Germany, **Lausanne** – Switzerland and **Nilüfer** – Turkey) that are involved in the project and therefore, have access to know-how and results achieved on the project so they can apply the developed model. At the moment, there are 2 observer cities, Guanzhou (China) and Bogota (Colombia).

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3. Introduction

The systems perspective on the financial challenge facing cities to achieve their climate change targets as taken by this Work Package is summarised in Figure 1. In this perspective, ultimately, the Outcomes (O) achieved by a City towards meeting its climate change targets are a function of the Gap (G) between the Targets (T) the city is trying to achieve and its current Performance (P), the Financing Mechanisms (F) and Business Models (M) it is able to employ, and its Capabilities (C) as a 'Smart-City-as-a-Network' as assessed by a measurement such as a Smart City Strategy Index (SCSI) (see D2.3, "*Internal Report on Findings*", Section 10). Whilst this Deliverable is primarily about business models and funding mechanisms, the notion of the gap between targets and performance is sufficiently important to warrant a separate Section for discussion, see Section 11.

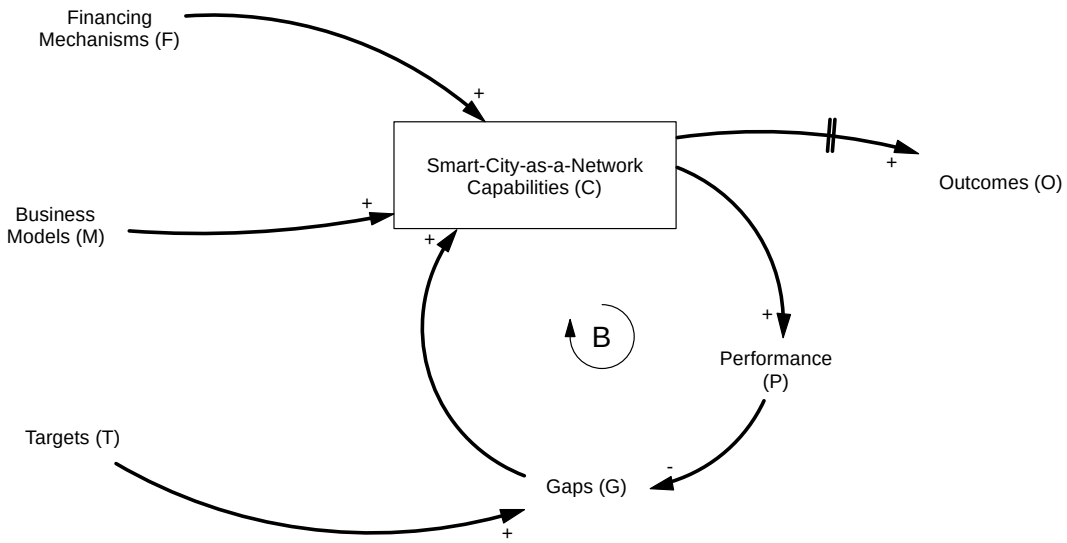

Figure 1 Systems perspective taken by Work Package 2 on the financial challenge facing cities.

That a triple bottom line perspective is taken almost goes without saying. However, the *financial* bottom line cannot be ignored or relegated (Schoormann, Kaufhold, Behrens, & Knackstedt, 2018). Capital investment for interventions still needs to be secured and a gap in financing that prevents a project from taking place cannot be closed by addressing the non-

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financial bottom lines. The assumption in this Work Package is that the triple bottom line is necessary consideration for financing the smart city but not by itself sufficient.

3.1 Relation to Other Project Documents

The work carried out in Task T2.4 and reported in this Deliverable makes use of information and results from other deliverables across the REPLICATE project, including earlier work in Work Package 2 as well as the cross-cutting activities carried out in Work Package 7, "*Cross Cutting Activities*", Work Package 9, "*Exploitation of results, industrial business plans*" and Work Package 10, "*Monitoring*". It also makes heavy use of the Deliverables reported by the Pilot Cities in their implementation of specific interventions. The specific deliverables referred to are listed in the next section.

3.2 Reference documents

This document is based in the following projects level documents:

Ref.	Title	Description
REPLICATE Grant Agreement signed 240713.pdf	Grant Agreement	Grant Agreement no. 691735
DoA REPLICATE (691735)	REPLICATE Annex 1 – DoA to the GA	Description of the Action
REPLICATE Consortium agreement signed December 2015 (7th December version)	Consortium Agreement	REPLICATE project – Consortium Agreement
REPLICATE Project Management Plan	D1.1 Project Management Plan (v.1) (29/04/2016)	REPLICATE Project Management Plan
REPLICATE District Management Plans	D1.4 District Management Plan San Sebastian D1.5 District Management Plan Florence D1.6 – District Management Plan Bristol	REPLICATE District Management Plans
REPLICATE Communication Plan	D11.1 – Communication Plan	REPLICATE Communication Plan

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WP2 Strategic Planning and Business Models	D2.1 – Report on the delivery of the three workshops D2.2 – Report on the Business Models of the Lighthouse cities D2.3 – Internal report on findings	STEEP Methodology, Foundational work for strategic analysis, and analysis of business models
WP3 San Sebastián Pilot	D3.1 – Buildings retrofitted D3.2 – Study of Biomass resources in Ametzagaina Park D3.3 – Report on DH construction including the maintenance program D3.5 – Report on the use of Electric Bus in Line 26 D3.6 – Report on the deployment of EVs in the city of San Sebastian D3.7 – Report on the deployment of charging infrastructure in the city of San Sebastian D3.8 – Report on the use of the ITS D3.9 – Use of Big Data for mobility services D3.10 – Report on High speed mobile network based on postWIMAX technology D3.11 – Report on Public Lighting System	Information about business models, costs, returns on investment, economics of the actions – with an impact on replicability of the business models and financing
WP4 Florence Pilot	D4.1 – Reporting on the state of the implementations in energy pilot actions WP4 D4.2 – Pilot action measures advancement sheets V1 D4.3 – Pilot action progress report year 2	Information about business models, costs, returns on investment, economics of the actions – with an impact on replicability of the business models and financing

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	D4.4 – Pilot action measures advancement sheets V2 D4.5 – Pilot action progress report year 3 D4.6 – ICT PILOT ARCHITECTURE D4.7 – Replicate Platform D4.8 – Replicate dashboard software D4.9 – REPLICATE APPs V1 D4.10 – Florence pilot action publishable report	
WP5 Bristol Pilot	D5.1 – Retrofitting in the neighbourhood partnership area of Ashley, Easton and Lawrence Hill D5.2 – Connection of a 13 block (700 flats) district heating network to a gas CHP energy centre D5.3 – ENERGY DEMAND PLATFORM DEPLOYED TO MONITOR ENERGY GENERATION AND DEMAND D5.4 – E-bikes Deployed in a Corporate Scheme D5.5 – Car Club expanded with ten Electric Vehicles D5.6 – ON -DEMAND EV MINIBUSES (BUZZ) DEPLOYED D5.9 – Development of ICT Smart City Platform concept and of integration of demonstration IT Systems	Information about business models, costs, returns on investment, economics of the actions – with an impact on replicability of the business models and financing
WP7 Cross Cutting Activities	D7.1 – Frameworks and Methodology	REPLICATE scale up plans

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	D7.2 and D7.3 – Report on technical solutions D7.4 and D7.5 – Report on management models D7.6 – Lighthouse cities' replication plans	
WP9 Exploitation of Results	D9.3 – Sectorial Business analysis / Exploitation potential in the field of energy, ICT, sustainable mobility and other remaining sectors included in REPLICATE	Industrial opportunities
WP10 Monitoring	D10.3 – Baseline analysis of city level indicators for follower cities and benchmarking with lighthouse cities	City level indicators for benchmarking

Table 1. *Reference documents*

The Reference Documents are not cited in the References section at the end of this deliverable. Where the Reference Document is first cited in the text it is referenced by its deliverable number and full title. Thereafter, the Reference Documents are cited in parenthesis by deliverable number and page number.

The Grant Agreement is the contract with the European Commission so takes precedence over all other documents.

3.3 Abbreviations list

GA	Grant Agreement
CA	Consortium Agreement
DoA	Annex I–Description of the Action
EC	European Commission
H2020	Horizon 2020
PC	Project Coordinator
PL	Pilot Leader
PMP	Project Management Plan
TC	Technical Coordinator

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WP	Work Package
WPL	Work Package Leader

Table 2. *Abbreviations list*

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4. Deliverable Description

This document presents the findings and conclusions of Task 2.4, "*Validating Replicability of City Business Models*" in Work Package 2 "*Strategic Planning and Business Models*".

The data collection and analysis, findings, discussion and conclusions are described under the following sections, which cover:

- Section 1: Executive Summary for this Deliverable.
- Section 2: REPLICATE project details.
- Section 3: Introduction to the work in Task 2.4 "*Validating Replicability of City Business Models*".
- Section 4: This section.
- Section 5: Presents the problematisation of the objective of the Task and purpose of the Project, and discusses the role of the city and the smart city in achieving climate change targets, a perspective on the smart city business model, and a typology of business models for evaluation purposes and provides a working definition of replicable business model that is fit for purpose.
- Section 6: Consists of a new review of the business model literature oriented towards providing insight into the replicability of business models from an Energy, Mobility and ICT perspective aligned with the interventions carried out in the REPLICATE Lighthouse Cities.
- Section 7: Presents the 8 generic Value Creation Ecosystem (VCE) Models together with additional variations of the models that have been elicited through the second round of data collection. The Section also includes summaries of model comprehensibility, model viability and intention by the REPLICATE cities to use the models for financing interventions in the future. Data on longer-term prospects for model use beyond 2025 are also presented.
- Section 8: The Models presented in Section 7 are reviewed from a portfolio perspective for each of the three REPLICATE Lighthouse cities with extensive cross reference to the WP3, WP4 and WP5 deliverable set. A Net Present Value (NPV) analysis of the pilot interventions is also included.
- Section 9: Presents data from the third round of data collection from the REPLICATE cities mapping the interventions onto the 8 generic VCE models and their variants
- Section 10: In the analysis of findings presented in this section three "Leading Contender" generic VCE models are identified as the likely mainstay of immediate next-step means of financing interventions in EU cities i.e., beyond SCC funding in

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the 2021-2025 period. Rejected models are also discussed. The value of the VCE approach is discussed.

- Section 11: Presents an analysis of the relevance of the models with respect to the scale of the financing problem and presents some estimates of the gaps that are emerging. Some alternative perspectives for communicating making progress towards closing the gaps are presented.
- Section 12: The prospects for replication are discussed in this section leading to a reflection on whether the EIP-SCC challenge of finding replicable business models has been achieved.
- Section 13: Presents lessons learned from the work carried out in this Task and where a number of new research questions are identified.
- Section 14: The innovations developed in this Task and overall Work Package are presented in this section.
- Section 15: Presents the final conclusions from this Task.

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5. Problematisation

"*Plans are useless but planning is indispensable*" – Eisenhower

5.1 Why Cities?...

For any municipality a commitment to achieving the target of zero carbon emissions by 2050 or 2030, or any other deadline within the next generation, is both audacious and ambitious. How much responsibility *should* cities be bearing? How much progress can a municipality make before the gap between what is achievable and the target must be addressed by citizens taking individual responsibility? Should regional, national or even supra-national government bodies be stepping-in to take over the burden?

Cities do seem to be caught in the middle between possibly irreconcilable narratives focussed on the individual and the state and consequently expected to shoulder a significant burden. In "*Why does everyone think cities can save the planet?*" Angelo and Wachsmuth (2020) introduce a Special Issue in Urban Studies focussed on this problematic. However, their claim that urban planning and sustainability planning "*are becoming two sides of the same coin*" (p2216) seems too general and simplistic. Perhaps, but not everywhere or equally – as evidenced by the narrow sample that makes up the cities within the REPLICATE project.

Of relevance here is the goal set by the REPLICATE project of finding replicable business models as an instrumental means of connecting sources of finance to 'ready worked-out' approaches to the interrelated problems of delivering sustainable energy, mobility and ICT solutions in a city. This goal aligns with the agenda of placing the city at the centre of enacting sustainability transitions (Geels, 2010), but the language of business models and the need for replication to achieve rapid scale-up naturally opens the door to the increasing financialisation of the city (O'Brien, O'Neill & Pike, 2019; Pike, O'Brien, Strickland, Thrower, & Tomaney, 2019).

From the perspective of finance, perhaps another way of looking at the centrality of cities is to ask the following question. Of the estimated total finance required[1] for a city to achieve its targets what percentage has to be secured by the municipality?

[1] Some estimates are presented and discussed in Section 11. They were also considered in D2.3, "*Internal Report on Findings*", but has been revisited in this Deliverable in the light of more recent information and a continually transforming financial landscape.

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The evolution of the thinking in this Work Package reflects the messiness and dynamic nature of this contested middle ground.

5.2 …and Why Smart Cities?

The smart city is clearly the focus of the funding of REPLICATE by the EU Smart Cities and Communities (SCC1) Programme and as the nexus of Energy, Mobility and ICT interventions. Angelidou (2015) divides the development of the smart city into two distinct strands of thought, urban futures and the knowledge and innovation economy. Whilst these are useful categories as starting points for charting the evolution of the smart city qua 'smart', the focus in this Work Package and Deliverables has been on the city as the instrumental focus of the aims of the SCC1 Lighthouse Project Programme. That is, sitting between broad EU Climate goals and mechanisms of replication such as the business models and financing mechanisms that will, in part, provide the means of achieving them. The relevance to an overtly smart agenda here is only apparent in the role that certain ICTs, such as Smart City Platforms (SCPs), play in the trajectory towards a city achieving its targets and as reflected through business model and replication analysis.

5.3 Business Model Innovation

There was an expectation that perhaps the vibrant research area of Sustainable Business Models (SBM), that is, those incorporating a Triple Bottom Line approach, as part of the wider Business Model Innovation (BMI) landscape would provide a rich seam from which to mine approaches suitable for application to the REPLICATE problem area. A comprehensive and very highly cited review of SBMs by Bocken, Short, Rana, and Evans (2014) identifies 8 basic archetypes grouped under the headings of Technological, Social and Organisational. The categorisation offered by the examples in each of these archetypes however offers little by way of substance for the municipality looking to bridge capital investment gaps left by inadequate grant funding. Scale-up options under the Organisational heading seem limited by what they can offer to address the gaps discussed in Section 11.

5.4 A Perspective on the Smart City Business Model

As observed in D2.3, "*Internal Report on Findings*", the majority of business and management literature is focussed on the firm, but not the city in its organisational form as the

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municipality[2]. Whilst the business model could be considered as central to a theory of the firm the same is not true of the municipality. In fact, the concept of the "Smart City Business Model" has only recently emerged from published research carried out in Work Package 9 of the REPLICATE project (Timeus, Vinaixa & Pardo-Bosch, 2020). Their argument rests on the observation that

> "*…while such smart services have the potential to deliver value to the city's residents, city governments cannot take for granted that they will in fact deliver value. This depends on how they are designed, implemented and governed; i.e. on the business models of smart services.*"

Their solution is the development of the City Model Canvas (CMC), derived from the Business Model Canvas (Osterwalder, Pigneur & Clark, 2010), as a tool for municipalities to explore design, implementation, and governance issues, and go on to define the smart city business model as

> "*…the way in which a city government organizes its services to create and deliver value for its citizens in a way that is economically viable, socially inclusive and environmentally sustainable.*"

The method of this triple bottom line approach is described in fully in D2.2 "*Report on the Business Models of the Lighthouse cities*" as well as in Timeus, Vinaixa and Pardo-Bosch (2020). It shares some similarities with the 'Non-Profit Business Model Canvas' developed in the EU FP7 project (257992) Smart Santander and operationalised as a Business Model Canvas Evaluation Tool for Smart Cities (BMETSC) (Díaz-Díaz, Muñoz & Pérez-González, 2017). Although specifically focussed on evaluation of smart city business models it does not open up any insight into dealing with the economic non-viability of certain solutions – the work *assumes* economic viability.

The question of what counts as *value* for citizens in the context of the delivery of services by a municipality is broad. Rodríguez Bolívar (2019) argues that

> "*public value creation is the new lens for analyzing smart cities. Based on participative governance models, local governments in smart cities must provide the tools and context to foster citizen engagement in public decisions and co-creation of public*

[2] Throughout this deliverable, *municipality* is used to refer to the organisational entity that is the actor of primary focus in the smart city.

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services. All this have to be addressed to increase the quality of life of citizens in their urban life."

This appeal to citizen engagement and co-production naturally suggests the relevance of transition theory (Geels, 2010). The importance of the consideration of Business Model Innovation (BMI) in achieving climate change targets in the city context is reflected in efforts to integrate business model perspectives into transition theory.

Sarasini and Linder (2018) do just this through an analysis of the example of new mobility services. Here, they treat the firm as a key performative actor primarily because it is the locus of BMI. Bolton and Hannon (2016) look at a systems understanding of how BMI acts in governing sustainability transitions. Whilst this research interesting in that it analytically separates BMI from technology innovation, with a view to understanding the contribution from BMI, to achieving transitions (to sustainability) it still anchors the concept of BMI to a theory of the firm, not of the municipality, or the municipality as a central node in cooperating network of actors as was explored in D2.3, "*Internal report on findings*", with the idea of the smart-city-as-a-network. Although Sarasini and Linder (2018) do raise the considerations of firms "*and their networks*" for the purpose of identifying research questions i.e. the existence of BMI arising from a network property is still to be researched.

Even more recent comprehensive reviews of Business Models and Sustainability take a firm-centric perspective as their unit of analysis e.g. De Giacomo and Bleischwitz (2020) and offer no insight the challenge facing the REPLICATE project. However, for the purpose of further defining the scope of the work in this Work Package and Deliverable the question of *value*, as shown in the *Value* Creation Ecosystem (VCE) analysis of financing mechanisms in Section 7, is narrowed to the benefits accruing to the citizen from the efforts of the municipality towards meeting its climate change targets through economically viable means. Therefore, actors in the ecosystem that are neither citizens or the municipality that are identified generically (see Table 4) are considered to be *necessary*, but they are not the focus of analysis. This removes the firm-centric idea of BMI from analytical consideration in this Work Package and turns the gaze firmly on the municipality.

5.5 A Typology of Business Models for Evaluation Purposes

When perspectives wider than purely economic are considered, for example by taking the triple bottom line approach, an analysis of business model replicability becomes even more challenging. Schoormann et al. (2018) have conducted a literature review of sustainability-oriented business model evaluation analysing 50 articles and discovering more than 40

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different evaluation techniques. This is both comprehensive and revealing. The only common feature of *all* the evaluation techniques reviewed is the test of economic feasibility (*ibid*, Table 1, Column labelled 'Economic', pp63-64). No matter what else is evaluated *in addition*, economic feasibility is fundamental to any business model; without economic feasibility there is no business model. Therefore, all the analysis presented in this Deliverable is predicated on finding and establishing economic feasibility.

In addition, by focussing on the straightforward question of *necessity*, that is, the catalogue of interventions that are *required* by particular dates in order for a municipality to reach its targets then we can attempt to match them to potential financing mechanisms that are economically viable.

Excluded from consideration, but possibly of relevance to future work, are analyses based on i) Product Service Systems (PSS) grounded in concepts of dematerialisation and servitisation and directed at BMI focussed on meeting final user needs rather than products e.g. Annarelli, Battistella and Nonino (2016), ii) Corporate Social Responsibility (CSR) influences on BMI e.g. Hu, Zhang and Yan (2020), and iii) the Public Value Management (PVM) paradigm and the smart city from a public value perspective (Cosgrave, Tryfonas & Crick, 2014).

5.6 Review of Purpose

The objective of the REPLICATE project has always been to "*generate smart city business models*", that is, sustainable city business models that will…

> "*…enhance the transition process to a smart city in the areas of the energy efficiency, sustainable mobility and ICT/Infrastructure, in order to accelerate the deployment of innovative technologies, organisational and economic solutions to significantly increase resource and energy efficiency, improve the sustainability of urban transport and drastically reduce greenhouse gas emissions in urban areas*" D1.1, "*Communication Plan*"

The ostensible purpose of Work Package 2 is for the three lighthouse cities and the three follower cities to have, at the end of the project, fully optimised Smart City Business Models that have been fully demonstrated and validated against stakeholder needs and proven to be replicable beyond SCC1 funding and…

> *"…addresses the core process of demonstrating the 'learning from the pilots' initial business plans, which will be analysed with a view to establishing their* ***viability beyond SCC1 funding.*** *The task will require engagement with key stakeholders in the pilots.*

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> *The main findings will be complemented by developing innovative business model designs for enabling viable financial landscapes."* (our emphasis)

However, as has emerged from the analysis conducted in this Work Package, the goal has developed into formulating an understanding of the relationship between strategic planning and the replicability of business models in the financing of the smart city. Hence the model presented in Figure 1.

The approach to the development of smart city business models in REPLICATE expected that they would emerge through...

> *"...being tested through large-scale demonstrators at the three cities are approached with an integrated planning through a co-productive vision, involving citizens and cities' stakeholders, providing integrated viable solutions to existing challenges in urban areas and to procure sustainable services. Sustainability of the solutions is fostered in three areas: economic and environmental and finally, fostering transparency in the public management."*

Whilst the project has implemented the large-scale demonstrators as described in the project proposal[3] and also showcased a co-productive vision working with wide groups of stakeholders and citizens we need to ask the question – have these interventions actually tested the replicability of business models *beyond SCC funding*? Or generated the sort of data we need to answer the question?

Whilst the City Model Canvas developed in D2.2, "*Report on the Business Models of the Lighthouse cities"*, and as transferred to the pilot cities, has provided a means for capturing a triple bottom line view of the city business model there nonetheless remains the problem of connecting this perspective to the essentially financial view of businesses within industries expecting to supply solutions over the next twenty to thirty years. Businesses' *single financial bottom line* is the only one that eventually matters when it comes to maintaining a sustainable and viable firm. The industrial view presented from D9.3, "*Sectorial Business analysis / Exploitation potential in the field of energy, ICT, sustainable mobility and other remaining sectors included in REPLICATE*", certainly underlines this point in terms of the expected market size for certain types of solution.

[3] And as modified in Contract Amendments.

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Clearly the replication plans developed in Work Package 7 and presented in D7.6, "*Lighthouse cities' replication plans*", offer a perspective that connects the pilot interventions with the longer-term prospects for the technologies deployed as viable solutions to the cities' needs to achieve their targets. The REPLICATE project, through its cross-cutting Work Packages design, thus mirrors the problem it is attempting to solve, where the expected impact on meeting climate change targets of the cross-cutting Work Packages 2, 7, 8 and 9 is effectively 'open loop', that is, we will only know for sure well beyond the end of the project itself. This is summarised in Figure 2.

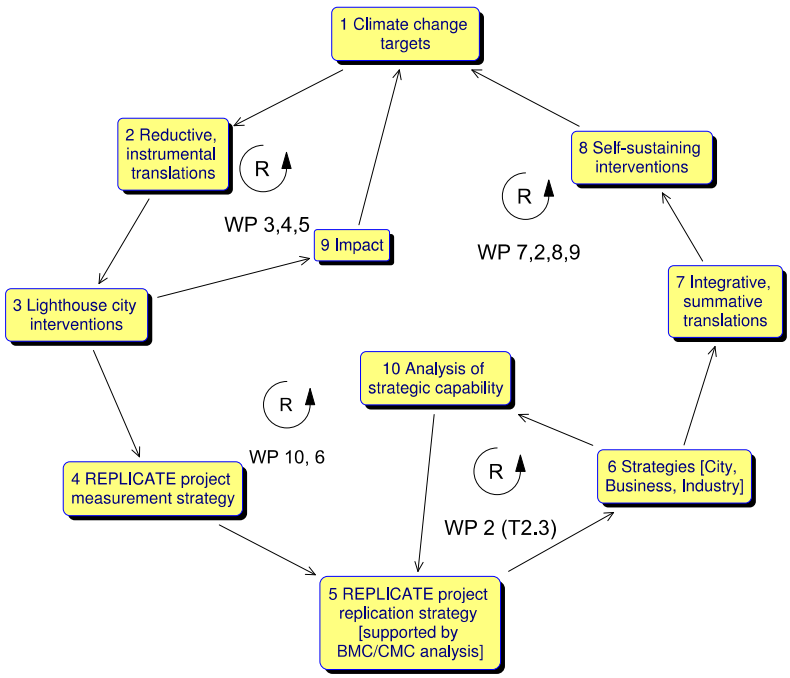

Figure 2. *Summary view of the reinforcing feedbacks inherent in the design of the REPLICATE project. The essential observation about the cross-cutting work packages 2, 7, 8 and 9 is that their expected impact on meeting climate change targets is 'open loop' i.e. beyond the end of the project itself (Yearworth, 2018).*

The "Systems Engineering in a context of systemic cooperation" SCOOPs model (Yearworth et al., 2015) has been used to understand work package synergies across the REPLICATE project, as shown in Figure 3. The same model has also been used to position planning activities, such as SEAPs, beyond the REPLICATE project as discussed in D7.6, "*Lighthouse cities' replication plans*" (pp19-20). The SCOOPs model is recursive, where the REPLICATE project has embodied

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principles of Evolutionary Systems Engineering, we can argue that these apply equally well to the EIP-SCC as a whole. In this regard, the 'Situate' quadrant that embodies the 'Sponsor' role is the essential part of the model that in effect closes the gap between what has been achieved from interventions and what still needs to be done.

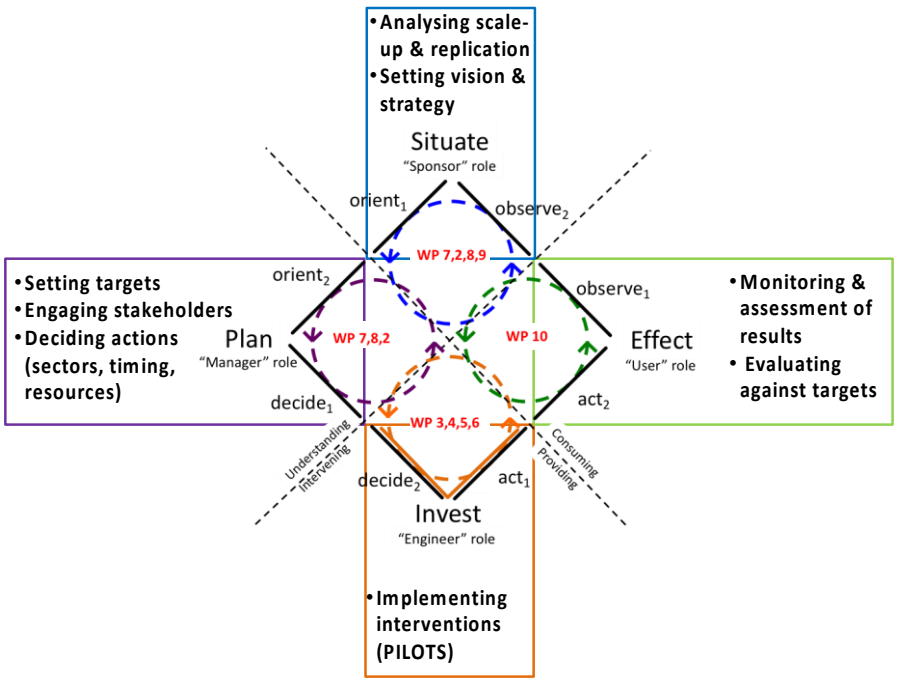

Figure 3. Application of the SCOOPS model (Yearworth et al., 2015) to understanding work package synergies across REPLICATE (Yearworth, 2018).

5.7 Therefore, what are Replicable Business Models?

The meaning of 'replicable business model' in the context of the REPLICATE project was discussed in D2.3, "*Internal Report on Findings*". The main conclusion was that replicability means more than the technical feat of replicating an intervention/action in another city, or establishing that there is wide demand matched to a technical solution e.g., as explored in WP5 of the REMOURBAN project (D7.1, pp13-14). Replication is meant here as the combination of a technical solution (intervention/action) together with a plausible method to finance the necessary capital investment, without recourse to grant funding (that is, beyond SCC1

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funding), so that a municipality can be self-sustaining in its transition to zero carbon[4]. This is largely consistent with the long-term economic feasibility view of interventions/actions/measures adopted in the analysis carried out in Work Package 7, which states that

> "*the specific business model is often under development, depending also on previous results and possible impacts of on-going activities*" (D7.6, p139)

And is therefore consistent with the open loop view above. That is, the replicability of business models can only be suggested at this point in time, they are yet to be proven.

Whilst this model presents a coherent picture of the challenge facing the REPLICATE project, the wider objective is to parlay the scale-up plans into a viable *engine* for delivering interventions at *scale* across the EU. Whilst the interventions in the REPLICATE project provide a calibration, via the monitoring activity carried out in Work Package 10, of the cost per Euro of CO_2 mitigated or avoided for each intervention in the pilot cities there is an implicit equation that needs to be balanced in order to get a true picture of the scale-up required and this is sketched as a fragment of a System Dynamics model in Figure 4.

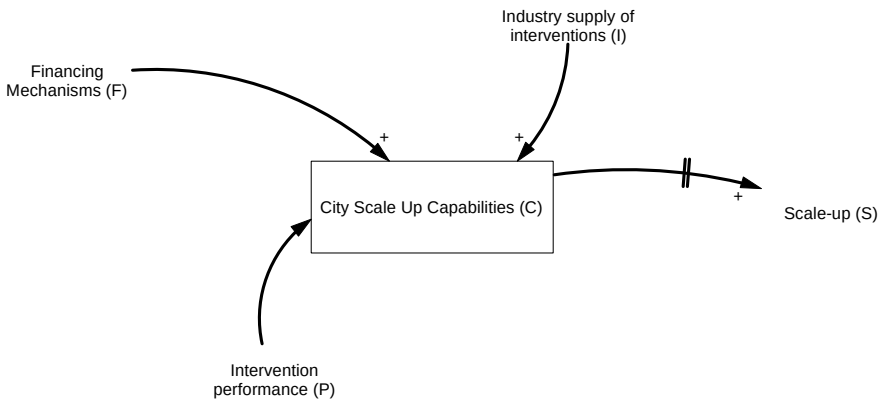

Figure 4. The scale-up problem

[4] Zero carbon is used throughout this Deliverable as a convenient shorthand for the myriad definitions and timescales that define this transition.

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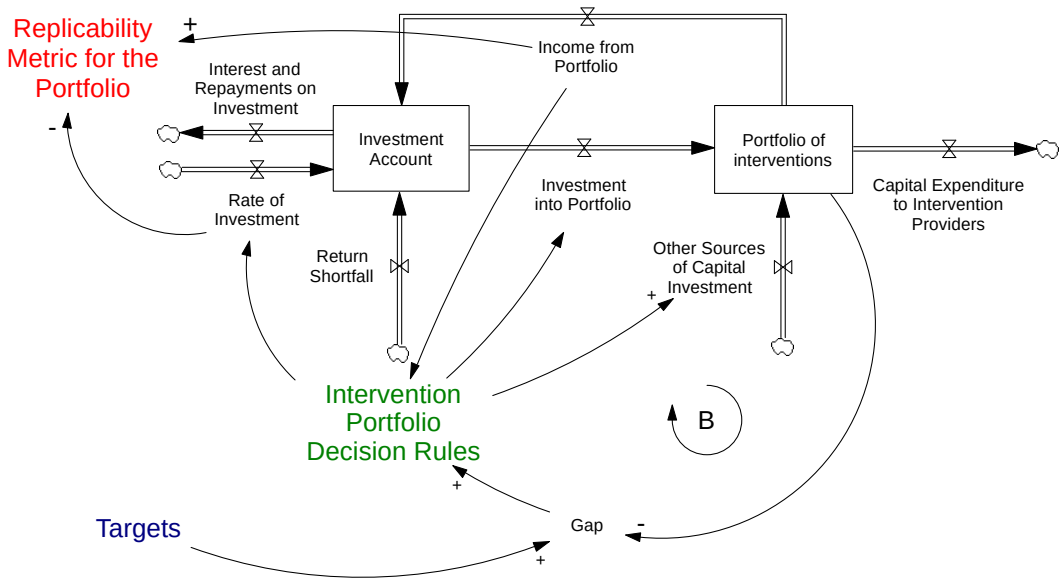
Conventionally a business plan would be a way of presenting a business model in a form that is digestible by investors, who would be concerned with a straightforward question of whether the business is likely to generate a return on their investment. The simplest method of deciding what business models to put forward to an investor would be to evaluate them in terms of a Net Present Value (NPV) calculation. If a model has a positive NPV then this is another way of saying that the sum of future cash flows as income, discounted at an appropriate hurdle rate[5], will exceed the borrowing costs associated with the capital investment required. This applies equally well to a single project-based intervention, such as a district heating system, as it would to a portfolio of interventions. This latter view is appropriate to understanding the scale-up process, which is summarised in the System Dynamics model (Sterman, 2000) presented in Figure 5. Even when Total Cost of Ownership (TCO) is considered, the model in Figure 5 still holds. Assuming all other aspects of municipal budgeting remain the same, that is, *ceteris paribus* conditions, a portfolio of the *necessary* interventions to address climate change targets requires additional investment to be raised for capital expenditure, in effect the investment inflows together with other sources of capital investment need to match the required expenditure outflows to intervention providers.



[5] This would typically be the Weighted Average Cost of Capital (WACC) for the organisation.

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Figure 5. Conceptualisation of cash flows associated with a portfolio of smart city interventions.

Additional savings reflected in lower TCO, e.g., of an Electric bus fleet over a Diesel bus fleet, would be reflected in one or more of the following flows changing i) generating higher <Income from Portfolio>, ii) lowering levels of <Other Sources of Capital Investment> required, and/or iii) lowering the <Return Shortfalls> needing to be made up.

Again, this demonstrates the decoupling of the business model (e.g., NPV based) and accounting model (e.g., TCO based) from the investment framing on the left-hand side of the model. The model, despite its simplicity, also highlights the strategic capability (identified as the 'stock' <City Scale Up Capabilities (C)> in Figure 4) that municipalities require to manage the simultaneous objectives of attracting inward investment for capital expenditure on interventions, maximising revenue potential from their portfolio of interventions, making use of alternative sources of capital investment, and eliminating shortfalls in investment returns.

In the analysis of REPLICATE business models from the reports on pilot cities' interventions presented in Section 8 the grouping adopted will therefore be at the city level, rather than sector or intervention type. This portfolio approach offers a number of advantages:

1. It matches the broad perspective of an investment mechanism like the Green Bond, which is structured on the basis of the use of proceeds[6] e.g., Gothenburg presents to its investors a portfolio view of interventions funded from the 'proceeds' from the bond issue through its allocation and impact reporting obligations,
2. Some of the individual interventions explored in the project have co-dependencies that cross the energy/mobility/ICT sectors e.g., integration of Electric Vehicle (EV) charging infrastructure into an Energy Demand Management System (EDMS) to aggregate and/or balance load via use of a Smart City Platform (SCP). The portfolio also enables synergies with sectors such as health care (D7.6, p139),
3. It makes it easier to present a business case for SCPs. They are a crucial enabler of many of the interventions explored in the project and where the argument that a SCP

[6] "*The net proceeds of Green Bonds should be credited to a sub-account, moved to a sub-portfolio or otherwise tracked by the issuer in an appropriate manner and attested to by a formal internal process linked to the issuer's lending and investment operations for Green Projects*" (International Capital Markets Association, 2016)

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can reduce future service delivery costs (see Sections 8.3.3, 8.4.3 and 8.5.3) needs some bolstering,

4. It integrates well with both a Systems perspective, brought into the project from STEEP and the use of the STEEP methodology, and also with the adoption in the REPLICATE project of Value Creation Ecosystem (VCE) modelling (Allee, 2000), introduced in D9.2, "*Methodology review and methodological framework definition*", and as used extensively in the scale up analysis in Work Package 7, and also in D2.3, "*Internal Report on Findings*", and this Deliverable,
5. Specific framework conditions (D7.6, p139), e.g., local laws and regulations, general spatial properties, historical development, and the prevailing socio-economic situation of any specific city, all of which are likely to be in a state of flux, will impact the replicability of business models in non-predictable ways. The use of a portfolio has the effect of rendering any specific intervention/action/measure less vulnerable to disruption, and
6. It enables the calculation of an overall intervention portfolio replicability metric, which would be of interest to credit rating agencies.

The four main financial flows in to and out of the <Portfolio of Interventions> stock in the model shown in Figure 5 – that is, <Investment into Portfolio>, <Capital Expenditure to Intervention Providers>, <Income from Portfolio> and <Other Sources of Capital Investment> – will be used as generic labels in the analysis. Note that we have chosen to include any direct grants made by the municipality to citizens as a contribution to capital expenditure on interventions as part of the flow <Capital Expenditure to Intervention Providers>, this is the ultimate intended purpose for these grants. In practice, municipalities may well choose to transfer funds directly to intervention providers rather than flowing the grants through citizens.

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6. Business Model Literature Review

This section presents recent literature concerning business models relating to all the interventions funded in the REPLICATE project. Recent is defined here as research results which may not have been known at the time the REPLICATE project was conceived (REPLICATE Project Consortium, 2015). Since research results in the scientific literature usually take a little while to circulate and become known the cut-off date for the review here is 2014. The relevant literature is presented in against categories of intervention that roughly match the interventions funded in the REPLICATE project and is divided into sections relevant to Energy and Mobility and, briefly, on ICT. The paucity of literature on the latter mirrors somewhat the findings from empirical work in this Work Package and is discussed in the Analysis of Findings in Section 10. The main concepts covered in each paper that are appropriate to the analysis in Section 10 are summarised in the final column of Table 3.

Intervention area	Articles	Relevant Concepts for Analysis
	6.1 ENERGY	
6.1.1 Retrofit	"Key aspects of building retrofitting: Strategizing sustainable cities" (Pardo-Bosch, Cervera & Ysa, 2019).	Value Creation Ecosystem (VCE), City Model Canvas (CMC), overcoming high upfront costs, co-creation, participation
6.1.2 Residential retrofit	"*Business models for residential retrofit in the UK: a critical assessment of five key archetypes*" (Brown, 2018)	atomised market model, market intermediation model, one-stop-shop, energy services agreement and managed energy services agreement, long-term energy-saving performance contracts (ESPC), integral project finance
	"*An energy leap? Business model innovation and intermediation in the 'Energiesprong' retrofit initiative*" (Brown, Kivimaa & Sorrell, 2019).	'Energies prong' retrofit business model i.e., non-atomised and non-incremental, coordinating intermediaries, financial model based on the performance contract
	"*Business models for full-service energy renovation of single-family houses in Nordic countries*" (Mahapatra et al., 2013)	full-service renovation packages including financing, mortgage finance plus investment subsidies
6.1.3 Commercial	"*Energy efficiency in commercial buildings: Capturing added-value of retrofit*" (Morrissey, Dunphy & MacSweeney, 2014).	value approach, value flows, value creation, Value Creation Ecosystem (VCE)

Intervention area	Articles	Relevant Concepts for Analysis
	"*Performing quantitative analyses towards sustainable business models in building energy renovation projects: Analytic process and case study*" (Moschetti, Brattebø, Skeie, & Lien, 2018).	sustainable business models, quantitative sustainability examinations, creation, and capture of sustainable value, multi-stakeholder perspective, Energy Service Companies (ESCOs)

Intervention area	Articles	Relevant Concepts for Analysis
6.1.4 Prosumer	"*Prosumers in the post subsidy era: an exploration of new prosumer business models in the UK*" (Brown, Hall & Davis, 2019).	prosumerism, post-subsidy environment prosumer business model struggle to be financially viable, energy service contracts
	"What is prosumerism for? Exploring the normative dimensions of decentralised energy transitions" (Brown, Hall & Davis, 2020).	prosumerism, theories of value, agency and change, competing 'value logics', market value logic / municipal value logic / Community value logic, governance, domestic aggregator, ESCO – energy-as-a-service
	"Prosumer integration in wholesale electricity markets: Synergies of peer-to-peer trade and residential storage" (Zepter, Lüth, Crespo del Granado, & Egging, 2019).	current market designs and business models lack incentives for prosumers, integrate prosumer communities into existing day-ahead and intraday markets, peer-to-peer trade
6.1.5 Social Housing	"*Social housing energy retrofitting: Business Model and supporting tools for public administration*" (Penna, Schweigkofler, Brozzi, Marcher, & Matt, 2019).	uncertainty of investment payback period, high investment costs, 40-year energy performance warranty, social housing organisation as source of finance

Intervention area	Articles	Relevant Concepts for Analysis
6.1.6 Energy Services Companies (ESCOs)	"*UK Local Authority engagement with the Energy Service Company (ESCO) model: Key characteristics, benefits, limitations and considerations*" (Hannon & Bolton, 2015)	LA owned 'arm's-length' model, private sector owned concession agreement model, community owned and run model, risk/strategic control/resources, obligation of LAs to play an active energy governance role, raise finance from both private and public sectors, LA insulated from financial risk, ESCO exposed to financial, technical and political risks, local authority owned 'arm's length' ESCO model, private sector owned concession agreement ESCO model, community ESCO model. See Appendix D – Characteristics of ESCO and EPC Models.
	"*Governing sustainability transitions through business model innovation: Towards a systems understanding*" (Bolton & Hannon, 2016)	systems theories in the business model – activity system approach/large technical system/multi-level perspective, technical and financial innovation, financial and technical risk, 'arms-length', willingness of external investors to finance, cost of capital, Public Works Loan Board, economic value = project's financial rate of return, separate legal entity → autonomy
	"*A review of energy performance contracting business models: Status and recommendation*" (Shang, Zhang, Liu, & Chen, 2017).	Energy Performance Contracting (EPC), Energy Performance Contracting Business Model (EPCBM), Energy Service Companies (ESCOs). See Appendix D – Characteristics of ESCO and EPC Models.

Intervention area	Articles	Relevant Concepts for Analysis
	"*ESCO business models for biomass heating and CHP: Profitability of ESCO operations in Italy and key factors assessment*" (Pantaleo, Candelise, Bauen, & Shah, 2014)	residential sector case study is the least profitable, grown slowly due to problematic access to finance, ESCO owns and controls the plant and network taking the whole financial risk, small ESCO and start-up companies with limited credit scores, ""*shared" mechanism – ESCO carries both the performance and the credit risk. ESCO repays the loan and the credit risk stays with the ESCO; the client assumes no financial risk and takes a shared quota of earnings from the ESCO operation. The client assumes no financial obligation other than to pay to the ESCO a percentage of the actual savings or the energy consumed*". ""*guaranteed" schemes with credit risk shared between ESCO and client, including "performance incentives" to the ESCO if specific targets are achieved.*"
	"*Energy Service Companies and Energy Performance Contracting: Is there a need to renew the business model? Insights from a Delphi study*" (Pätäri & Sinkkonen, 2014).	viability of energy performance contracting (EPC), creditor's knowledge of project financing, credit ratings of the ESCO and client, public procurement and accounting rules, financing options – ESCO Financing, third party financing (TPF), customer financing; shared savings/guaranteed savings

Intervention area	Articles	Relevant Concepts for Analysis
	"*The UK market for energy service contracts in 2014-2015*" (Nolden & Sorrell, 2016)	businesses offering energy service contracts, types of contract, focused on established technologies with high rates of return, procurement frameworks for energy service contracts in the public sector, potential limited by high transaction costs, Carbon and Energy Fund (CEF) – SPV, clients taking on low-cost loans, EU Energy Efficiency Directive standardise the definition of EPCs, "*source of finance may include working capital provided by the client or by the ESCO, loans from financial institutions and equity from risk investors. Of particular importance is whether the investment is primarily financed through debt taken on by the client and hence appears on the client's balance sheet, or whether the investment is financed by the ESCO*", Public sector markets, access to low-cost financing – UK public sector market has taken longer to develop than in the USA and many European countries. See Appendix E – Emerging Energy Efficiency Business Models.
	"*A comparative review of municipal energy business models in Germany, California, and Great Britain: Institutional context and forms of energy*	municipal energy company development, "*monopoly functions where municipal companies are not competing with other market players and thereby face fewer financial and operational risks, enable municipal energy companies to promote energy decentralization in business activities",*

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Intervention area	Articles	Relevant Concepts for Analysis
	decentralization" (Brinker & Satchwell, 2020)	
	"*Public-private partnerships for energy efficiency projects: A win-win model to choose the energy performance contracting structure*" (Carbonara & Pellegrino, 2018)	model for assessing and benchmarking the net benefits of different EPC structures, balancing private sector's profitability needs and public sector's economic interests, related to NPV and business models, describes allocation problem. See Appendix D – Characteristics of ESCO and EPC Models.

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Intervention area	Articles	Relevant Concepts for Analysis
6.1.7 District Heating	"*Challenges for business change in district heating*" (Lygnerud, 2018)	deregulated heat market, municipal ownership dominates, financing of new district heating predominantly undertaken by municipalities, business model canvas
	"*Business models for district heating*" (Sandoff & Williamsson, 2015)	municipally owned/private/partnership between public and private entities/stakeholder owned, different financial requirements, some firms have easier access to capital with long-term view on risk and profitability
6.1.8 Energy Demand Management Systems	"*Fundamentals and business model for resource aggregator of demand response in electricity markets*" (Lu et al., 2020).	resource aggregators as emerging market participant, resource aggregation, basic information prediction, market bidding strategy development, settlement process, distributed generation, energy storage system, controllable load of customers, "*RA ought to properly handle the bilateral needs during its transaction, e.g., the market information, the physical constraints and response characteristics of the available DR resources, etc. Therefore, the business model is of central significance for the RAs to develop optimal interests-seeking bidding strategies in the market and scheduling schemes for the DR resources.*" See Appendix F – Demand Aggregation Model.

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Intervention area	Articles	Relevant Concepts for Analysis
6.1.9 Solar Photo-Voltaics (SPV)	"*Photovoltaic energy systems with battery storage for residential areas: An economic analysis*" (Cucchiella, D'Adamo & Gastaldi, 2016)	profitability of PV systems in the residential sector without subsidies, profitability of energy storage in a mature market, economic results of integrated PV-battery systems using Net Present Value (NPV), Break-Even Point (BEP), defines BEP for residential PV battery systems becoming economically viable in a mature market
	6.2 Mobility	
6.2.1 Vehicle-to-Grid (V2G)	"*Using electric vehicles for energy services: Industry perspectives*" (Weiller & Neely, 2014)	opportunities for new business models with "smart" charging networks, V2G (vehicle-to-grid), home energy demand management systems, renewable energy storage, lack of joint investment and revenue models between EV industry players, "*residential energy services with EVs…are possible within existing technological, social and economic systems. Smart charging is feasible but of limited interest for grid optimisation and/or balancing services as long as EV sales are low. All grid-level business models are limited by two main factors: the EV market development and the value proposition to users. The energy service applications only have a business case if deployed in conjunction with other elements in the home*"
	Vehicle to grid V2G (Sovacool, Kester, Noel, & Zarazua de Rubens, 2020)	vehicle owners, energy suppliers, transmission and distribution system operators, fleets, aggregators, mobility-as-a-service providers, renewable

Intervention area	Articles	Relevant Concepts for Analysis
		electricity independent power providers, public transit operators, grid services, aggregation, bundling, secondary markets, innovation activity systems – content/structure/governance, "*Enabling a transition to meet this growing demand for passenger transport, but also to remain low carbon and meet existing energy and climate targets, is an immense challenge of finance, because it can require "hugely ambitious" and "unprecedented" levels of upfront investment*", infrastructure developer, charging service provider, load orchestrator, mobility provider

Intervention area	Articles	Relevant Concepts for Analysis
6.2.2 Electric Buses	"*How Shenzhen, China pioneered the widespread adoption of electric vehicles in a major city: Implications for global implementation*" (Li, Ye, Liao, Ji, & Ma, 2020)	financial leasing, national and local subsidy 50% of capital cost of bus, 40% subsidy of charging infrastructure, "*city adopted a business model that incentivized cooperation between third-party financial institutions, EV manufacturers, and charging facility operators to reduce the initial financial burden and risk of EV adoption by pooling purchasing power through leasing and vehicle sharing while disassociating vehicle and battery maintenance*", "*transition to EV adoption with an innovative financing model that allowed risk diversification while leveraging a wide range of financial resources, including central government and municipal funding as well as the private sector. Under this model, risks were shared among bus companies, vehicle manufacturers, third-party financial leasing companies, and charging facility operators. Capital costs were kept separate from operational costs and the vehicle value chain was kept separate from the battery value chain.*" See Appendix G – e-Vehicle Business Models.
	"*Developing a viable electric bus service: The Milton Keynes demonstration project*" (Miles & Potter, 2014)	time required to recharge, special-purpose Enabling Company, "*The enabling company provides a business model in which learning can occur and shields the bus operator from the initial risk of innovating*" – trading capital cost of battery with charging times to reduce payback period

Intervention area	Articles	Relevant Concepts for Analysis
6.2.3 Shared e-Vehicles	"*Optimal Service Pricing and Charging Scheduling of an Electric Vehicle Sharing System*" (Xie, Wei, Wu, Ding, & Mei, 2020)	"*dedicated EV mobility model is proposed to capture the spatial transportation of energy without tracking every single vehicle. Price elasticity is described by a linear demand-price function. The company schedules the aggregated charging of unoccupied EVs in each parking lot, aiming at maximizing the total profit*"
6.2.4 E-Taxis	"*Can charging infrastructure used only by electric taxis be profitable? A case study from Karlsruhe, Germany*" (Funke & Burgert, 2020)	Can charging infrastructure be profitable if only used by taxis? "*currently taxi charging infrastructure would require public funding or other business models, in the medium to long term, an exclusive use by taxis would be sufficient*", "*Currently, charging infrastructure could hardly be profitable if only used by Tesla Model S taxis since the lower TCO of the electric vehicles could not compensate for the necessary fees for exclusive charging infrastructure usage.*" See Appendix G – e-Vehicle Business Models.
	"*Recharging systems and business operations to improve the economics of electrified taxi fleets*" (Hsieh, Nunes, Pan, & Green, 2020)	battery swapping emerges as cost-effective option but requires higher upfront investments for inventory, increasing vehicle fleet size enhances the economic viability of double-shift taxi electrification, electrification of high-use vehicles requires government support;

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Intervention area	Articles	Relevant Concepts for Analysis
6.2.5 E-bikes	*"Solar-E-Cycles, Empowering People Project 2014-2019"* (Roger & Omari, 2019)	18-month payback in a pay-as-you-go business model, rapid scaling strategy
6.2.6 Smart Parking	"Internet of Things Approach to Cloud-based Smart Car Parking" (Atif, Ding & Jeusfeld, 2016)	broker-based framework integrates business and service level agreements using a utility-driven algorithm, dynamic prices of (parking-related) services
6.3 ICT		
6.3.1 Mobility as a Service (Maas)	"*Electric Vehicle Mobility-as-a-Service: Exploring the "Tri-Opt" of Novel Private Transport Business Models*" (Cooper, Tryfonas, Crick, & Marsh, 2019)	Energy Trilemma, financial support for consumers to meet the upfront purchase costs of ULEVs, "Plug-in Car Grant" scheme, investment in national charge point network, digitally-enabled innovative business models, business models for balancing systems yet to achieve commercial viability

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Intervention area	Articles	Relevant Concepts for Analysis
6.3.2 IoT	"*Business models for developing smart cities. A fuzzy set qualitative comparative analysis of an IoT platform*" (Abbate, Cesaroni, Cinici, & Villari, 2019)	fuzzy set qualitative comparative analysis (of methodological interest), BMC/E3/Archetypal Business Model, the most significant observation from this paper is that "*financial building blocks, i.e., "revenue streams" and "cost structure", for a similar reason. Indeed, most of the cases under examination has experienced neither revenues nor a permanent cost structure*" i.e., that IoT business models were too financially immature to analyse
6.3.3 Big Data & Analytics	"*Big data and analytics as strategies to generate public value in smart cities: Proposing an integrative framework*" (Cronemberger & Gil-Garcia, 2019)	public value, value chains in a networked economy, public value/ smart cities/BDA advanced independently, requires Information sharing, integration, and collaboration (ISIC). Conclude this is underdeveloped from a business model/financing perspective
6.3.4 The Smart Home	"*Critically reviewing smart home technology applications and business models in Europe*" (Furszyfer Del Rio, Sovacool, Bergman, & Makuch, 2020)	nexus between business models and policy, 15 separate business models, most models are not capital intensive, analysis according to e-business models of Amit and Zott (2001) would be appropriate. See Appendix H – Smart Home Business Models.

Table 3. Summary of recent literature on business models relevant to the analysis conducted in this Task.

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7. Routes to Financing City-Led Intervention

The financing models presented in this section were presented in their original form in D2.3, "*Internal Report on Findings*". They were derived as a means of re-interpreting and then summarising the Value Creation Ecosystem (VCE) models presented in D7.5, "*Report on management models v2*", into a generic form. The intention was that this form would capture both the flows and the actors[7] in a generic manner and therefore present models that could be replicated in other cities. The models were reviewed at the General Assembly and Project Review in Florence in M45 and have been subject to consultation via a modified Delphi process (Dalkey & Helmer, 1963; Morton, Ackermann & Belton, 2007).

The final form presented here is a result of the 3 Rounds of consultation to finalise the models and to also map interventions to specific models from the perspective of "beyond SCC1 funding" in the years beyond the end of the REPLICATE project. The models below, and the mappings (presented in Section 9) therefore represent the considered view of the REPLICATE project cities about how a portfolio of smart city interventions could be funded without recourse to grants such as from the EU SCC Programme.

7.1 Process

In order to carry out an evaluation of these models, the work in this Task proceeded via three rounds of questioning and response. The intention was to arrive at an assessment of the current state of financing of smart city interventions and also foreseeable plans. These financing models are not mutually exclusive, it is conceivable that more than one is in use, or are contemplated. The associated questions were designed to establish whether these models do in fact capture actual and envisaged financing mechanisms.

The original source models are derived from REPLICATE deliverables D9.3, "*Sectorial Business analysis / Exploitation potential in the field of energy, ICT, sustainable mobility and other remaining sectors included in REPLICATE*", and D7.5, "*Report on management models v2*" and also with reference to Pardo-Bosch, Cervera and Ysa (2019) and the original development of the Value Creation Ecosystem (VCE) technique as a means of showing value exchanges in a value network by Allee (2000).

[7] VCE models only contain actors and the flows between them (Allee, 2000).

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The descriptions of the models, the models themselves and the examples provided were revised on the basis of comments that were provided in Round 1. Comments that were addressed were then deleted from the Round 2 document.

New material in Round 2 was added to the document arising from feedback from across the partners e.g., addition of Model 8 in Section 7.10 to include a generic ESCO model.

7.2 Actors

In order to create generic models, it was necessary to define a set of generic actor roles. These roles were introduced at the General Assembly in Florence in M45 and defined for the first time in D2.3, "*Internal report on findings*". They have been further clarified in response to comments arising from Round 1 of the exercise.

Actor	Definition
Citizens	Citizens are viewed as being the ultimate recipients[8] of all interventions as indicated by the flow of "better environment".
Municipality	Understood in its usual sense. The central coordinating organisation in all the VCE models. Whilst other models of financing interventions could exist that do not include the municipality they are not included in this deliverable; i.e., the models are municipality-centric.
Funding Body	Typically, this is understood to be the European Commission – being the channel for EU funding and requesting details of a municipality's SECAP objectives and other monitoring data. It could also stand-in for any other source of grant-based funding. Where this body is interested in monitoring data only and is not supplying grant funding then it is re-labelled as "Monitoring Body".
Intervention Suppliers	Generic term for any Third-Party Organisation that provides interventions to private or business owners of property (e.g., Solar PV systems), businesses, or individuals (e-Taxis). Interventions analysed in this work package are listed in Table 10.

[8] Or beneficiaries. However, this term is reserved for those actors in *beneficial* receipt of financial flows to enact an intervention. These, so called, "Intervention Beneficiaries" could also be Citizens, however because the types of flow in the VCE are different these two roles are identified separately.

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Intervention Beneficiary	Either owners of property that require investment to cover capital expenditure in interventions (e.g., Solar PV) or purchasers/users of equipment to enact an intervention (e.g., buying an e-taxi or e-bus, or leasing an e-bike). The Intervention Beneficiary could also be a company that is providing a service (e.g., a District Heating System). Interventions analysed in this work package are listed in Table 10. Finally, private individuals who are Intervention Beneficiaries are clearly Citizens too. However, for simplicity and clarity it is useful in the following VCE Models for these to be shown as separate entities as they have different flows associated with them.
Infrastructure Provider	The provider of infrastructure that is deployed in the municipality that requires capital investment
Financial Institutions	The providers of loans/finance to either i) private or business owners of property, or ii) Special Purpose Vehicles (SPVs) created by municipalities. This entity also stands-in for the more complex arrangement of issuing bonds. On the 'other side' of the Financial Institutions actor, and not shown in any of the models for the sake of simplicity, are the investors that are the ultimate source of capital.
Special Purpose Vehicle (SPV)	An organisation that has been created by the municipality either with sole ownership or as a Joint Venture (JV) to enact a role that 'circumvents' some of the limitations faced by a municipality e.g., such as certain restrictions on borrowing and procurement. Such SPVs could well be 'Teckal Exempt' in the EU (Yearworth, 2020, pp. 24,26,32) and may be used to raise finance for significant infrastructure investment.
Crowdfunding Platform	A company that operates a crowdfunding platform and can offer crowdfunding as a service to a municipality and connect to individuals or groups that will be providing investment (not shown in the model). The municipality is thus the initiating actor of the funding need.
Partner Organisation	The 'other' shareholder (to the Municipality) of a SPV when it is a Joint Venture, can also be referred to as a Strategic Partner.
Monitoring Body	Organisation that has an interest in obtaining data about the performance of interventions

Table 4. List of Actors appearing the VCE models and Definitions of their roles.

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The set of VCE models is presented below in Sections 7.3 to 7.10. Below each model are the questions that were used to first, clarify whether the model did in fact make sense in its generic form i.e., its 'comprehensibility' and secondly, to establish its viability as a potential mechanism that could be used to finance capital investment in smart city projects beyond SCC and other similar funding.

The answers to these questions are presented in Section 7.12 for model comprehensibility and in Section 7.13 for model viability. Analysis of the findings from these answers are deferred to Section 10, following the presentation of the data in Section 9, which maps interventions back onto the 8 VCE Models.

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7.3 Model 1

Model 1, shown below, is intended to capture the situation where the beneficiaries of the smart city interventions are fully funded by either supranational bodies (EU), national government, or regional government. This is the baseline VCE model for the smart city Financing Capability Model (FCM). All of the possible financial flows are shown, but variations of this model include 1a) the case where no grant finance flows to the beneficiary, and 1b) the case where no finance flows between the Funding Body and the Intervention Suppliers as well as no finance flows to the Intervention Beneficiaries. It is also the case that this model captures the situation where the Intervention Supplier is actually provided by an infrastructure that is owned by the Municipality and the Intervention Supplier is simply a sub-contractor offering interventions using the Municipal owned assets. This is distinct from the Model 3 situation.

Notes:

1. The Key to this model is the existence of the funding opportunity provided by the Funding Body, which drives the process.
2. Intervention Suppliers are any organisation capable of supplying a smart city intervention to an Intervention Beneficiary.
3. Smart City Objectives are used in all the models as a placeholder name for any data about performance of interventions that needs to be collected, processed and returned to a Funding Body or Monitoring Body. These could be, for example, sustainable development goals or SECAP objectives (as was shown in D2.3).
4. Although Environmental Benefits to citizens are singled out in the model, these could be considered as standing-in for a wide ranges of benefits that extend to innovation, social inclusion, higher quality of life etc..

5. Agreements are contractual arrangements that exist between a Municipality and Intervention Suppliers that govern the flow of Grant Funding from the Municipality via Intervention Suppliers to Intervention Beneficiaries.
6. Although it is possible that the Intervention Beneficiary is funded by the Funding Body directly, it was thought to be sufficiently rare not to include as a variant of Model 1 in this round.

Example:

The supply of smart white goods and associated controls and monitoring equipment to 150 households as part of the EDMS intervention in Bristol (Described in D5.3, "energy demand platform deployed to monitor energy generation and demand"). In this case the Intervention Suppliers are Samsung (primarily) for the white goods, and Loxone for the monitoring and control. The Intervention Beneficiaries are the 150 households selected to take part in the trial. Therefore, an example of Model 1b

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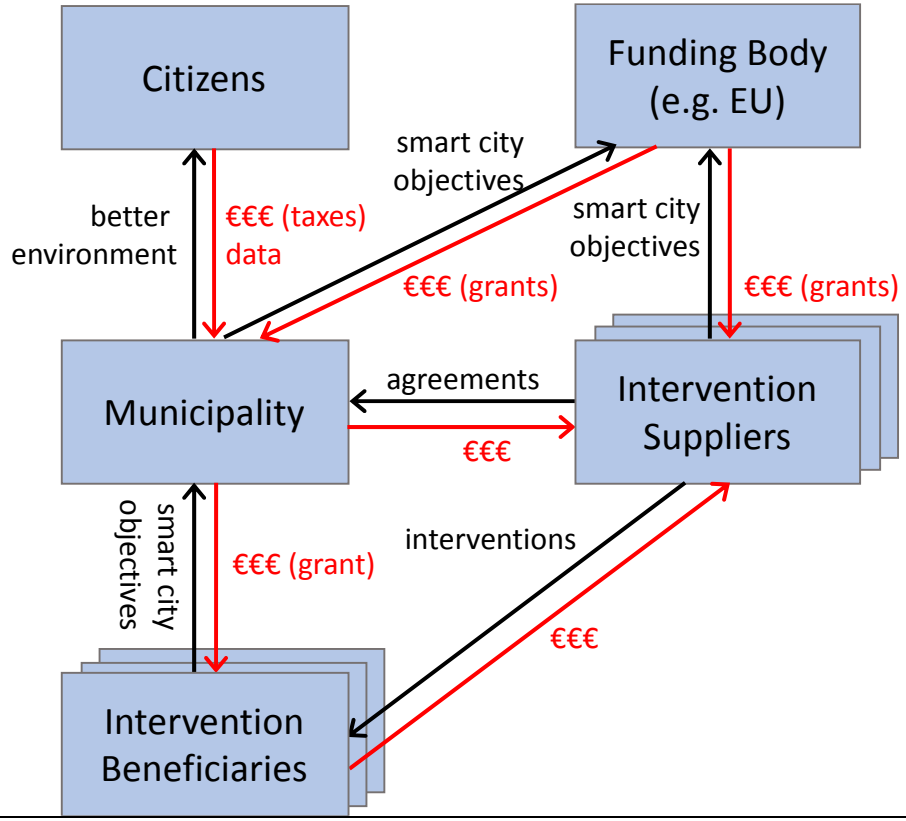
Model 1



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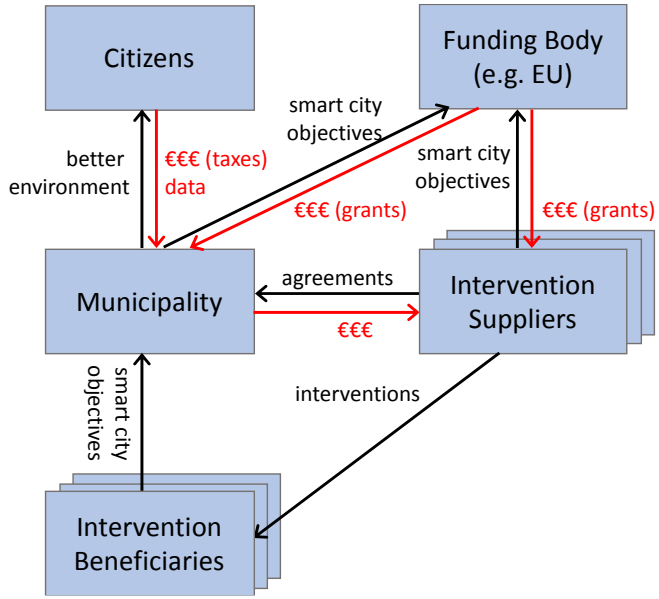
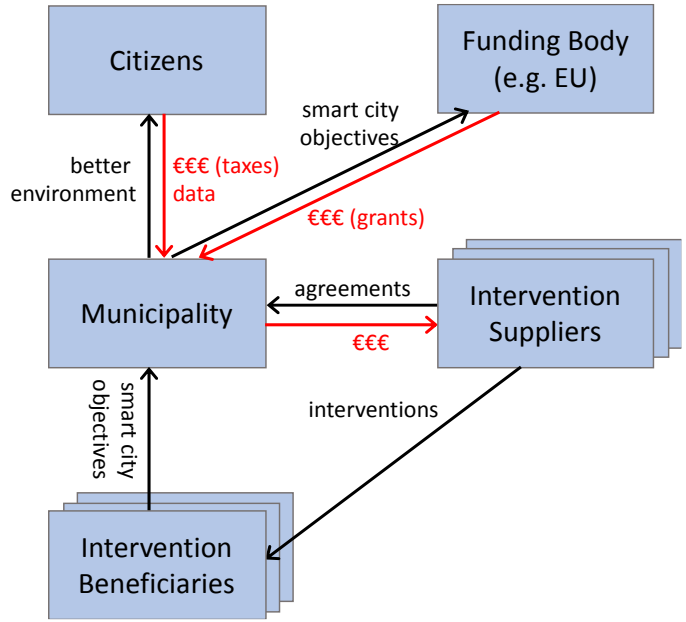
Model 1a



Model 1b



Project no. 691735

REPLICATE PROJECT

Renaissance of Places with Innovative Citizenship And Technology

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Question 1:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4/D7.5? If your answer below is No, please give your reasons and if appropriate consider updating Model 1 (and variations 1a and 1b) as supplied in the file VCE-Generic-T2.4-MODEL1.pptx

Question 2:

We assume that this financing model is recognisable as currently being used in the Pilot Cities in the REPLICATE project. Please supply an estimate of how much financing has been raised through this model since January 2016. What percentage of this was from REPLICATE?

Question 3:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions/smart city/sustainability targets in your city in the period 2021-2025?

If your answer below if Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way. Also, please provide details about any ways or means your city has to influence the timing and the topics of the Funding Body calls in order to match their own targets? Or do targets get influenced/changed to match the Funding?

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Question 4:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city beyond 2025?

7.4 Model 2

Model 2, shown below, extends Model 1 with the addition of Financial Institutions that provide loans to Intervention Beneficiaries. All of the possible financial flows are shown. Two significant variations of this model exist. In variant 2a) the municipality enters into an agreement with Financial Institutions to raise monies that can be used to co-finance interventions for the Intervention Beneficiaries. In variant 2b) there is no grant finance flowing anywhere and Intervention Beneficiaries are solely financed through loans from Financial Institutions. In this case the Municipality is merely monitoring the situation.

Notes:

The Financial Institution is any organisation regulated by the appropriate financial services regulator to offers loans for capital expenditure on interventions relevant to the overall climate change targets of the municipality.

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Example:

Loans for taxi drivers to purchase electric taxis in Florence and reduction in taxi licence fee charged by the municipality (Reference REPLICATE Deliverable D7.1).

Model 2b) seems to cover the case where the municipality expects targets (in whole or part) to be achieved by Intervention Beneficiaries borrowing whatever is required to finance interventions – the case where meeting a target is "not in the gift of the municipality" (Reference REPLICATE Deliverable D2.3).

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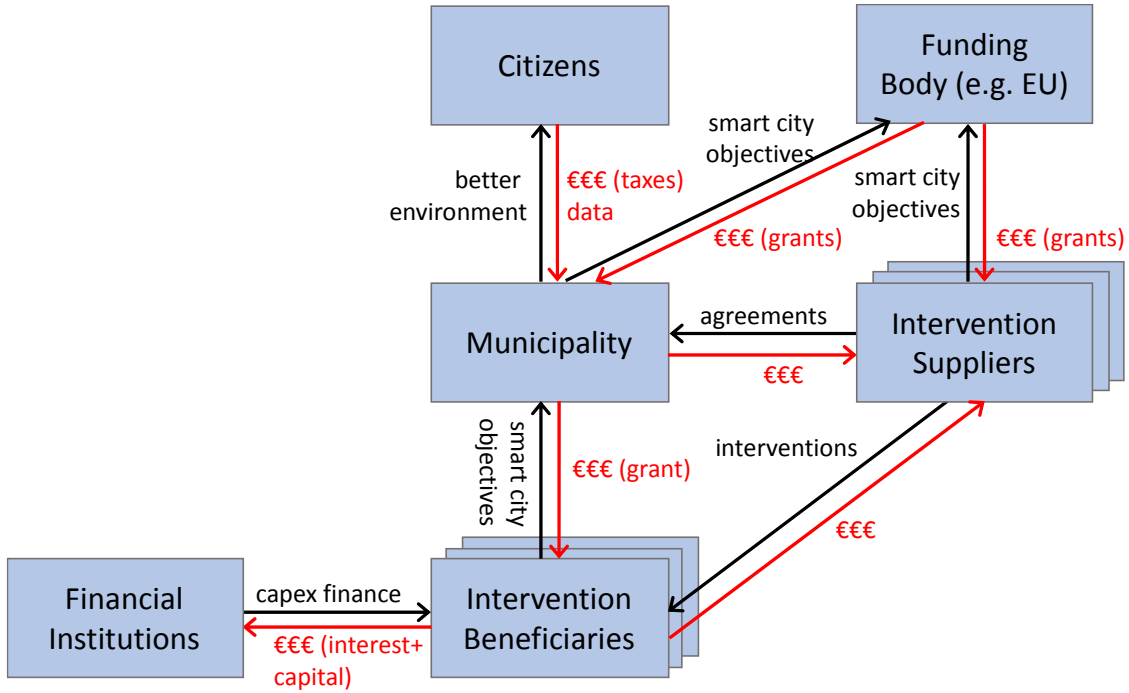
Model 2



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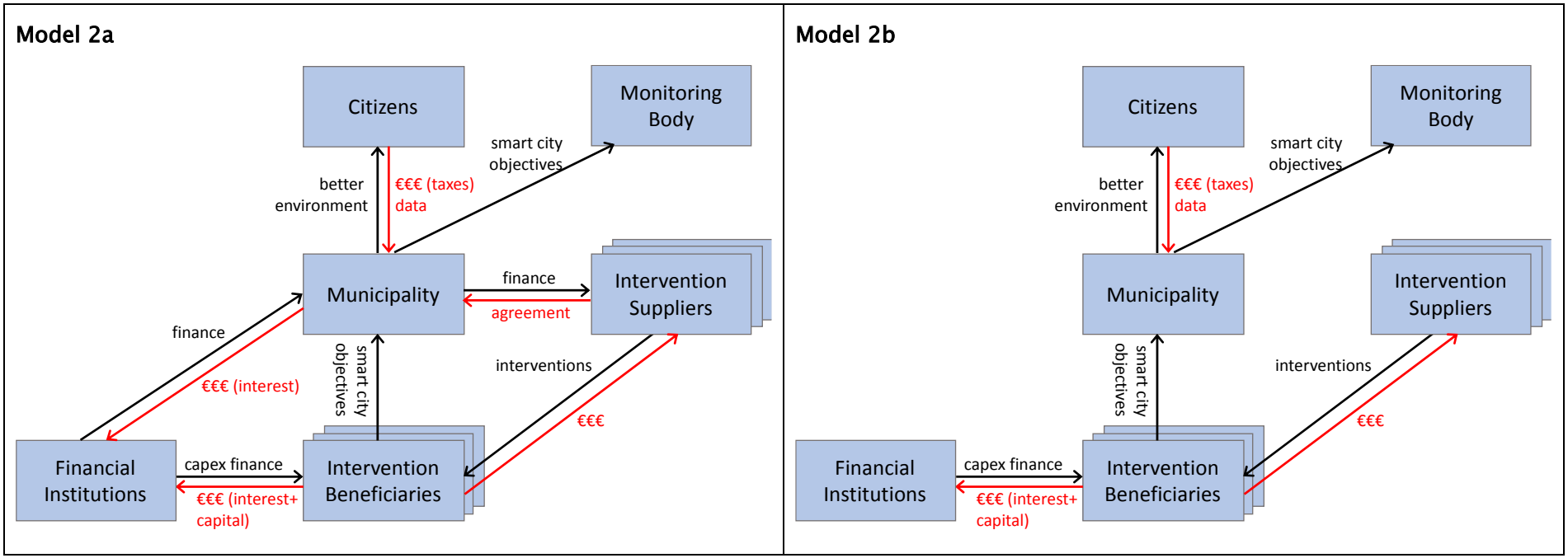

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Question 5:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4/D7.5?

If your answer below is No, please give your reasons and, if possible, consider updating Model 2 (and variation) as supplied in the file VCE-Generic-T2.4-MODEL2.pptx

Question 6:

Is this financing model recognisable as currently being used in your city?

If your answer below is Yes, do you have any way of assessing how much finance has been raised by Intervention Beneficiaries from Financial Institutions since January 2016?

If your answer below is No, please would you explain how this model, or its variant 2a, is not capturing, in a generic form, current financing arrangements in your city?

Question 7:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025?

If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way. How do you estimate this?

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7.5 Model 3

Model 3, shown below, attempts to capture the City Leap Process in Bristol. A strategic Partner Organisation is being sought through a procurement process to be an equity partner with the Municipality in the creation of a Special Purpose Vehicle (SPV) to act as a capability partner in delivering on the sort of interventions outlined in the City Leap Prospectus (Bristol City Council, 2018). The capital to establish the SPV will be raised from the Strategic Partner to an amount equivalent to the value of the assets that the Municipality will transfer to the SPV (Bristol City Council, 2019b). Note that some of these assets can be intangible, see Question 11 below. Presumably the SPV will be able to raise further capital e.g., by issuing bonds, and that some of this capital will be available to fund Intervention Beneficiaries in exchange. See Question 12 below about what this exchange might entail. The City Leap process is described fully in D2.3, "Internal report on findings".

A variation of this model, 3a, shows a SPV that has been created without a partner organisation providing investment i.e., it is wholly owned by the municipality.

Notes:

1. Even though the Funding Body is shown it is now no longer providing funding but retains a monitoring role. It could be re-labelled, see Table 4.
2. This model is possibly incomplete as it is still an ongoing process in Bristol.

Examples:

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Model 3 – the City Leap Process in Bristol. See (Bristol City Council, 2018, 2019b, 2019a, 2020a).

Model 3a – the example of SILFI S.p.A. in Florence (Reference Deliverable D4.2).

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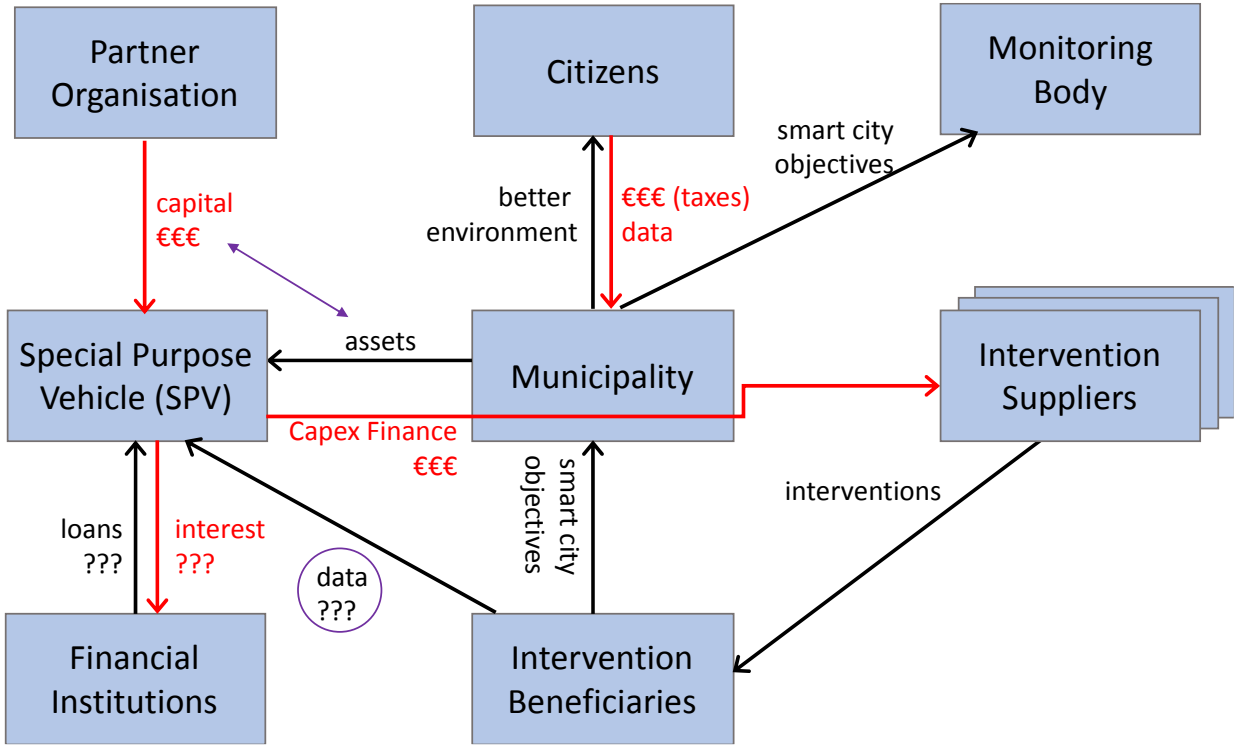
Model 3



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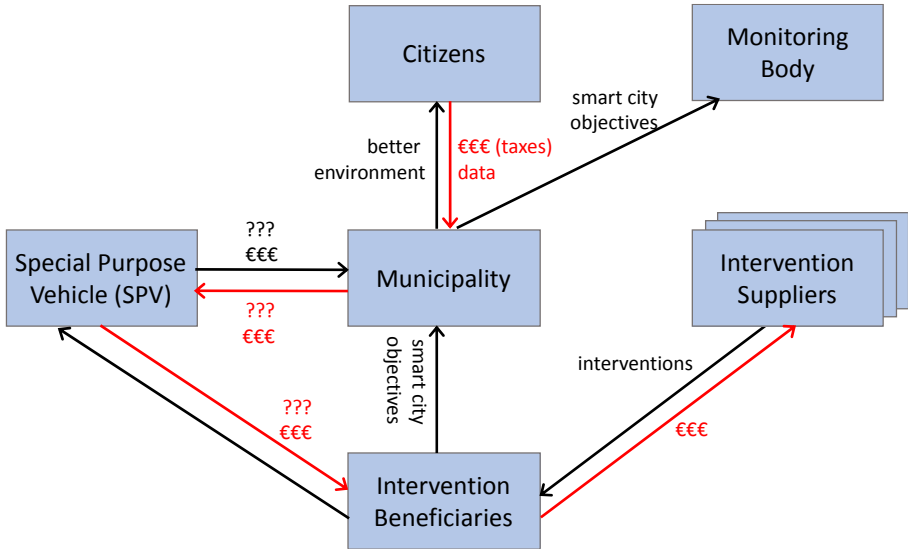
Model 3a



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Question 8:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4/D7.5?

If your answer below is No, please give your reasons and if appropriate consider updating Model 3, and variant 3a, as supplied in the file VCE-Generic-T2.4-MODEL3.pptx

Question 9:

Please would you comment on the viability of this finance model for your city, would you ever consider using a model like this?

If your answer below is No, what are your reasons for not using this model?

If your answer is Yes, please would you share more details about when and how? Also, details about status?

Question 10:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025?

If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way.

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Question 11:

For Model 3, the question was asked at the General Assembly in Florence in October 2019 of what assets *might* flow from the Municipality to the SPV in exchange for capital flows from the Partner Organisation to the SPV. The list of potential assets is listed below. Please would you update this list by either adding new assets that might be transferred or putting a strikethrough line through assets you consider would not be (or should not be) transferred.

Answer:

Question 12:

Model 3 also identifies possible assets that might flow from the Intervention Beneficiaries to the SPV. Again, the question of what these assets might be was asked at the General Assembly in Florence in October 2019. The list of potential assets is listed here. Please would you update this list by either adding new assets that might be transferred or putting a strikethrough line through assets you consider would not be (or should not be) transferred.

Answer

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7.6 Model 4

Model 4, shown below, is a development of Model 3. Here the SPV is the source of finance to provide Infrastructure Services from an Infrastructure Provider.

Notes:

This model is possibly incomplete and is only included here as speculation.

Example:

No known example, this speculative and possibly represents an evolutionary step between Model 3 and Model 5.

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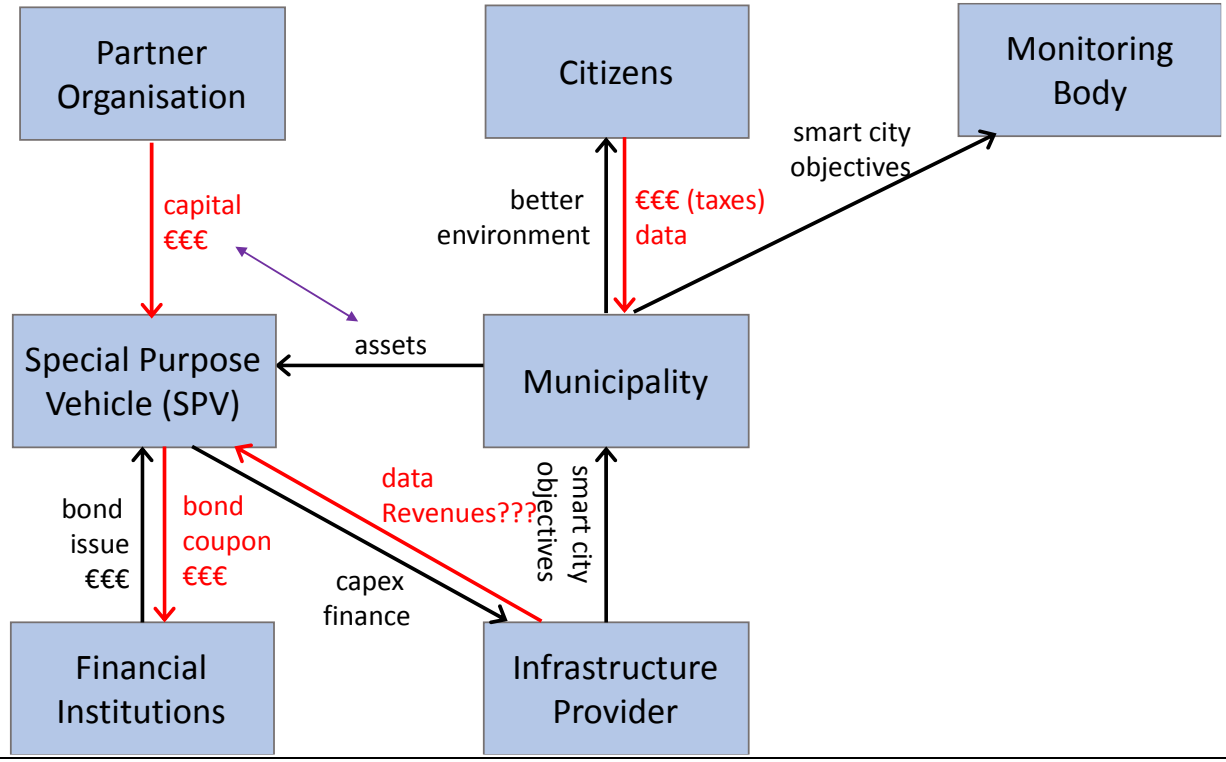
Model 4



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Question 13:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4?

If your answer below is No, please give your reasons and if appropriate consider updating Model 4 as supplied in the file VCE-Generic-T2.4-MODEL4.pptx

Question 14:

Please would you comment on the viability of this finance model for your city, would you ever consider using a model like this?

If your answer below is No, what are your reasons for not using this model?

If your answer is Yes, please would you share more details about when and how? Also, details about status?

Question 15:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025?

If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way.

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7.7 Model 5

Model 5, shown below, is a highly evolved version of Model 3.

In order to raise capital finance to build new infrastructure the municipality creates a Special Purpose Vehicle (SPV) that is sufficiently independent of the municipality to be able to issue bonds. This SPV delivers benefits to citizens directly, e.g. transport services. The SPV could also persist as the owner and operator of the infrastructure. The SPV may be more complex than a single company entity and may in fact be a group structure as shown by the multiple boxes. The SPV may make further bond issues to raise further capital to improve or extend existing infrastructure.

This situation is prevalent in the USA for financing infrastructure buildout raising capital via the issue of municipal bonds.

The City Leap process started in Bristol might be the first step in the UK towards this type of financing in the future.

Notes:

See role descriptions in Table 4.

Example:

New York Metropolitan Transportation Authority (MTA) green bond issue of $5.307Bn in the period 2016-18 (Standard and Poor's, 2019)

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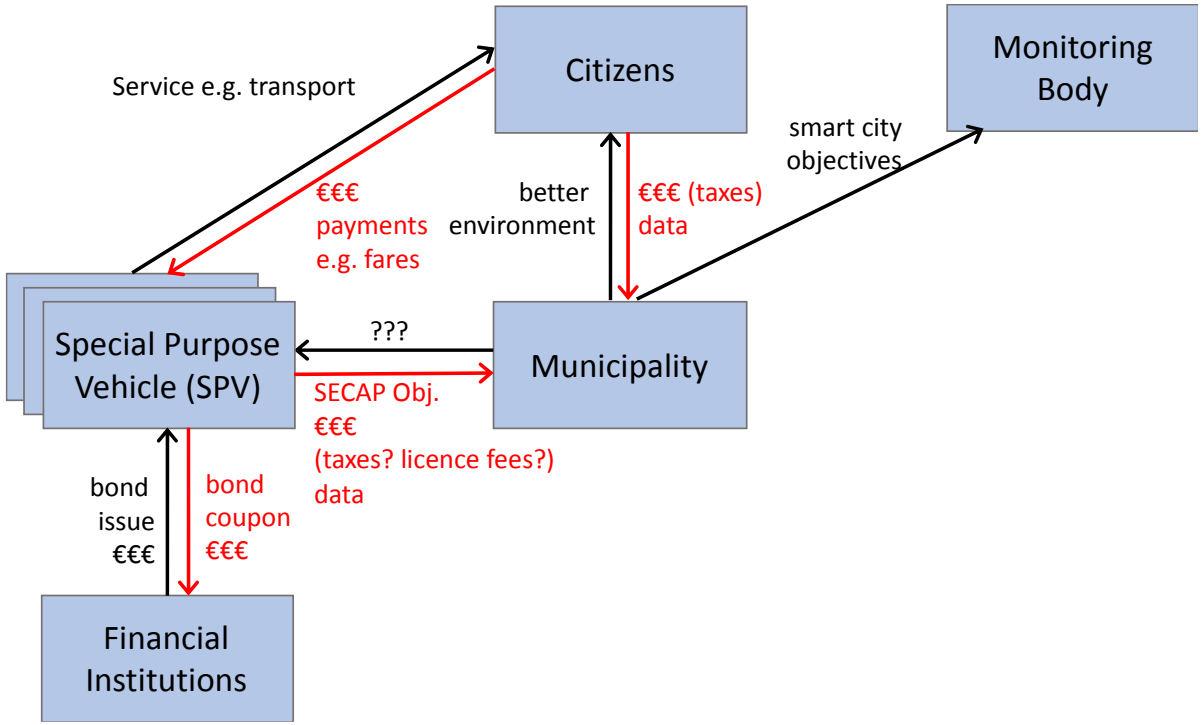
Model 5



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Question 16:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4/D7.5?

If your answer below is No, please give your reasons and if appropriate consider updating Model 5 as supplied in the file VCE-Generic-T2.4-MODEL5.pptx

Question 17:

Please would you comment on the viability of this finance model for your city, would you ever consider using a model like this?

If your answer below is No, what are your reasons for not using this model?

If your answer is Yes, please would you share more details about when and how? Also, details about status?

Question 18:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025?

If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way.

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7.8 Model 6

Model 6, shown below, represents the situation where the municipality raises finance directly by the issuance of green bonds following emerging governance standards e.g. International Capital Markets Association (2018); Nordic Public Sector Issuers (2020).

The municipality works with the Financial Institution to write a prospectus and handle all the regulatory approvals to issue the bonds. The organisational position is not too different from the issue of a corporate bond, except that here these are clearly 'municipal bonds'. From an investor's perspective municipal bonds may offer better tax positions, at least in the USA.

Notes:

Not shown in the model are i) the markets on which the bonds are issued, ii) the credit rating agencies, and iii) the investors who buy the bonds. See the role descriptions in Table 4.

Example:

The City of Gothenburg issuance of green bonds (City of Gothenburg, 2016, 2017b, 2018a, 2019; Moody's, 2016; Standard and Poor's, 2017).

> "*Since October 3, 2013, the City of Gothenburg has issued Green Bonds on five occasions raising a total of SEK 5 550 million of funding supporting the transition to a low-carbon and climate resilient society. At the time of publication approximately 14 percent of the city's debt consists of Green Bonds*" (City of Gothenburg, 2017b).

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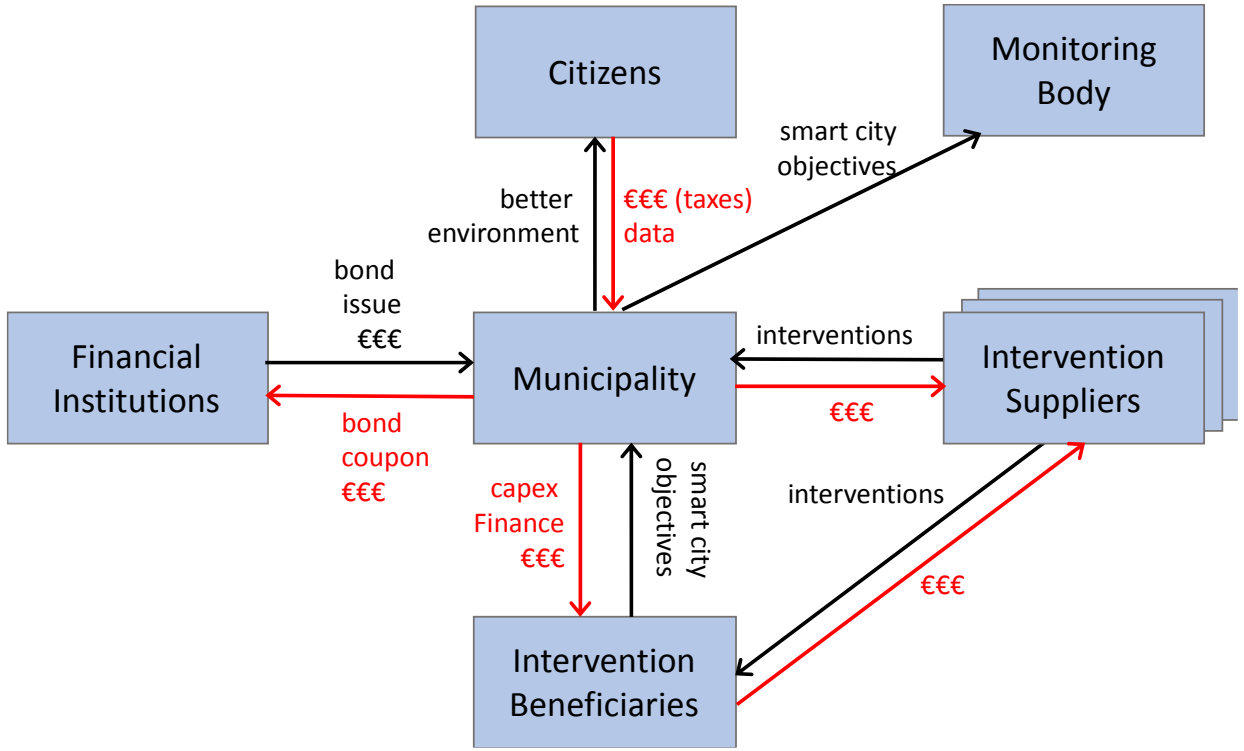
Model 6



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Question 19:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4?

If your answer below is No, please give your reasons and if appropriate consider updating Model 6 as supplied in the file VCE-Generic-T2.4-MODEL6.pptx

Question 20:

Please would you comment on the viability of this finance model for your city, would you ever consider using a model like this?

If your answer below is No, what are your reasons for not using this model?

If your answer is Yes, please would you share more details about when and how? Also, details about status?

Question 21:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025?

If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way.

7.9 Model 7

Model 7, shown below, represents the situation where the municipality raises finance directly through crowdfunding and the use of a crowdfunding platform.

Notes:

Here the Crowdfunding Platform is managing the crowdfunding process on behalf of the municipality. See the role descriptions in Table 4.

Example:

Has this approach been used? It has been considered theoretically (Carè, Trotta, Carè, & Rizzello, 2018; Langley & Leyshon, 2017).

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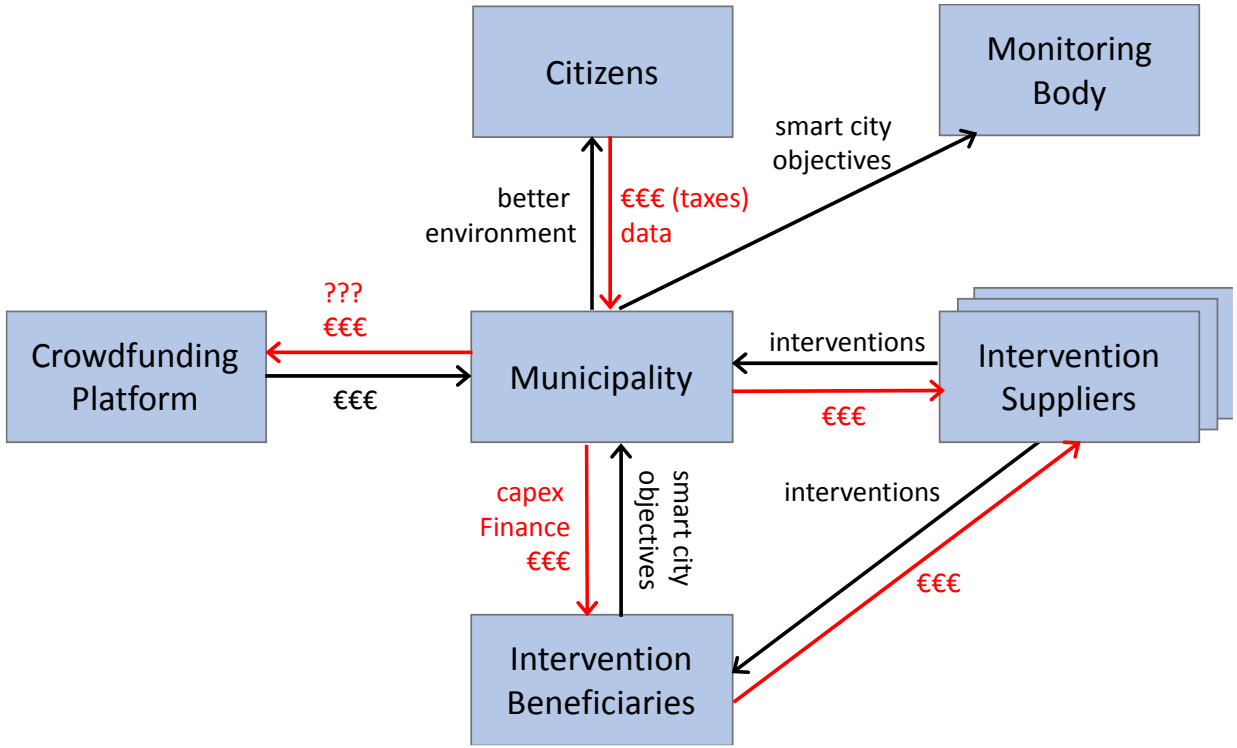
Model 7



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Question 22:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4?

If your answer below is No, please give your reasons and if appropriate consider updating Model 7 as supplied in the file VCE-Generic-T2.4-MODEL7.pptx

Question 23:

Please would you comment on the viability of this finance model for your city, would you ever consider using a model like this?

If your answer below is No, what are your reasons for not using this model?

If your answer is Yes, please would you share more details about when and how? Also, details about status?

Question 24:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025?

If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see being raised this way.

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7.10 Model 8

Model 8, shown below, represents a generic Energy Services Company (ESCO) in relation to the actors of interest in this work package. Since ESCOs can exist in total independence of a Municipality, of interest here are what relationship(s) may exist between an ESCO and a Municipality, and thus what flows between them. The questions below are posed from this perspective.

Notes:

Example:

Unknown.

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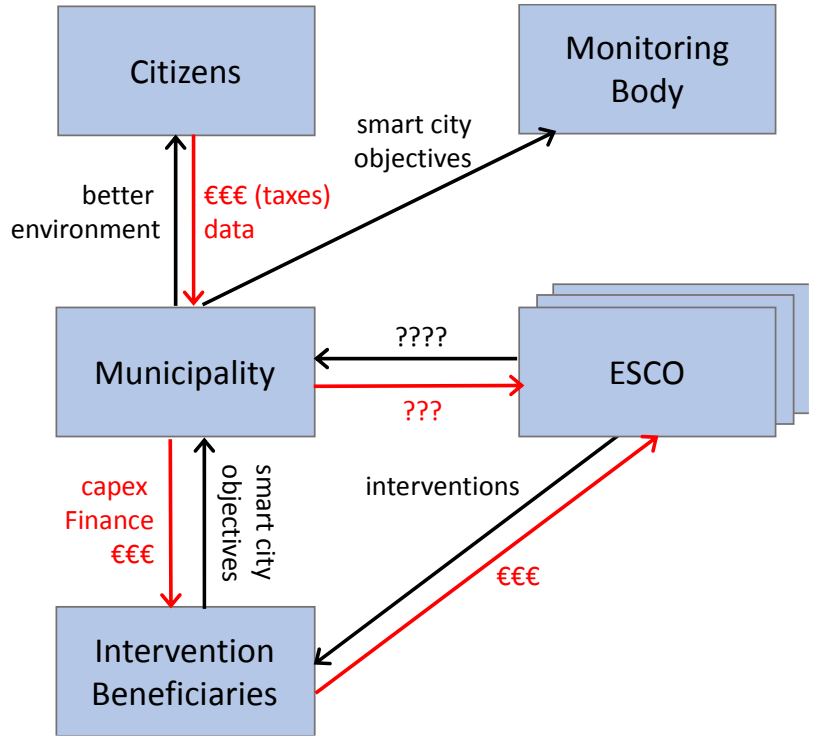
Model 8



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Question 25:

Does this model and the associated text make sense to you in the context of financing arrangements for smart city interventions and knowledge of the VCE notation from the General Assembly in Bristol in October 2016, and the Deliverables D2.3 and D7.4/D7.5?

If your answer below is No, please give your reasons and if appropriate consider updating Model 8 as supplied in the file VCE-Generic-T2.4-MODEL8.pptx

Question 26:

Please would you comment on any relationship that exists between an ESCO and the Municipality? Would you ever consider being in a relationship with an ESCO?

If your answer below is No, what are your reasons for not using this model?

If your answer is Yes, please would you share more details about the relationship and specifically what flows between the Municipality and the ESCO.

Question 27:

Do you envisage this model as contributing to the financing of interventions targeted towards achieving carbon emissions targets in your city in the period 2021-2025? If your answer below is Yes, please provide an estimate how likely this will be and some estimate of the scale of finance you see flowing through the ESCO.

7.11 Additional Models arising from Round 2

The following variational models have been proposed in Round 2 and are referenced in the following sections summarising the answers to questions.

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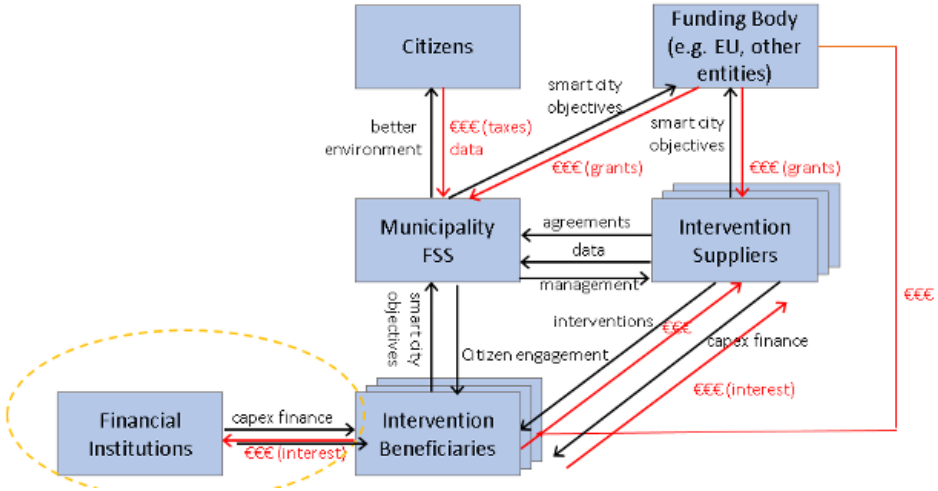
7.11.1 Model 1c

MODEL 1c-Building retrofitting
-Mix model 1 and 2-



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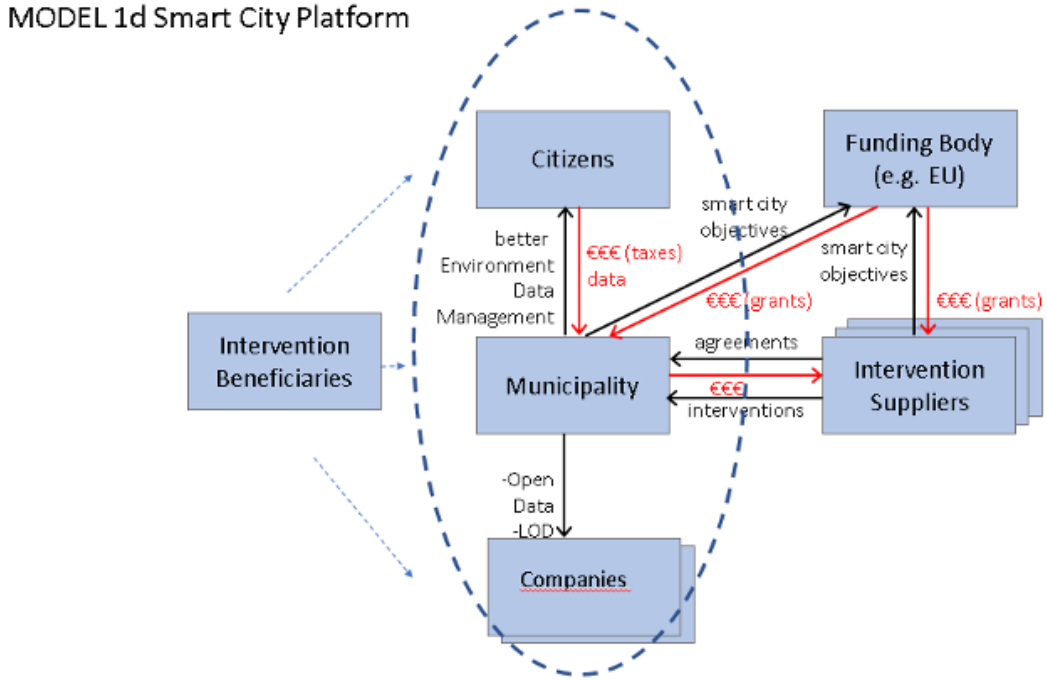
7.11.2 Model 1d



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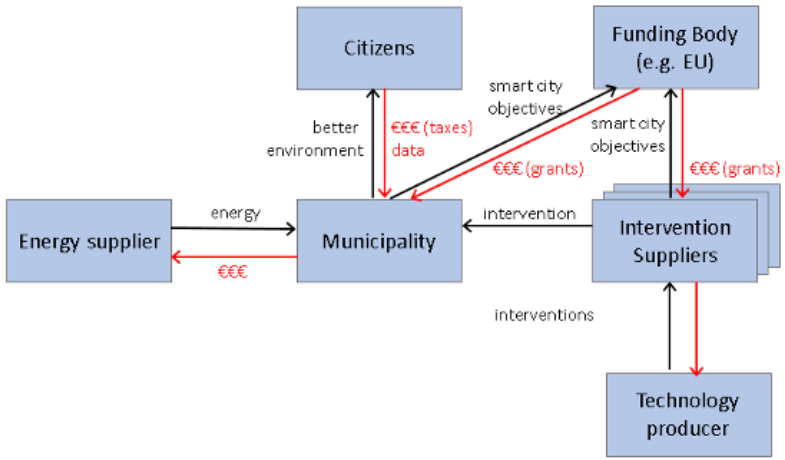
7.11.3 Model 1e

MODEL 1e-Smart Public Lighting



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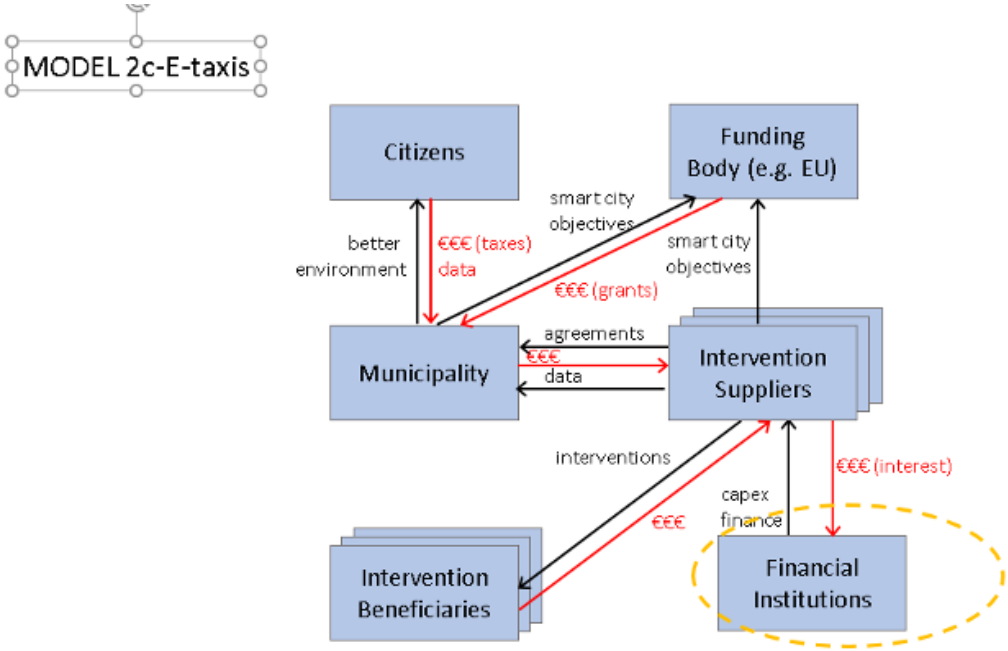
7.11.4 Model 2c



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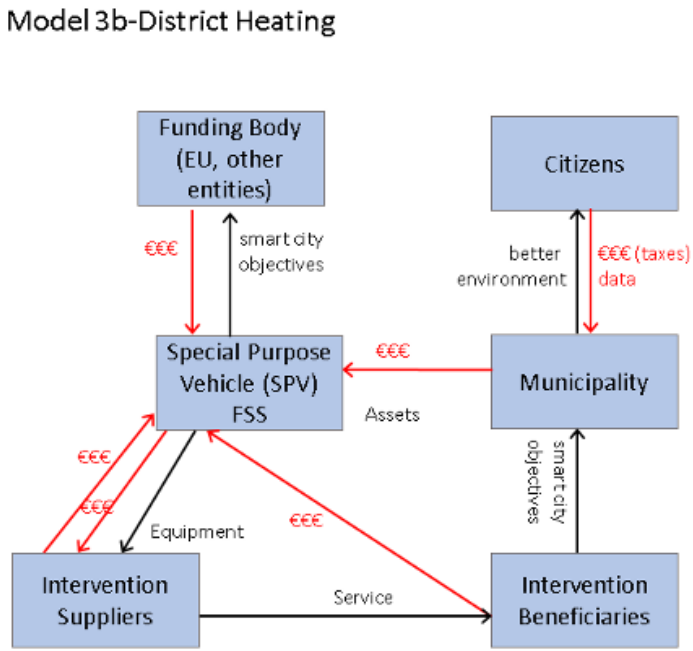
7.11.5 Model 3b



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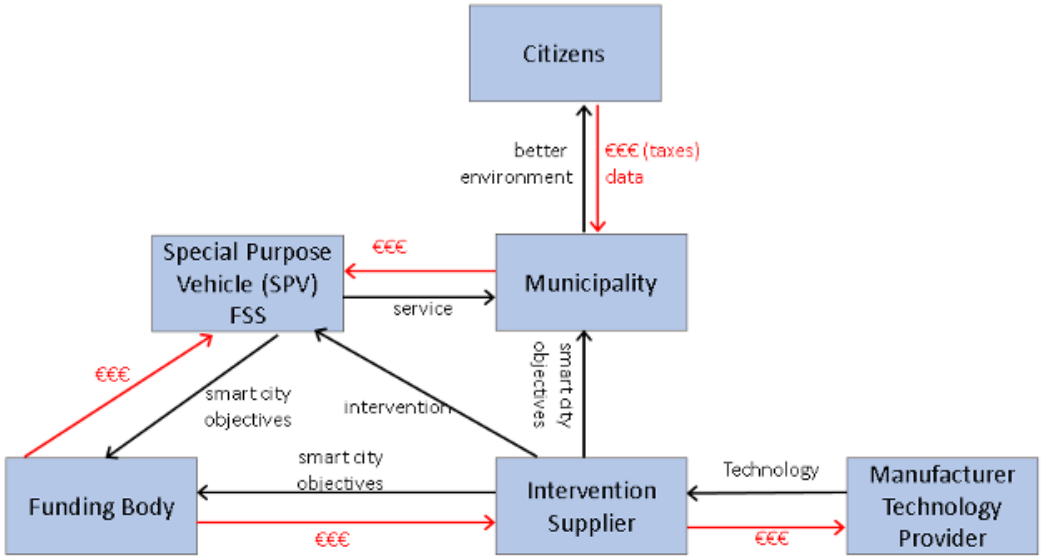
7.11.6 Model 4a

Model 4a-High speed mobile network



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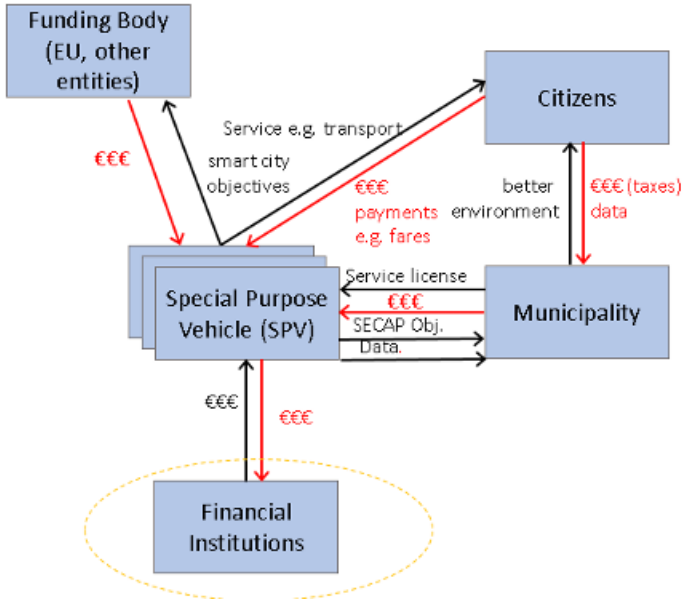
7.11.7 Model 5a

Model 5a-Buses



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7.12 Model Comprehensibility

The first important question concerning each model was its general comprehensibility, that is, does it make sense as a VCE model in context – were the actors and flows in a meaningful and recognisable configuration given the context of smart city financing? The answers are presented below in Table 5. Whilst a simple Yes/No summary is presented, the clarifications and qualifications received in the data collection process are reproduced as fully as possible in the Data presented at Section 7.17. This level of detail is included for reference purposes and contributes to the analysis of findings in Section 10.

Model	Question	San Sebastián	Florence	Bristol	Essen	Lausanne	Nilüfer
1	Q1	Yes[a]	Yes	Yes	Yes	No[b]	Yes
2	Q5	Yes[c]	Yes	Yes	Yes	Yes[d]	Yes
3	Q8	Yes[e]	Yes	Yes[f]	Yes	Yes[g]	Yes
4	Q13	Yes[h]	Yes	No[i]	Yes	No[j]	Yes[k]
5	Q16	Yes[l]	Yes	No[i]	Yes	No[j]	Yes
6	Q19	Yes	Yes	Yes[m]	Yes	No[n]	Yes
7	Q22	Yes	Yes	Yes[o]	Yes	Yes[p]	No[q]
8	Q25	Yes	Yes	Yes[r]	Yes	Yes[s]	Yes

Table 5. VCE Model Comprehensibility

7.13 Model Viability

The second guiding question concerning each model was its general viability, that is, would it ever make sense to use it in the context of financing smart city interventions? Note that Model 1 is already considered viable in that it describes, generically, the way in which the interventions were funded in the Pilot cities in REPLICATE and therefore viability has been shown by, more or less, completion of the individual projects in the city to deliver the interventions over the lifetime of the project.

Of course, the question of viability is going to be highly dependent on a range of factors not least the regulatory environment and place-specific needs of the city. However, the expectation from the empirical grounding of the generic models in this Work Package in data collected in Work Package 7 is that at least some of these models would be viable for use and cold be considered. The answers are presented below in Table 6. Again, whilst a simple Yes/No summary is presented, the clarifications and qualifications received in the data collection

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process are reproduced as fully as possible in Section 7.17 and are included for reference purposes and contribute to the analysis of findings in Section 10.

Model	Question	San Sebastián	Florence	Bristol	Essen	Lausanne	Nilüfer
2	Q6	Yes[t]	Yes[u]	Yes[v]	Yes[w]	Yes[x]	Yes[y]
3	Q9	Yes[z]	Yes[aa]	Yes[bb]	Yes[cc]	No[g]	No[dd]
4	Q14	Yes[ee]	No[ff]	No[i]	Yes[cc]	No[j]	Yes[k]
5	Q17	Yes[gg]	Yes[hh]	Yes[ii]	Yes[jj]	No[j]	Complex[kk]
6	Q20	No[ll]	No[mm]	Yes[nn]	No[oo]	No[n]	No[pp]
7	Q23	No[qq]	No[rr]	Yes[ss]	Yes[tt]	Yes[p]	No[uu]
8	Q26	No[vv]	No[ww]	No[xx]	Yes[yy]	Yes[s]	Complex[zz]

Table 6. VCE Model Viability

7.14 Intention to Use

The third guiding question about each model concerned the municipality's intention to use a model in the time frame immediately after the REPLICATE project. This question affirms both the comprehensibility and viability of each model and begins to suggest something of its general applicability beyond the REPLICATE project.

Model	Question	San Sebastián	Florence	Bristol	Essen	Lausanne	Nilüfer
2	Q7	Yes[aaa]	Yes[bbb]	No[ccc]	Yes[ddd]	Yes[eee]	Yes[fff]
3	Q10	Yes[ggg]	Yes[hhh]	Yes[iii]	No	No	No[jjj]
4	Q15	Yes[kkk]	No[lll]	No[mmm]	No	No	No[nnn]
5	Q18	Yes[ooo]	Yes[ppp]	No[qqq]	Yes[rrr]	No	No[kk]
6	Q21	No[sss]	No[ttt]	No[uuu]	No	No	No
7	Q24	No[vvv]	No[www]	No[xxx]	No	Yes[p]	No
8	Q27	Yes[yyy]	Yes[zzz]	No[aaaa]	Yes[bbbb]	Yes[s]	Yes[cccc]

Table 7. Intention to use a VCE Model in the period 2021-2025

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7.15 Longer-Term Prospects

The final item of data collection in Round 2 was to elicit opinions on whether there was likely to be any change in intention to use the Models beyond 2025 i.e., whether the situation summarised in Table 7 was likely to remain static. The raw data are presented below in Table 8.

7.15.1 San Sebastián			
Financing Model	In Current Use	Expected Use (2021-2025)	Expected Use Beyond 2025
Model 1	Yes, variations of these models		
Model 1a			
Model 1b			
Model 1c	Yes	Yes	Yes
Model 1d	Yes	Yes	Yes
Model 1e	Yes	Yes	Yes
Model 2	Yes, variations of these models		
Model 2a			
Model 2b			
Model 2b	Yes	No	No
Model 3	Yes, variations of these models		
Model 3a			
Model 3c	Yes	Yes	Yes
Model 4	Variation of this model		
Model 4a	Yes	Yes	Yes
Model 5	Variation of this model		
Model 5a	Yes	Yes	Yes
Model 6	No	Maybe (to be further analysed)	Maybe (to be further analysed)
Model 7	No	Maybe (to be further analysed)	Maybe (to be further analysed)
Model 8	No	Yes	Yes

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7.15.2 Florence			
Financing Model	In Current Use	Expected Use (2021-2025)	Expected Use Beyond 2025
Model 1 (Grant)	Yes (pilot action)	Yes (local recovery plan and other national programs)	yes (2030 targets and EU projects)
Model 1a	Yes	Yes	yes
Model 1b	yes	yes	yes
Model 2 (Funding body agreement)	yes	Yes	Don't know
Model 2a	Yes (boilers)	Don't know, national schemes already available	Don't know
Model 2b	no	Yes (monitoring 110%)	Don't know
Model 3 (SPV with partner)	Yes (Publiacqua)	yes	yes
Model 3a (municipal SPV)	Yes (SIlfi, Casa spa)	yes	yes
Model 4 (SPV financing infrastructure services)	No	Don't know, maybe on energy and data infrastructures	Don't know
Model 5 (complex SPV x green bonds)	Don't know (Publiacqua?)	Don't know	Don't know
Model 6 (municipal green bonds)	In the past, not in Replicate	No	Don't know
Model 7 (crowdfunding)	Yes	Yes (adaptation measures)	Don't know
Model 8 (ESCOs)	Don't know (only "facilitating" through the helpdesk)	yes	yes

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7.15.3 Bristol			
Financing Model	In Current Use	Expected Use (2021-2025)	Expected Use Beyond 2025
Model 1	Yes	Yes	Yes
Model 1a	Don't know	Don't know	Don't know
Model 1b	Yes	Don't know	Don't know
Model 2	Don't know	Don't know	Don't know
Model 2a	Don't know	Don't know	Don't know
Model 2b	Don't know	Don't know	Don't know
Model 3	In development	Yes	Yes
Model 3a	No	No	No
Model 4	Yes	Yes?	Don't know
Model 5	Don't know	Don't know	Don't know
Model 6	Don't know	Don't know	Don't know
Model 7	No	Don't know/yes?	Don't know/yes?
Model 8	No	Don't know/yes?	Don't know/yes?
7.15.4 Essen			
Financing Model	In Current Use	Expected Use (2021-2025)	Expected Use Beyond 2025
Model 1	Yes	Y	Y
Model 1a	Yes	Y	Y
Model 1b	Yes	Y	Y
Model 2	Yes	Y	Y
Model 2a	Yes	Y	Y
Model 2b	Yes	Y	Y
Model 3	N	N	N
Model 3a	N	N	N
Model 4	N	N	N
Model 5	N	Y	Y
Model 6	N	N	N
Model 7	N	N	Y
Model 8	Y	Y	Y

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7.15.5 Nilüfer			
Financing Model	In Current Use	Expected Use (2021-2025)	Expected Use Beyond 2025
Model 1	Y	Y	Y
Model 1a			
Model 1b	Y	Y	Y
Model 2	Y	Y	Y
Model 2a	Y	Y	Y
Model 2b	Y	Y	Y
Model 3			
Model 3a	Y	Y	Y
Model 4	N	DN	DN
Model 5	N	DN	DN
Model 6	N	DN	DN
Model 7	N	DN	DN
Model 8	N	Y	Y

Table 8. Change in intention to use financing models beyond 2025

The data in Table 8 present views on current use of the models, immediate prospective use in the period beyond the end of REPLICATE project i.e., beyond SCC funding, and finally of their projected use beyond 2025. As would be reasonably expected, the degree of uncertainty increases beyond 2025 and cuts both ways. The ongoing relevance of the models and their impact in municipal decision making about financing interventions is, however, clearly indicated and is discussed further in Section 10.

7.16 Tradeable Assets for Model 3

Model 3 requires that the Municipality transfers ownership of assets to the SPV and that financial capital to the notional value of these assets is supplied by the Partner Organisation. Questions 11 and 12 in Rounds 1 and 2 of the data collection exercise requested more details about what these assets might be. These questions were seeded with a list built on the original collection of potential assets at the REPLICATE General Assembly in Florence in M45. The sum total of potential assets is listed in Table 9. To suggest something of the contested nature of transferring publicly-owned assets through this mechanism the table splits responses into assets that municipalities think would be acceptable and those that should not be transferred and assets can appear in both rows.

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Question	Sum of Responses
Q11. What assets might flow from the Municipality to the SPV in exchange for capital flows from the Partner Organisation to the SPV?	Real estate (as sales or rentals) Real estate management Permits to install/build infrastructure Mobility/transport infrastructure Social housing Smart grid Physical infrastructure (generally) +existing renewable energy assets Human resources Public space +green and blue space i.e., harbour All subsidiary companies Waste streams Water management Service delivery capabilities Intellectual property Data +communication channels Software (e.g., Apps developed by the municipality) Infrastructures (recharging points, depot…) Connectivity network Lighting infrastructure
Q11. What assets SHOULD NOT flow from the Municipality to the SPV in exchange for capital flows from the Partner Organisation to the SPV?	All subsidiary companies Intellectual property Software (e.g., Apps developed by the municipality) Real estate sales or rentals Smart grid Human resources
Q12. Possible assets that might flow from the Intervention Beneficiaries to the SPV?	Higher performance interventions Data Interest payments Expertise Services Social acceptance Data privacy solutions

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Q12. Possible assets that SHOULD NOT flow from the Intervention Beneficiaries to the SPV?	Interest payments

Table 9. Potential municipal assets that could be transferred, and should not be transferred, to an SPV to satisfy capitalisation requirements for Model 3.

7.17 Data for Table 5, Table 6 and Table 7.

[a] The model of the retrofitting intervention is a mix of model 1 and 2 (1c). The city of Donostia/San Sebastian is analysing and exploring other models for instance, ESCO model (model 8 in this document or a variation of it) where the public funding is reduced and evolves into a public-private collaboration model. The model associated to the Smart City platform of Donostia/San Sebastian is also a variation of the model 1 presented in 1d. For this action the scale-up of the platform is expected, it is foreseen that data sources available in the city will gradually be integrated in the platform. The model could evolve. As an example, companies could pay for the data of the platform to use it to create products and services for example (this model would need further analysis). Smart Public Lighting deployed in the Replicate project framework is a variation of model 1,1e). The Smart Public Lighting model might evolve to a model 5 where there is a flow of the asset to a SPV. It could be also managed by an ESCO (similar to model 8).

[b] This model is not applicable in Lausanne. In Switzerland, to the knowledge of the respondent, there are never any projects subsidized 100% by a national or cantonal (regional) body. The main reason is the possibility, for the municipalities, to raise their own taxes, therefore not to depend financially on the state or the region. For large projects, in general, funding is distributed 1 / 3-1 / 3-1 / 3 between the three political levels state-region-municipality.

[c] A variation of model 2 (2c) is associated to the E-taxis deployment in the Replicate project framework

[d] According to your explanations, if the beneficiary of the action borrows from a financial institution to carry out the action, Model 2 applies. In this case, our subsidy program for energy efficiency actions applies.

[e] The model variation 3b, describes the intervention of the District Heating system deployed in Txomin neighbourhood of San Sebastian as part of Replicate project.

[f] This Model is in effect Bristol's City Leap Process.

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[g] It is not planned to use a Special Purpose Vehicle; it is too complicated legally although the law authorizes the creation of this type of vehicle. For example, small mountain municipalities use it to manage hydraulic electricity production. For large cities, it is easier to use the energy contracting model.

[h] The high-speed wireless connectivity network is represented by model variation 4a

[i] Although the confidential nature of the procurement process associated with the City Leap Process means that a clear answer on this Model is not clear.

[j] No, same reasons as for model 3.

[k] But most of the time this infrastructure provider is public, this one is too much on the market operation side to be viable for municipal investment perhaps not in the USA…

[l] The funding model in Dbus is represented in model 5a. Dbus is a public municipal company and acts as a SPV in the city.

[m] Is there not also potential for the capex to go to suppliers in some instances as well? In this case the beneficiaries aren't the citizens but say the municipality or owner i.e. co-wheels for instance? How does the UK govt model of financing the green deal come into this? https://www.gov.uk/green-deal-energy-saving-measures

[n] Not considered. It is specified that this is the first Swiss case! The reason is to widen the circle of possible funding. Currently, there is more demand for projects from financial institutions than there are possibilities for implementation in the field!

[o] Possibly.

[p] As part of a participatory budget project, it is planned to support projects in which the promoters finance 50% of their ideas. It may be a form of crowdfunding.

[q] Tech and Capital-intensive investments not likely to be feasible to be advances via crowdfunding…

[r] In a previous model, the ESCO worked with the BCC Energy service as an extension service delivery and retail provider. Unfortunately, we are unsure what this looks like now going forward in the current situation

[s] Our Utilities act as an ESCO. The aim of energy contracting is to guarantee the quality of the work. In the example of our future eco-district, this is the only possibility of guaranteeing 100% renewable heat production in the district.

[t] Variation 2c is associated with the E-taxis in the Replicate project framework. In future, a variation of this model might be more suitable where funds could directly go to the intervention supplier.

[u] This model has been activated by the municipality for example to finance the boilers update in the domestic sector. Currently it is outdated because of the 110% scheme promoted by the

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National Government covering more aspects of buildings retrofitting: the municipality is planning to activate, through its helpdesk, a support for citizens aimed at facilitating the adhesion to the 110% National Program (administrative/financial issues as well as technical ones like the impacts assessment and building energy certificate)

[v] It is possible that this model has been used for the Salix financing.

[w] 2b – Yes: No way to asses finance raised. 2a – Yes. The financial institution typically being the state-owned NRW Bank. Will show in municipal budget, so can potentially be assessed.

[x] Around € 25 million.

[y] Cannot assess amount raised.

[z] Variation 3b for district heating. Also see Endnote i.

[aa] Yes, as already reported it is the model in use for SILFI who's the SPV owned by the municipality with the scope of managing some smart services like smart public lighting, public charging network, wi-fi public system. Also, Casa SPA, the public company owned by metropolitan area municipalities, is another example in the field of social housing management. In the case of water management, the model is in use by the public-private company Publiacqua (more like Model 5)

[bb] Although there is some uncertainty currently of the process. CL is being reviewed. Our holding companies have seen recent turmoil – BIO was dissolved and Bristol Energy has been sold to private sector organisations. Others are still operational such as Bristol Waste and Goram Homes

[cc] But highly unlikely. The current decision makers are very sceptical about creation of new SPV.

[dd] Legal barriers to setting up SPV in local government.

[ee] Variation 4a used for public high-speed wireless connectivity. The intervention will be founded by public funds when available, with own resources and through public-private collaboration models, for instance, the agreement with private companies for the service use, etc.

[ff] It could be an evolution of the model in use for specific infrastructures/services

[gg] Variation 5b describes Dbus, the public municipal company that manages urban public transport in San Sebastián.

[hh] It seems to be the model in use in case of water management and related infrastructure where Publiacqua is the SPV participated by the municipality. (see picture at https://www.publiacqua.it/chi-siamo)

[ii] City Leap (Model 3) could explore this model, however as CL is behind the original timelines of delivery and without the Strategic Partner on board yet it is difficult to predict

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[jj] Considered within EU Project SCORE (https://www.score-h2020.eu/) to finance PV Systems on municipal roofs and rented property. SPV is mainly a "Renewable Energy Community" in the sense of the RED II. Currently we are looking for pilots. Implementation planned in 2021.
[kk] "As a continuation of the response to Q15, the SPV's are more likely to be hybrid PP corporations controlled by public interests. In Stuttgart for instance the SPV is majority municipal. Advancing re-municipalization of water, energy and other utilities in in many countries in Europe; water in France, energy in Germany, (rail in UK?) may become unstoppable in the new normal!"
[ll] Interesting, but further exploration is required.
[mm] The model has been considered in the past, but due to the complexity of the bond market for a public institution like a city it has been abandoned.
[nn] It is possible that the Triodos Bank offers a similar scheme.
[oo] Not without any SPV as intermediate. Municipality is not allowed to engage this way. At least not Essen with budget constraints and duty to fulfil only obligatory tasks.
[pp] Probably more viable in relatively more autonomous administrative cultures
[qq] Interesting, but further exploration required.
[rr] Crowdfunding has been activated for specific project of adaptation (planting trees) or social aids during pandemic period (food for older people and families, IT devices for children to be able to attend to on-line school courses, special devices for hospitals…) or even for cultural association. It has never been adopted for mitigation actions.
[ss] EU funded project SONNET with the Bristol City Council (BCC) Energy Service started in July 2020. Exploring the feasibility of crowdfunding as a means of raising capital to install energy efficiency measures within community buildings. Bristol pilot involves BCC Energy Service and Bristol Energy Networking (subcontracted) to engage building managers and citizens. The primary output will be a cabinet paper to gain support for a new financing approach.
[tt] Has already been considered to raise money for PV installations and LED lighting but is no longer planned.
[uu] Opportunities may exist for smaller scale investments and maybe energy cooperatives…
[vv] However, some implementations described in other models might evolve to an ESCO model e.g., retrofitting interventions in the city.
[ww] This model could be used when the business model is attractive and the main obstacle is the investment, for example, in case of residential buildings. The problem for the municipality is the selection of the ESCO (public tender). Otherwise, it could just "facilitate" the interventions with promotion about possible benefits and impacts in general, as they do with the helpdesk,

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and ask for data. This is the model in place for national grants where there is the national energy agency (ENEA) instead of the municipality.

[xx] As Bristol Energy has just been sold, it is not sure what the future of an ESCO holds for Bristol City Council interaction. It will very much depend on how the City Leap process plays out.

[yy] Essen is majority owner of Stadtwerke Essen. Main services of Stadtwerke Essen are supply of gas and water. Additional services are being developed. Essen is minority owner of RWE and of STEAG, two large ESCOs. See SCORE project. Renewable Energy Community as an ESCO with Essen being part owner.

[zz] In the description of model 8 "since the ESCO can exist in total independence from a municipality…" an independent ESCO is envisioned it seems. First point is that a "dependent" ESCO may be very useful for the municipality, land use advantages granted to commercial entities could be tied to ESCO connected EE or RE investment. Second point, an independent ESCO could also be very useful for decarbonization investments with clearly defined framework of action targeting for instance the urban building stock, even individual households. Aggregation brings efficiency gains and feasibility for the ESCO

[aaa] Model 2c combines public and private funding and this could be an example of a public-private collaboration model and a possible evolution of the interventions funding models. The city of Donostia/San Sebastián is working on the development of funding/financing models where the private funds are reinforced, so in this sense, other collaboration models are being analysed and implemented.

[bbb] It could be implemented in mobility sector (e-taxi fleet), while for buildings the national programs are more attractive.

[ccc] If used it would need to contribute to achieving the cities challenging carbon emissions reduction.

[ddd] Variant 2b is the case when private investors retrofit or buy other smart city goods and services without funding schemes. Hard to estimate: 5,000 cases a year on average at €3,000 each = €15 Million/year.

[eee] With Lausanne's future climate plan, these amounts should be multiplied by 4 for the period 2021-2015, or around €100 Million

[fff] Already quite widespread via special finance facilities made available to Turkey via WB and EBRD. The TURSEFF and TUREEF facilities have distributed around €400 Million in credit since 2016, at better than market conditions to end-users (SMEs, homes, others).

[ggg] The replication of the District heating system is being analysed, in a different scale. Taking into account the characteristics of the city of Donostia/San Sebastian the replication of the

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District Heating system at district level is not being considered currently since there are not new districts under construction (that was the case in Txomin district). Nevertheless, the replication possibility is being analysed for a District Heating system with different size and other characteristics. The financing model for the replication of the District Heating implementation might be the same or very similar to the one described above (3b) (taking into account that the size will be different). At this moment it is difficult to estimate the scale of finance for this intervention.

[hhh] SILFI has already extended the smart lighting to the whole city (investment of €8.5 Million) and will go on managing additional smart services as well as electric mobility public charge. Casa spa intends to implement the refurbishment plan of social housing in the metropolitan area, contributing to Florence sustainability and social targets.

[iii] Providing City Leap continues as anticipated, then 100% likely to contribute. Additionally, Bristol Waste and Goram Homes, both SPVs owned by Bristol City Council, conform to this model and are contributing to meeting the City's CO_2 targets.

[jjj] A more likely model would be municipality owned energy companies.

[kkk] The model 4a will be used in the future. In the next 5 years period the following activities are planned related to the high-speed mobile network: design and deployment of a communication network (cable or wireless) to provide connectivity to all public management devices for Water and Sanitation, Mobility, Traffic control, Security, Environment, smart pilot projects, etc. Definition and a deployment of communication nodes, supported on public network, to provide data and electricity with the purpose of facilitating the deployment of new generation networks by operators (especially 5G). Definition of the management model that allows the use of infrastructures and networks by operators. This is the scale of finance estimated until 2026: 500.000€ (2021), 1.000.000€ (2022), 1.000.000 € (2023), 500.000€ (2024), 250.000€ (2025) and 250.000€ (2026). The extension of a broadband or high-capacity network throughout the urban territory will provide an improvement in the management of all public services and this could improve the reduction in CO_2 emissions.

[lll] Perhaps later.

[mmm] Efforts are currently directed at the City Leap process.

[nnn] Although a future "Green New Deal" and other government post-Covid finance instruments in Asia could be a way forward.

[ooo] Model 5a, in which public external funds are received would promote the transition to electric buses of the municipal fleet. The current situation is that the price of the electric buses is almost the double of a diesel bus. Taking into account the current situation where the use of public transport has decreased (due to Covid -19) and so the profitability is getting worse,

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the balance between sustainability-climate change targets and the service continuity, is key. The city is analysing how to give answer to both issues. The aim of Dbus is to achieve the 100% of the bus fleet hybrid or electric by year 2030 so different models are being further analysed. The hybrid 12 meter-buses acquired have a cost of 287.000€ per bus.

[ppp] In case of public water – see details of loans and grants and investments at https://www.publiacqua.it/sites/publiacqua/files/bilancio_esercizio_2019_a.pdf

[qqq] Depending on outcome from the City leap process it might get explored as a possibility.

[rrr] €2 Million.

[sss] Possibly in the future.

[ttt] Maybe later on, when the green bonds EU framework will be more defined.

[uuu] Smart city ambitions include carbon emission reduction as it is a part of our corporate and One City Strategies. Bristol has an ambition for the city to be carbon neutral by 2030 and developing a low-carbon and sustainable city will enhance Bristol's ability to remain competitive in the global economy and be more resilient. Smart technologies have an important role to play in reducing carbon emissions and are becoming more commonplace.

[vvv] Although some projects in the city do use this model.

[www] It could be in use when business models are not that attractive and people could support the implementation for other purposes (social, cultural, environmental…).

[xxx] Very possibly – in R&D phase though so unsure of what scale of finance just yet.

[yyy] In the case of building retrofitting.

[zzz] In the case of buildings refurbishment, it will be one of the most popular models. It is foreseen to have investments for more than €100 Million in the private buildings sector within 2030.

[aaaa] Given that Bristol Energy has just been sold this seems unlikely, but depends on progress with the City Leap process.

[bbbb] €50 Million/year.

[cccc] The Nilüfer SEAP has estimated €300 Million investment in the first year in this area. Low hanging fruit would be the first step especially related to public buildings energy efficiency projects

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8. Review of the REPLICATE Business Models

8.1 Net Present Value Analysis (NPV)

The Data Canvas framework originally set out in D7.1, "*Report on peer-review methodology including templates and supporting materials*" (pp21-23) and subsequently updated in D7.5, "*Report on management models v2*" (pp12-103) contributed to the analysis in this Deliverable. Specifically, data for each action on Financing – e.g., CAPEX and OPEX, Source of Financing, Operational Lifetime, and Annual Revenue – and also Market Analysis, where data on costs savings were available. However, as an indication of the problems associated with determining return on investment (that is, NPV) is that of the 37 actions analysed in D7.1 (pp 50-200) and subsequent revisions of the information in D7.5 (pp12-103) only 8 interventions (highlighted green) had complete-enough data to do the calculation. However, it should be noted that a number of interventions reported by San Sebastian indicated financing by amortization suggesting debt financing.

The NPV position is summarised in Table 10. In this table[9], Revenues could also be cost savings, as these can be considered as revenues according to the portfolio model if they accrue directly to the municipality (e.g., electricity saved from installing LED lighting) rather than passing directly back to the citizen (e.g., cost savings due to reduced energy use arising from retrofitting or connection to a district heating system).

[9] Note that CAPEX, OPEX and Revenue figures have been rounded to nearest €1,000 and presented using a UK style i.e., with the € symbol first and using M to denote millions, and k to denote thousands. Note that later in the Deliverable Bn is used to indicate billions.

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8.2 Data for Table 10

#	Action	CAPEX[a]	OPEX[b]/yr	Lifetime (yrs)	Revenue[c]/yr	NPV[d,e]
San Sebastián						
1	Building Retrofitting	€4.15M[f]	€72k (D7.1, p53)	various[g]	Direct[h]	-
2	District Heating[i]	€3.443M[j]	100% subcontracted	various[k]	Direct[l]	-
3	Smart Public Lighting	€385k (D7.1)[m]	€150k (D7.1)	various[n]	€13k (D7.1)[o] €14k (D7.5, p37)	-
4	High-speed wireless connectivity	€410k (D7.1) €400k (D7.5, p71)	-	-	Various[p]	-
5	EDMS[q]	-	-	-	-	-
6	Electric buses and recharging infrastructure	Cost of each e-bus: €520k[r] Cost of recharging stations: €34k Cost of each new battery: €220k	-	7[s]	Various[t]	-
7	E-taxis	No direct funding[u]	-	-	Various[v]	-
8	EV Recharging	2 recharging points: €34k each[w]	-	-	-	-

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#	Action	CAPEX[a]	OPEX[b]/yr	Lifetime (yrs)	Revenue[c]/yr	NPV[d,e]
9	Municipal EV and e-motos fleet	E-vehicles: €82k[x] E-motos: €16k	-	8[y]	Various[z]	
10	Smart Mobility Platform	€400k (D7.5, p61)	-	-	-	-
11	Smart City Platform (SCP)	€280k	Personnel costs[aa]	-	-	-
12	Linked Open Data	-	-	-	-	-
13	Big Data for Mobility	€300k (D7.5, p64)	-	-	-	-
14	Citizen Participation Platform	-	-	>5[9]	-	-
Florence						
15	Building Retrofitting	€1.500M[bb]	€0	>20	~€60k	(€417k)
16	District Heating with RES & TES	>€3.500M[cc]	-	>20		
17	Smart Public Lighting	€1.5M (D7.5, p39)	Negligible	10	€394k (NC)	€4.610M
18	Smart Grid/Resilience	€600k	-	15-20	Direct[dd]	-
19	EDMS/Smart info	€60k	-	3-4	Direct[ee]	-
20	E-Taxi/Fast Recharge	€370k (D7.5, p47)[ff]	Complex	5-8	(€75k)[gg] (D7.5 p47)	-
21	E-Mobility Promotion	€200k (D7.1)	-	5-10	0.0 (D7.1) Direct for drivers	-
22	Smart City Control Room	€800k[hh] (D7.5, p90)				

#	Action	CAPEX[a]	OPEX[b]/yr	Lifetime (yrs)	Revenue[c]/yr	NPV[d,e]
23	Active Citizenship	€50k	-	-	Direct	-
24	IoT Developments	€74k	€700	5	Various[ii]	-
Bristol						
25	Energy Retrofitting & Smart Homes	€2.110M	Direct	5[c]	Direct	-
26	District Heat Network	€1.298M	Negligible	>15-20	€193k[jj]	0.0[h] Break-even
27	Community PV	€562k -€674k (D7.1)	€10k (D7.1)	20-25	€11k[kk] (D7.1)	(€580k) – (€692k)
28	Smart Connected Homes	-	-	5	-	-
29	EDMS	-	-	-	-	-
30	Active Citizenship	Complex	-	-	-	-
31	Smart Mobility (parking)	Complex	-	-	-	-
32	Smart Mobility (e-bus)	0.0 (lease)	€216k (D7.1)	5[ll]	€270k NC	€261k
33	Smart Mobility (e-bike)	0.0 (lease) NC	-	-	-	>€0k[mm]
34	Smart Mobility (e-cars)	-	-	-	-	-
35	Smart Mobility (journey plan)	-	-	-	Direct	-
36	EV Charging	€2.912M (D7.1)	€243k (D7.1)	5[m]	€843k[nn] (D7.1)	0.0[m] Break-even
37	EV Promotion	€56k (D7.1)	-	-	-	-

Table 10. Data extracted from D7.1 (pp51–201) relevant to a determination of NPV for an intervention/action.

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[a] The amount shown excludes any direct grants to the intervention provider or recipient. However, where this exists, the figure is shown in italics.

[b] Where OPEX is to be funded directly by the recipients of the intervention this is shown as 'Direct'.

[c] Or cost savings, as these can be considered as revenues according to the portfolio model if they accrue directly to the municipality (e.g., electricity saved from installing LED lighting). Where savings accrue to the recipient of the intervention (e.g., cost savings due to reduced energy use arising from retrofitting or connection to a district heating system) then these are shown as 'Direct'.

[d] Assuming an almost negligible hurdle rate of 1%

[e] The return period has been set to be the same as the operational lifetime, but in practice could be longer

[f] €1.336 M from REPLICATE, €2.000 M from Basque Government and €810k from residents – funding through Best Tables.

[g] Different parts of the retrofitting have different lifetimes.

[h] District heating and domestic hot water, saving on expenses, reduction in CO_2 greenhouse gas emissions, reduced noise and increased efficiency, improvement in the energy rating, buildings with homogeneous aesthetics integrated with newly built homes and revaluation of housing.

[i] Since October 2008 the total investment on the District Heating has been €3.443M. From this amount, €726k is the amount received from the REPLICATE project, €1.597M resources from the city council, €75k funds obtained by another public entity and €1.045M private funding coming from the operator.

[j] €726k is the amount received from the REPLICATE project, €1.597M resources from the city council, €75k funds obtained by another public entity and €1.045M private funding coming from the operator. Funding through amortization

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[k] There are 3 different periods of amortization depending on the control systems, pipes central building etc. Control systems: 5 years. Pipes & Infrastructures: 20 years. Equipment: 10 years

[l] Heating available 365 days a year 24 hours a day, lower risks as there are no combustion elements in the building, closer Forest biomass, monitoring, platform that can be accessed by users, reduction in CO_2 greenhouse gas emissions.

[m] Funding through amortization

[n] Each part of the lighting system has a different lifetime

[o] Consumption reduction, Economic savings due to consumptions and maintenance costs reduction, Management improvement

[p] Management improvement, Maintenance cost reduction, Service improvement, Improvement on the network capacity to support municipal service, CO_2 emissions reduction, Consumption reduction, Noise reduction

[q] Energy Demand Management System

[r] Funding through amortization

[s] Batteries lifetime (new models): 7 years

[t] CO_2 emissions reduction, Consumption reduction, Noise reduction

[u] Funding through monitoring

[v] CO_2 emissions reduction, Consumption reduction, Noise reduction

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[w] The recharging infrastructure of the e-buses has been deployed with REPLICATE funding. The recharging infrastructure in underground parking, gas stations etc. in the city has been deployed without REPLICATE funding. The recharging infrastructure is necessary for the promotion of the electromobility in the city and contributes to the revenues related to the electrification of the vehicles. The recharging infrastructure is necessary for the promotion of the electromobility in the city and contributes to the revenues related to the electrification of the vehicles.

[x] For E-motos ~€9k from REPLICATE, for E-Vehicles ~€40k€ funding from REPLICATE. Funding through amortization.

[y] E-motos: 8 years amortization period; E-Vehicles: 8 years amortization period.

[z] CO_2 emissions reduction, Consumption reduction, Noise reduction, Maintenance cost reduction

[aa] 2 people have been hired

[bb] There is a national incentive around 10%

[cc] This is the total cost of the intervention. REPLICATE grant €2.000M, but also national incentives active on these measures >€1.0000M aren't reported

[dd] Service providers, users

[ee] Users' savings

[ff] For the fast stations; €2k for the e-vehicles

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[gg] Shown as negative because the e-taxi licence fee is reduced to €175k from the normal amount of €250k. These have been additional licences that wouldn't have been distributed if the e-mobility action were not activated. For municipality 'Direct' for the infrastructure manager (TBD), 'Direct' for taxi drivers (savings on licence costs, discount on e-vehicle, maintenance savings and savings on fuel costs.

[hh] Estimated market value

[ii] Benches none. Waste TBD (collection). Irrigation TBD (-30% water consumption).

[jj] This was calculated by setting the hurdle rate to 8% (D7.1, p136) and goal seeking to set the NPV to zero assuming a payback period of 15 years.

[kk] Is this correct, given that OPEX is €10k?

[ll] Assumed. However, NPV will always be greater than zero using the OPEX and Revenue figures given.

[mm] Assuming rental income exceeds the lease charge.

[nn] Calculated by using the default hurdle rate and goal seeking to set the NPV to zero and assuming a payback period of 5 years (D7.1, p195).

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The following Sections 8.3, 8.4 and 8.5 provide a further commentary on Table 10 and consider the complexity of the situations in each city where data are incomplete or missing (indicated by dashes in Table 10) or where the benefits from interventions/actions/measures funded by the municipality accrue directly to the citizen or the intervention provider, thus making it difficult to assess the overall replicability of the business model, on any grounds.

8.3 San Sebastián Business Models

8.3.1 Energy

The District Heating scheme in San Sebastián is innovative…

> "*…because of the business model implemented. Fomento San Sebastian and the Municipality agent own the District Heating, and consequently the policies that will govern the operation of the systems will be public. In fact, the DH development project is also highly innovative for the city and region, as it is the first publicly owned DH system in the Basque Country.*" Deliverable D3.3, Report on the District Heating Construction

Also considered innovative as it is quite different from more traditional "*concession formats*" (D3.3, p17,52). In this regard, the direct public ownership of an infrastructure illustrates the need for the municipality and/or its subsidiary companies (e.g., FSS in this case) to directly raise capital, especially as FSS is considering the possibility of replicating this approach in other areas of the city. In terms of increasing <Portfolio Revenue> and illustrating how potential co-dependencies between actions impacts replicability, the analysis of the potential for Biomass, D3.2, "*Study of Biomass resources in Ametzagaina Park*", as a sustainable fuel for the DH system concluded that it would not be financially viable. On the other hand, the domestic retrofitting program undertaken in Txomin Enea (D3.1, "*Buildings retrofitted*") included connecting to the DH system at the same time as the retrofitting activities. Capital expenditure that would have been associated with the DH system installation and connection was thus reduced.

The public-private financing mechanism used for the DH pilot demonstration in the REPLICATE project is presented in Section 7, Model 3b. The <Capital Expenditure to Intervention Providers> is provided by a combination of financing from the REPLICATE project budget (~20%), the Municipality of San Sebastián (50%) and the remainder from a consortium formed of Ferrovial Servicios S.A. and Tecnocontrol Servicios S.A. (~30%) (D3.3, "*Report on DH construction including the maintenance program*", p20-21). The completed DH system would

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then be rented to contracted company who would maintain and operate the system on behalf of FSS, who would also maintain an oversight by ensuring strict adherence to SLAs.

8.3.2 Mobility

> "*Municipalities and transport authorities must base their investment decisions on the best available data which usually focuses solely on direct financial costs. Costs related to environmental and social impacts are rarely factored in because relevant data is not easily available. However, we are including here the results of the partnership between Volvo Group and KPMG, in order to give an understanding of how things change if societal costs are built into the cost of ownership, before comparing different transport solutions, such as diesel, biogas and electric buses.*" D3.5, Electric Bus Line Report

The TCO analysis from KPMG illustrates the point made above in Section 5.7 and the use of the model in Figure 5, where it is stated that…

> "*…the TrueTCO of an electric bus is higher than that of a diesel bus when only direct financial costs are taken into account. The bar on the far right shows that the TrueTCO of an electric bus is lower than that of a diesel bus when the costs of environmental and socio-economic impacts are considered.*" D3.5, Electric Bus Line Report p35

There has been a poor uptake of electric cars, as previous schemes have been directed towards renting or sharing rather than ownership. Barriers include overcoming user awareness of limitations of the technology, higher initial ownership costs, and problematic charging network (D3.7, "*Report on the deployment of charging infrastructure in the city of San Sebastian*", p17-18). Also, since personal vehicle use is being discouraged in San Sebastián the EV investment in San Sebastián has been directed towards municipal vehicles, such as cleaning vehicles and police cars and especially buses and e-bikes (D3.6, "*Report on the deployment of EVs in the city of San Sebastian*").

However, the focus here is on the business model of the EV charging network as this is a significant obstacle to overcome, it is also an example where National regulation has mandated that an EV charging service must be provided by the private sector, not the municipality. However, since poor uptake means little financial incentive for the private sector to invest in the EV charging network build-out there still remains a role for the municipality, but only where the municipality has any degree of control, which is principally linked re-charge (e.g., public car parking) and emergency re-charge points. There is some ambiguity about whether the municipality is able to subsidise the price of re-charging (D3.7, "*Report on*

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the deployment of charging infrastructure in the city of San Sebastian", p20), and recent regulatory changes about the role of the "*charge manager*" as sole responsible party legally permitted to re-sell electricity means that clarity on the business model for re-charging is lacking. At the moment, Model 1, Model 2, and Model 7 in Section 7 cover the current situation for investing in charging infrastructure.

8.3.3 ICT

D3.8, "*Report on the use of the ITS*", clearly indicates the centrality of the Mobility Platform (MP) in delivering on the promise of Intelligent Transport Systems (ITS) and urban mobility management in San Sebastián. The MP is central to providing data integration from sensors (e.g., IoT) and support for Big Data and generation of business intelligence and decision support for the municipality. The layered architecture conforming to open standards enables extensibility and thus easy development of new applications and their integration into the platform. The development of a MP, and by extension other instances of Smart City Platforms (SCPs), will need to be financed as a necessary infrastructure without a viable business model – see Model 1d in Section 7.11.2. This is also supported by data collected as part of T2.3 and reported in D2.3, "*Internal Report on Findings*".

The Municipality's potential for monetising data from the mobile network via Euskaltel, as a Mobile Virtual Network Operator (MVNO), is envisaged by extracting information from mobility analytics algorithms which can then be used to reduce costs on the deployment and management of (other) infrastructures (D3.9, "*Use of Big Data for mobility services*", p40). This corresponds to the Municipality using this capability to, in effect, boost <Income from the Portfolio>, because costs will have been reduced elsewhere.

Similarly, the deployment of network infrastructure to

> *"…provide a future proof backhaul platform that will be able to provide several and very different services from the lighthouses cities to the final users such as citizens, small business and other services providers.*" D3.10, p7

Based on WiMAX technology this solution has *"…low infrastructure costs and wireless last mile connectivity yield a payback in terms of months*" (D3.10, P30). Again, the ICT as deployed here, through a quick return on investment, is able to provide an asset into a portfolio that boosts <Income from the Portfolio>.

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Finally, the analysis of existing public street lighting in San Sebastián shows an annual energy consumption of €3M and a €1.774M annual maintenance charge, which could be reduced by replacing existing lamps with LED lighting and introducing intelligent lamp posts[10], the former offering a simple return on investment to calculate and the latter contributing to boost <Income from the Portfolio> through the provision of data into a SCP.

8.4 Florence Business Models

The structuring of the Florence deliverables D4.1, D4.3, D4.5 and D4.10 into an overall account of the collection of mobility and energy actions suggests a portfolio view consistent with an allocation and impact annual report to investors. Furthermore, the public tendering process in Italy places a strict requirement that the finance for a procurement must be in place (i.e., "*in the cash*") before issuing the tender document (D4.3, p64)

> "*When the economic / financial aspects will be approved, it will be possible to proceed with the public tendering: according to the national law, all the amount of the project is supposed to be "in the cash" of the city before publish the public tender*" (D4.2, p23)

Suggesting the sequence of raising finance then disbursement is similar to the idea of "*use of proceeds*" (International Capital Markets Association, 2016). Considering the interdependence of actions is also important. D4.10 refers to energy efficiency (retrofit), renewable energy integration, electric mobility and the ICT Platform and smart lighting as 'synergic' (D4.10, p11).

The following documents are referenced for the energy and mobility sections below. The individual reports contributing to Section 8.4.3 are referenced separately.

1. D4.1, "*Reporting on the state of the implementations in energy pilot actions WP4*"
2. D4.2, "*Pilot action measures advancement sheets V1*"
3. D4.3, "*Pilot action progress report year 2*"
4. D4.4, "*Pilot action measures advancement sheets V2*"
5. D4.5, "*Pilot action progress report year 3*"
6. D4.10, "*Florence pilot action publishable report*"

[10] With a range of smart technologies including radar detectors, video cameras, audio units, Wi-Fi hotspots, rain sensors and vehicle counters.

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8.4.1 Energy

The main barrier to the retrofitting action in Florence is the "very high" cost of installation (D4.2, 18), and that subsidies are only paid after the work has been completed. Thus <Capital Flows to Intervention Providers> are high and since benefits accrue to the household not the municipality there is no corresponding <Income from Portfolio>. Retrofitting is thus one of the most significant burdens on a portfolio of interventions should a municipality chose to take on the responsibility of financing them, in full or in part. However, subsidies from the National Government do exist such as the

> "*"Conto Termico (CT) 2.0", which funds 40% of the insulation with some limitations on the amounts due to the project and the funding coverage*" (D4.5, p12)

However, the national schemes that exist in Italy (D4.10, p26) – i.e., "thermal account", "white certificates" and tax deductions (up to 65%) – are all variations of Model 8 in Section 7.10, where these capital flows direct to intervention providers are essentially bypassing the municipality, and thus does not appear in the model in Figure 4. They potentially reduce the amount of <Capital Flows to Intervention Providers> and therefore some estimate of this direct funding amount needs to be made, see the research question raised in Section 13.3.

The national roll out of smart meters (D4.10, p27) illustrates another national level intervention funded via the National Authority for Electricity and Gas that offers direct benefits to consumers and DNOs (D4.10, p27) and therefore fall outside of the scope of the model shown in Figure 5.

Overall, the lessons learned from the energy actions pertain to reducing <Capital Flows to Intervention Providers>. For retrofitting the approaches to cost minimisation include tailored modelling and simulation to more accurately predict installation costs (D4.10, p14). In the case Thermal Energy Storage (TES) an indication of an annual income of €60k over the expected lifetime of 20 years needs to be put in the context of the capital expenditure of €1.5M (D4.2, p19). Even assuming an almost zero hurdle rate (WACC) of 1% gives a NPV that is *negative* by €417k. This shortfall will have to be found by the Municipality. However, the NPV is in practice more difficult to evaluate and may in fact be worse than this due to the complexities encountered during construction (D4.10, pp25-26).

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8.4.2 Mobility

For EV charging, the high costs of installation can be offset if planned as part of a wider active demand management strategy in partnership with the DSO (e-distribuzione) (D4.10, p15) and regard to obtaining the best supply tariff (D4.10, p16), which has the real effect of increasing <Income from Portfolio>. Sharing the capital expenditure financing with the DSO and co-finance by the Regional Government (D4.3, p47) reduces the effective <Capital Expenditure to Intervention Providers> that needs to be found by the municipality (D4.2, p69). For the DSO

> *"…its investments allow to increase the RAB (Regulatory Asset Based) value and it receives a remuneration in tariff for the part of costs that are not funded*" (D4.2, p52)

Which therefore takes place outside the scope of the portfolio model shown in Figure 5.

Grants to e-taxi drivers, in the form of reductions in license fees to increase uptake of EVs, represent a reduction in <Income from Portfolio>, but incentives to enable uptake i.e. reductions in insurance costs and exemption from Vehicle taxes for 5 years (D4.2, p68) takes place outside the scope of the portfolio model in Figure 5. However, increases in the use of EV charging points offer opportunities for further tariff negotiation and demand management offsets with the DSO.

8.4.3 ICT

The SCP can provide a data integration point for electricity demand management in the case of EV charging data but also a much wider integration role for IoT data coming from smart bins, smart benches, smart irrigation, which open up opportunities for either reducing service costs or introduction of new services delivered through conventional channels or new Apps (D4.10, p21-22; D4.9). The establishment of the public company "Common Line" in 2006

> "…*with the aim of managing and further developing the eGoverment multi-channel platform 055055.it. Common Line manages a common single platform providing hundreds of online services of eGovernment to more than 30,000 registered users, with more than 400,000 accesses a year to online services*" (D4.10, p30)

handles more than €12 Million transactions per year and provides a citizen facing delivery point for services derived from data in the SCP.

Integrated traffic management and mobility applications can also be integrated.

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The installation of Smart Lighting (D4.10, p23) primarily offers a clear business case if at the time of installing sensing devices and traffic access control points the light source is replaced by LEDs. Initial <Capital Expenditure to Intervention Providers> is recovered by what is in effect a real increase to <Income from Portfolio> arising from the reductions in the overall energy costs for public lighting. However, the revenue from the smart IoT devices installed on the lampposts is "*depending on the additional services and the use of the data collected*" (D4.2, p42).

Despite its centrality there is still no clear business model for the SCP. However, EU and National programs "(UIA, PON METRO, ...)" are designed to support SCP developments. Expectations are high…

> "*Between 2016 and 2020, the EU expects the market size to increase by 36.9%, to a value of 75.7 billion EUR in 2020.*" (D4.6, p41)

However, market projections are properly the concern of Work Package 9, except that the same EU source talks about €1.7Billion costs savings to be made across Europe from these investments. However, the ROI is clearly poor. D4.7, Replicate Platform, provides a clear articulation of the enablement offered by the APIs supported by the Florence SCP (D4.7, Table 1).

According to D4.9, REPLICATE APPs V, App development in Florence is seen as having no revenue potential

> "*From the economic perspective these apps are intended for being used as complementary to environmental programs in local governments (municipalities, regions, etc.) therefore no direct economic revenue from the final users is foreseen*" (D4.9, p27)

E-mobility promotional measures and Active Citizenship Apps incur costs i.e. <Capital Expenditure to Intervention Providers> but no clear indication of possible revenues (D4.2, pp80-81, 87). Other smart IoT devices, e.g., smart bench, smart waste bins, also incur costs i.e. <Capital Expenditure to Intervention Providers> but again with no revenues indicated (D4.2, p94).

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8.5 Bristol Business Models

8.5.1 Energy

The calculation of the funding to offer for energy improvement actions in the Bristol households included in the pilot was based on the use of Building Energy Specification Table (BEST) calculations of the expected kWh/m^2 savings expected after installation. The energy improvement actions considered included loft insulation, replacement boilers, LED lighting, and solar PV. The funding offered to households was up to 90% of the costs for insulation, 25-90% for boilers, and 40-60% for the solar PV.

Clearly, returns from these capital investments will always be realised by the households, not the municipality. From the perspective of the model in Figure 4, these represent *capital flows out of the system* as <Capital Expenditure to Intervention Providers> with no corresponding boost to <Income from Portfolio>. Therefore, a critical decision facing a municipality is how much will these one-way capital flows need to feature in order to make a significant contribution to a city meeting its climate targets and what model for financing will work? Specifically, for Bristol, will the City Leap process, Model 3 in Section 7.5, contribute here?

For the specific case of Solar PV there is also the complication of Feed-In-Tariffs (FITs). Again, these do not boost a municipality's <Income from Portfolio>, since the financial benefits accrue to the householder, but their level (or existence) does affect the householders' decision-making and therefore how much investment the municipality believes is a necessary subsidy to stimulate action. How a national FIT affects decision making is highlighted in Bristol by the following

> *"One of the key incentives in the past for solar PV installations was the UK Feed-in-Tariff which bought solar produced energy at a cost per unit when fed back into the grid. This enabled solar PV systems to pay for themselves much quicker and also accelerated the number of homes installing solar PV. This ended in April 2019 without a replacement coming into force until January 2020, and as a lot of homes were aware of this incentive, it did prove to be a stumbling block for certain homes who decided to not proceed to installation." D5.1, p40.*

D5.1, "*Retrofitting in the neighbourhood partnership area of Ashley, Easton and Lawrence Hill*", p45, reinforces the view that subsidy is necessary as a grant to the householder in order to stimulate uptake of these types of domestic intervention. The question is how much this should be as a percentage of the total cost, and how much this is affected by the existence of

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grants from national or regional governments and also whether FITs exist and their level? The REPLICATE project has found that in Bristol this range is quite wide i.e., 25-90%, depending on the intervention.

The connection of flats to a district heating system described in D5.2, "*Connection of a 13 block (700 flats) district heating network to a gas CHP energy centre*", involves connecting a new gas-fired CHP with an existing biomass CHP and enlarging the scope of an existing network. The tendering process for this complex infrastructure procurement was complicated and required iteration to eventually arrive at form of contract[11] that would minimise the <Capital Expenditure to Intervention Providers>. The corresponding <Income from Portfolio>, will arise from Heat Sales (D5.2, p7) although it is unclear at present at what sort of level compared to the capital invested.

The energy demand platform reported in D5.3, "*Energy Demand Platform Deployed to Monitor Energy Generation and Demand"*, is an example of leveraging an arbitrage opportunity implemented as an Energy Demand Management System (EDMS). The business model arises from the possibility that electrical demand at a community level can be aggregated and potentially managed in such a way as to offer a demand management capability that is attractive to a DNO. In exchange for favourable tariffs[12], the owner of the EDMS must take control over the switching on and off of household white goods. How this arbitrage model is covered by Model 3 in 7.5 or Model 8 in Section 7.10 is open to interpretation. The EDMS is ideally implemented via connection to a SCP (D5.3, p14). This would then offer the possibility of further scale up e.g. by aggregating demand from, and control over, an EV charging network, which was discussed in the context of the Bristol pilot (D5.3, p42, p54). Further, this would also provide an integration point for a wide range of businesses, especially SMEs, to access data and develop further commercial services (D5.3, p56) e.g. as discussed below in the case of extracting information from journey planning Apps to optimise EV charging. The income from the arbitrage would boost <Income from Portfolio> as well as avoiding the unnecessary costs arising from having to deliver solutions that have to be robust to worse-

[11] In this case a NEC (New Engineering Contract) option C (Target Cost) contract "*as this form of contract generally works well with projects that have an unknown quantity of changes*" (D5.2, p12)

[12] The arbitrage arises in effect because the owner of the EDMS would be buying electricity in a *different market* to that available to individual domestic consumers, i.e., wholesale compared to retail.

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case energy use scenarios (D5.3, p55). In effect the deployment of an EDMS can reduce <Capital Expenditure to Intervention Providers>.

8.5.2 Mobility

The e-Bike mobility solution in Bristol reported in D5.4, E-bikes Deployed in a Corporate Scheme, provides a detailed breakdown of costs, that is <Capital Expenditure to Intervention Providers>, in the case of a wholly owned solution, but is yet to ascertain revenues i.e. <Income from Portfolio>. In the case where the e-Bikes are leased then the <Income from Portfolio> should be positive so long as the rental charges to users exceed lease charges – which they should do as this is another example of a wholesale arbitrage model, although it is unclear what its relationship would be in relation to Model 3 in 7.5 or Model 8 in Section 7.10. The car club solution – D5.5, Car Club expanded with ten Electric Vehicles – although not explicit about capital investments, seems to suggest a similar arbitrage business model to e-Bikes and indeed states that

> "*We consider that the success and organic growth of Co-wheels has provided significant experience in optimal set-up for running a viable and self-financing scheme.*" (D5.5, p32)

The success of an on-demand e-Minibus – D5.6, On-Demand EV Minibuses (Buzz) Deployed, was critically dependent on sourcing the necessary vehicles. The business model explored the need for financial subsidy to make it viable. From the portfolio model view this subsidiary can take two forms; either i) the requisite contribution to <Income from Portfolio> for this type of on-demand e-vehicle solution can come from a per-journey subsidy (D5.7, p17), alternatively ii) pump-priming can be seen as a contribution to <Other Sources of Capital Investment> (D5.7, p18); there is also no reason why these cannot be combined. Both these approaches can be incorporated into either Model 3 or Model 8

The enablement of journey planning Apps, e.g. through connection to data available via a SCP, and the potential to return valuable information about intended journeys back into the SCP, illustrates the sort of service ecosystem that can emerge from the investment in a SCP (Yoo, Henfridsson & Lyytinen, 2010). In D5.8, the Travelwest Journey Planner is described. This provides an example of how an App can be developed that offers a benefit to an individual traveller but also an aggregate cumulative benefit to a city in terms of reduced emissions. In future, either

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I. Municipalities make their own investment in terms of <Capital Expenditure to Intervention Providers> to create journey planner Apps that generate <Income from the Portfolio> for the municipality and/or reduce <Other Sources of Capital Investment> e.g., by reducing up-front capital expenditure investments such as the example cited of San Francisco instrumenting 6,000 parking bays at a cost of $23M (D5.8, p22), or
II. Apps emerge in the service ecosystem, predicated on the fact that there is some value in the data contained in the SCP that can be monetised, or that the journey planning App can monetise the data it collects from travellers.

There is a strong assumption about the necessity of the SCP in this second case, which leads on to a discussion of the contribution of the SCP to the business models presented in Section 7.

8.5.3 ICT

The development of the SCP in Bristol is described in D5.9, "*Development of ICT Smart City Platform concept and of integration of demonstration IT Systems"*. Investment in an SCP, which entails <Capital Expenditure to Infrastructure Providers> opens up the…

> "*…ability to deliver dynamic, real-time city management across key areas such as transport, energy and safety is a key strategic objective as we recognise that more effective city management will lead to better outcomes for citizens and reduced service delivery costs.*" (D5.9, p9)

These expected reductions in service delivery costs can be thought of as a real <Income from Portfolio>. Therefore, a return on investment in SCP developments can be calculated, but this requires the viewpoint of the model presented in Figure 5. Incorporating innovations such as Software Defined Networks (SDN) and conforming to open standards such as FIWARE should contribute to lowering the <Capital Expenditure to Infrastructure Providers> of future SCP developments.

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9. Mapping Interventions to Financing Mechanisms

This final Round of data collection for Task 2.4 addressed the mapping of interventions/actions/measures to possible future financing mechanisms. Based on the familiarity of the VCE models established in the first two rounds of the data collection exercise the intention was to identify which mechanism(s) would likely be used in each city to source the capital investment required for a range of interventions/actions/measures. There was a single time horizon for this mapping that matched the scope of the questions in the Round 2 document – that is, the next 5 years immediately post REPLICATE 2021-2025.

Each city the REPLICATE project was posed a hypothetical question – to consider the scenario that were the municipality to face the necessity of having to initiate a similar range of projects as instigated across the pilot cities in REPLICATE, but this time without the benefit of SCC1 funding, what would be the primary or main source of capital investment? Based on this choice, which of the 8 VCE models (plus variants) in the Round 2 Document would this source correspond to, if any? The intention was to capture the realm of possibility, to stimulate the widest possible investigation of financing mechanisms and thus replication.

The list of interventions/actions/measures is derived from the sum of all those funded during the REPLICATE project across the three pilot cities was compiled. All the cities were invited to contribute data into in rows 16 onwards in the Tables in Sections 9.1 to 9.6 concerning any significant further Interventions/actions/measures being considered by the municipality that would either i) help illustrate sources of capital investment that would be different from the interventions/actions/measures listed in rows 1-15, or ii) draw attention to interventions/actions/measures not considered in the REPLICATE project but could be financed by any of the VCE models considered. Bristol returned data against this question and offered examples of community renewable energy and electric mobility solutions more appropriate to Bristol's geography. Electric mobility solutions are already in place in Florence and San Sebastian with e-taxis in both cities. In San Sebastian e-buses (and also micro e-buses) lines are being reinforced with new electric vehicles, and also the existing e-bikes network has just been expanded all around the city. In addition, community renewable energy is also under analysis in San Sebastián even if in Spain the European law is expected to be revised next summer 2021.

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9.1 San Sebastián[13]

	Action (Intervention)	Primary source of capital investment	Applicable VCE Models
1	Building Retrofitting (domestic)	For the retrofitting action deployed in the project the main source of capital comes from REPLICATE and the Basque Government[14], with the additional contribution from home owners. The ESCO	1c, 7, 8

[13] Fomento San Sebastián works for the economic development of the city and so the economic sustainability is key in the development of the activities, this is why several collaboration models are in use and the analysis and promotion of these collaborations will continue in the future. The city of San Sebastián will continue working on public on public-private collaboration models in order to guarantee the economic sustainable development of the city. In Table 11 the most probable models to be used in the short term are included as well as some other models that could be also used, nevertheless, further analysis is required to validate them. The city also works in the development of other innovative collaboration and business models that might contribute to the financing of the implementations and to the creation of innovative business models.

[14] There is an important funding from EU through Replicate and an additional funding has been obtained afterwards by FSS through negotiations with the Basque Government. One part of the investment is covered by the owners (citizens) and some could follow the ESCO model even if it has not been the main solution chosen by dwellings.

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		model designed is not so common for the citizens involved, nevertheless it should be appropriate for replicated interventions. For the scale up and replication of this action it is expected to increase the private funding contribution, establishing other collaboration models.	
2	Building Retrofitting (public)		1, 2, 7, 8
3	District Heating (CHP)	The investment in the District Heating system comes from the own funds of the City Council in first place (46,5%), from the investment from the private operator in second place (30,5%) and the public funds in third place (23%). Other models such as ESCO models might be possible.	3b, 8 (possibly)
4	District Heating (TES)		
5	Energy Demand Management Systems (EDMS)	n.a	

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6	Smart Grid & Related	n.a	
7	Electric Buses	The acquisition of the two electric buses has been mainly funded by Replicate. The hybrid buses in the city have been acquired with own resources or funds from other entities.	5, 5a, (6 possibly)
8	e-Taxis	The agreements signed between San Sebastian City Council and the taxi drivers have promoted the acquisition of electric vehicles for the taxi service.	1+variations 2+variations
9	e-Bikes		5+variation.
10	EV Charging Infrastructure	The recharging infrastructure in underground parkings, gas stations etc. in the city has been deployed without Replicate financing.	1,2,7
11	Smart City Platform (SCP)	The funds from REPLICATE project have boosted the implementation of a smart platform at city level and have been the main funding stream in the first years of its implementation. From 2021 onwards, the	1d (other possibilities not modelled)

		main capital investment source will be the own resources of the City Council.	
12	IoT Sensor Network	n.a	
13	App Development	n.a	
14	Smart Lighting	TBC	1e, 5, 8 (and variations)
15	High-Speed Wireless Connectivity	Main capital investment came from own resources, the funds coming from Replicate have been significant during the project lifetime, however, the action was in operation before and will continue in the next years.	4a (others possible)

Table 11. Mapping of interventions to applicable VCE models for San Sebastián

9.2 Florence

	Action (Intervention)	Primary source of capital investment	Applicable VCE Models
1	Building Retrofitting (domestic)	ESCOs, Banks also exploiting public funds (110%)	2,8, (5)

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2	Building Retrofitting (public)	ESCOs or public (rotation fund)	1,8,3a[15]
3	District Heating (CHP)	Public (national)/ESCOs	1,3,8
4	District Heating (TES)	Public (national)/ESCOs	1,3, (5,8)
5	Energy Demand Management Systems (EDMS)	ESCOs and energy providers	3,8, (4)
6	Smart Grid & Related	Private	1,4
7	Electric Buses	Public (municipal, regional, national) already foreseen in SUMP/private of the PT company	1,2
8	e-Taxis	Private	2, 1
9	e-Bikes	Private	2,8
10	EV Charging Infrastructure	Public/private	3, 4
11	Smart City Platform (SCP)	Public/private (public services providers)	1,3,4
12	IoT Sensor Network	Public/private	1,3,7

[15] For social housing

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13	App Development	Private or public	1,3[16], 8[17]
14	Smart Lighting	Public (rotation fund)	3
15	Public WiFi	Public	1,3

Table 12. Mapping of interventions to applicable VCE models for Florence

9.3 Bristol

	Action (Intervention)	Primary source of capital investment	Applicable VCE Models
1	Building Retrofitting (domestic)	Public / Private	1 & 3a
2	Building Retrofitting (public)	Public / Private	3a
3	District Heating (CHP)	Public / Private	3a
4	District Heating (TES)	Public / Private	N/A currently but possibly 3a
5	Energy Demand Management Systems (EDMS)	Private / ESCO	3a, 8

[16] Mobility
[17] Energy

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6	Smart Grid & Related	Private / ESCO	1, 3a, 8
7	Electric Buses	Bristol is not exploring electric buses (research has gone into alternatives such as hybrid and biodiesel due to the topography of Bristol)	N/A
8	e-Taxis	Private	1
9	e-Bikes	Private	1
10	EV Charging Infrastructure	Public / Private	1 & 3a
11	Smart City Platform (SCP)	Unsure if this will be further explored just now – Likely to require further grant funding to develop further	1
12	IoT Sensor Network	Private &/or Public	1 & potentially 3a
13	App Development	Private/SME/Academia – partnership	1

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14	Smart Lighting	Potentially internally though Highways or govt funding	1
15	Public WiFi	No known plans for this in the immediate future	N/A
16	Community Renewable Energy	Crowd funding and Public / Private	1, 3a, 7 or 8
17	Electric Buses & vehicles	Private &/or Public	1 & commercial investment

Table 13. Mapping of interventions to applicable VCE models for Bristol

9.4 Essen

	Action (Intervention)	Primary source of capital investment	Applicable VCE Models
1	Building Retrofitting (domestic)	Private/Citizens	1b, 2b, 3, 5, 6
2	Building Retrofitting (public)	Municipality (also regional and federal Public)	1a, ,1b, 2a, 3, 6
3	District Heating (CHP)	Energy utility company	1a, 1b, 2a, 3, 6, 7, 8
4	District Heating (TES)	Energy utility company	1a, 1b, 2a, 3, 6, 7, 8

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5	Energy Demand Management Systems (EDMS)	Intervention Beneficiaries	1a, 3, 8
6	Smart Grid & Related	Municipality/Private	1a, 1b, 3, 4, 8
7	Electric Buses	Municipality (also regional and federal Public)	1a, 1b, 3, 5, 8
8	e-Taxis	Taxi companies	1a, 2b, 5
9	e-Bikes	Private	1a, 1b, 4, 5
10	EV Charging Infrastructure	Energy utility company	1a, 2b, 3, 4, 8
11	Smart City Platform (SCP)	Municipality	1a, 1b, 8
12	IoT Sensor Network	Private	1a, 4, 8
13	App Development	Start-ups	1a, 2b, 7
14	Smart Lighting	Municipality	1a, 1b, 3, 4, 8
15	Public WiFi	Private	1a, 1b2a, 4
16	PV on public roofs	Municipality and citizens	1a, 1b, 3, 6, 7, 8
17	PV on roof of municipal housing company	citizens	1a, 1b, 3, 6, 7, 8

Table 14. Mapping of interventions to applicable VCE models for Essen

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9.5 Lausanne

	Action (Intervention)	Primary source of capital investment	Applicable VCE Models
1	Building Retrofitting (domestic)	Private	None
2	Building Retrofitting (public)	Public	None
3	District Heating	Public	2, 8
4	Energy Demand Management Systems (EDMS)	Public	8
5	Smart Grid & Related	Public	None
6	Electric Buses	Public	None
7	e-Taxis	Private	2a
8	e-Bikes	Private and Public	2a
9	EV Charging Infrastructure	Public and Private	8
10	Smart City Platform (SCP)	Public	None
11	IoT Sensor Network	Public and Private	None
12	App Development	Public and Private	None
13	Smart Lighting	Public	None

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14	Public WiFi	Public	None

Table 15. Mapping of interventions to applicable VCE models for Lausanne

9.6 Nilüfer

	Action (Intervention)	Primary source of capital investment	Applicable VCE Models
1	Building Retrofitting (domestic)	Private Finance Inst. National funds EPC's (8)	2b,8
2	Building Retrofitting (public)	Funding bodies EPC's (8)	1a,1b,8
3	District Heating (CHP)	Funding bodies (National, International)	1a,1b
4	District Heating (TES)	Funding bodies (National, International)	1a,1b
5	Energy Demand Management Systems (EDMS)	Funding bodies EPC's (8)	2b,8
6	Smart Grid & Related	National funds	4[18]
7	Electric Buses	International financial inst. Funding bodies	1a,1b

[18] Simplification of Model 4 with infrastructure provider investing

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8	e-Taxis	Financial Inst.	5[19]
9	e-Bikes	Funding inst.	1a,1b
10	EV Charging Infrastructure	National funds	4[20]
11	Smart City Platform (SCP)	Funding bodies	1a,1b
12	IoT Sensor Network	Financial inst.	2b
13	App Development	Financial inst.	2b
14	Smart Lighting	Funding bodies	1a,1b
15	Public WiFi	Funding bodies	1a,1b

Table 16. Mapping of interventions to applicable VCE models for Nilüfer

9.7 Summary

The Following table provides a summation of the relevant models for each intervention. The quality of the analysis that follows reflects the interpretations of the REPLICATE city partners as to the applicability of the models and their variants.

[19] With SPV as in EBRD Finance Facility Financial Intermediaries (usually commercial banks)
[20] Simplified

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	Action (Intervention)	Applicable VCE Models – Pilot Cities	Applicable VCE Models – Follower Cities
1	Building Retrofitting (domestic)	1,1c,2,3a,5(p),7,8	1b,2b,3,5,6,8
2	Building Retrofitting (public)	1,2,3a,7,8	1a,1b,2a,3,6,8
3	District Heating (CHP)	1,3,3a,3b,8	1a,1b,2,2a,3,6,7,8
4	District Heating (TES)	1,3,3a(p),5(p),8(p)	1a,1b,2,2a,3,6,7,8
5	Energy Demand Management Systems (EDMS)	3,3a,4(p),8	1a,2b,3,8
6	Smart Grid & Related	1,3a,4,8	1a,1b,3,4,8
7	Electric Buses	1,2,5,5a,6(p)	1a,1b,3,5,8
8	e-Taxis	1,1(+),2(+)	1a,2a,2b,5
9	e-Bikes	1,2,5a,8	1a,1b,2a,1b,4,5
10	EV Charging Infrastructure	1,2,3,3a,4,7	1a,1b,3,4,8
11	Smart City Platform (SCP)	1,1d,3,4	1a,1b,8
12	IoT Sensor Network	1,3,3a,7	1a,2b,4,8
13	App Development	1,3,8	1a,2b,7
14	Smart Lighting	1,1e,3,5,8	1a,1b,3,4,8
15	Public WiFi/High Speed Wireless Connectivity	1,3,4a	1a,1b,2a,4

Table 17. Summative mapping of interventions to applicable VCE models

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	Action (Intervention)	Applicable VCE Models – Pilot Cities	Applicable VCE Models – Follower Cities
1	Building Retrofitting (domestic)	3a,5(p),7,8	3,5,6,8
2	Building Retrofitting (public)	3a,7,8	3,6,8
3	District Heating (CHP)	3,3a,3b,8	3,6,7,8
4	District Heating (TES)	3,3a(p),5(p),8(p)	3,6,7,8
5	Energy Demand Management Systems (EDMS)	3,3a,4(p),8	3,8
6	Smart Grid & Related	3a,4,8	3,4,8
7	Electric Buses	5,5a,6(p)	3,5,8
8	e-Taxis		5
9	e-Bikes	5a,8	4,5
10	EV Charging Infrastructure	3,3a,4,7	3,4,8
11	Smart City Platform (SCP)	3,4	8
12	IoT Sensor Network	3,3a,7	4,8
13	App Development	3,8	7
14	Smart Lighting	3,5,8	3,4,8
15	Public WiFi/High Speed Wireless Connectivity	3,4a	4

Table 18. Summative mapping of interventions to applicable VCE models with Funding (Model 1 and variants) and Direct (Model 2 and variants) models removed.

Key for both Table 16 and Table 17 – (p) – possibility of use (+) – all variations

	Interventions with no 'Direct Model' (Model 2) component of finance i.e., 100% via the municipality

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10. Analysis of Findings

The conceptualization of business models in Value Creation Ecosystems and the consideration of the municipality as the central actor in the 'smart-city-as-a-network' (Yearworth, 2020) aligns well with the influential analysis approach of Amit and Zott (2001), which positions business models as *configurations of activities* within strategic networks. The generic VCE models that have been captured from contributions by the REPLICATE cities and the extensive mapping carried out in Work Package 7 and as presented in Sections 7.3 to 7.11 above can be thought of as *schematics for value engineering* in the smart city-as-a-network. Therefore, the final piece of the replicable business model puzzle was to contextualise the data about the comprehensibility and viability of financing mechanisms identified, as presented in Sections 7.12 and 7.13 respectively, and the corresponding mapping of interventions on to them as shown in Sections 9.1 to 9.6, with the amount of work municipalities will have to do in order to bridge the financing gap between the current rate of investment into the city for interventions to meet targets and estimates of the total that is required. Whilst the gap analysis, which involves projections, is addressed in the next section the essential bridging piece is provided by the data presented in Section 7.14. Here, an expression of the *intention* to use a specific Model, out of all the main models and variations described, shows exactly which of them has immediate utility in bridging this gap.

During the data collection exercise, the Models were referred to exclusive by number. However, for the remainder of the analysis and discussion the individual Models, and their variants, have been associated with more descriptive labels as follows

- Model 1: 'Grant Funding Model' – the straightforward case of financing interventions via grants awarded from regional, national or supra-national bodies.
- Model 2: 'Direct Model' – predominant characteristics are that i) capital financing flows directly to Intervention Beneficiaries from Financial Institutions, and ii) there is no direct financing flow from the Municipality to the Intervention Beneficiaries.
- Model 3: 'EU SPV Model' – originally inspired by the Bristol City Leap process, is also representative of other relationships between a Municipality and a Special Purpose Vehicle. Also associated with the legal notion of Teckel Exemption and therefore requiring certain control and ownership tests to be met.
- Model 4: 'Transitional Model' – hypothesised as an intermediate step in the possible transition from Model 3 to Model 5.

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- Model 5: 'USA SPV Model' – originally presented as a representation of the highly evolved use of SPVs by Municipalities in the USA and associated with the issue of Municipal Bonds. However, the data suggest that this Model is perhaps more indicative of an arms-length relationship between the Municipality and the SPV and is more recognisable in the EU than originally assumed.
- Model 6: 'EU Municipal Green Bond Model' – a straightforward capture of the case of the City of Gothenburg and its direct issue of Green Bonds.
- Model 7: 'Crowdfunding Model' – characterised by the interface between the Municipality and a Crowdfunding platform, or its intermediary, for the purposes of raising investments.
- Model 8: 'ESCO Model' – designed to capture the characteristics of an ESCO providing energy services to an Intervention Beneficiary moderated by an Energy Performance Contract. The precise nature of the relationship between the ESCO and the Municipality is not defined.

The following analysis draws a distinction between i) leading contenders, ii) highly viable but rejected models, iii) models with specific, but perhaps not generic, utility, and iv) models for immediate deployment. The final category here draws on the data collected to populate Table 10, building on data presented in D7.1, "*Report on peer-review methodology including templates and supporting materials*", and as updated in Round 2 of the data collection in this Task, and identifies interventions that have a clearly defined positive NPV and can be deployed immediately with comparatively straightforward business cases.

From the declared intention to use data (Table 7), it is clear that none of the Models has universal applicability across the six REPLICATE cities, although the 'EU SPV Model' and the 'ESCO Model both come close. We should not be too surprised at this as the cities represent, on one hand, a wide diversity in regulatory and political environment, and the other, a specificity of needs arising from locale and path dependencies. However, from the data we can discern some patterns.

Disregarding for now the simple case of the 'Grant Funding Model', the leading contenders for municipal focus in the 2021-2025 timeframe are a) the 'EU SPV Model' (70% coverage of interventions in Table 17), b) the 'ESCO Model' (67% coverage of interventions in Table 17), and c) the 'USA SPV Model' (27% coverage of interventions in Table 17). The 'EU Municipal Green Bond Model' is considered to be highly viable due to its success in Gothenburg but is

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almost completely rejected by the Pilot Cities[21] and only indicated for use in financing retrofitting and district heating by one of the Follower Cities.

Clearly there is every reason for Municipalities to encourage the use of the 'Direct Model', where Intervention Beneficiaries have a direct relationship with sources of capital to finance interventions; it lessens their burden of responsibility. However, in attempting to conduct a gap analysis in Section 11, at least in outline, estimating total investments required by cities and determining how much flows via the Municipality and how much directly via the 'Direct Model' (and presumed variations) seems to be critical information that is missing. The summary of intervention mappings in Table 17 also highlights where the 'Direct Model' does not apply.

The REPLICATE cities are highly dependent on the 'Direct Model'. San Sebastián have contributed a variant of the Model (Model 2c in Section 7.11.4) as a potential public/private collaboration model to leverage or reinforce private funds[aaa]. Florence sees its potential use in the mobility sector, specifically for e-taxis[bbb]. Essen sees the relevance of variant 2b to retrofitting and estimates that this is potential responsible for about €15M investment per year, but also comments on the difficulty of producing an estimate[ddd]. Lausanne's future climate plan estimates that the Model is likely to contribute about €100M in the period 2021 to 2025[eee]. Nilüfer estimates that the widespread use of the Direct Model has been responsible for distributing €400M of finance since 2016 at better than market conditions[fff]. It is important to note here that mis-estimating finance flows through the 'Direct Model' is likely to be problematic and discussed further in Sections 11 and Section 13.3.

It is interesting to note that the 'Direct Model' is considered more relevant to the 15 interventions by the Follower Cities than it is for the Pilot Cities i.e., 10/15 cases (66.7%) compared to 6/15 (40%). Perhaps the availability of SCC funding has masked awareness of the possibility? This suggests that generating reliable estimates of the amounts of financing flowing directly to Intervention Beneficiaries might be problematic. The 'Direct Model', despite its prevalence (53% coverage of interventions in Table 17), is discussed separately because it is largely outside the control of the Municipality, although subject to its influence; see Section 11.

[21] Apart from one "potential" use for e-Bus financing.

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10.1 Leading Contenders

10.1.1 'EU SPV Model'

The derivation of the 'EU SPV Model' was originally motivated by the need to capture the ongoing City Leap Process in Bristol, whilst at the same time appreciating that the relationship between the Municipality and the SPV in this Model also seemed to capture the VCE of other Municipally owned SPVs.

San Sebastián have contributed a variation of the Model (Model 3b in Section 7.11.5) to capture the use of an SPV to channel finance for district heating[i,z]. The use of the model in Florence is well established through the Municipal owned SPV 'SILFI' responsible for managing a range of systems such as smart public lighting, public charging network and public wifi[aa]. It is also used as the Model for managing finance for social housing in the city.

The Model defined by the City Leap process in Bristol it is still, nonetheless, an uncertain prospect, although it is being used for social housing (Goram Homes) and Bristol Waste[bb]. Its singular and wide degree of expected application in Bristol, more or less to the exclusion of other Model consideration, appears to be a high-risk strategy. A considerable amount depends on the successful conclusion of the City Leap strategic partner procurement process and its implementation. This is especially so, now that Bristol Energy has been sold and is thus signalling a retreat from the 'ESCO Model'. On the other hand, it is difficult to see what other options are available to Bristol, or indeed to any other UK city. The creatively entrepreneurial spirit shown by Bristol is a testament to its commitment to securing a zero-carbon future for its citizens in response to the absence of the support it needs from UK Government.

Whilst the 'EU SPV Model' is viable for the Pilot Cities and also Essen, although its use is unlikely[cc]. It is not relevant to Lausanne or Nilüfer for legal reasons; Nilüfer because municipalities are legally prevented from setting up SPVs in Turkey[dd] and Lausanne, because they are considered too complicated legally and where it is far easier to use an energy contracting model via an ESCO[g].

10.1.2 'ESCO Model'

The ESCO Model is widely applicable according to the REPLICATE cities' intention to use it, with the exception of Bristol as discussed above[aaaa]. San Sebastián, Florence and Nilüfer

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intend to use it for building retrofitting and energy refurbishment. As a model it has been widely studied, as summarised in the review in Section 6.1.6 and as summarised in

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Appendix D – Characteristics of ESCO and EPC Models, and therefore there is little that needs adding here.

However, the sale of Bristol Energy during the data collection exercise was a surprising development. Up to the point at which Bristol Energy was sold it was augmenting the energy services provided by the Municipality including, most obviously, retail energy offerings aligned to policy objectives[r]. Notwithstanding the time it takes to get academic works published, the extensive analysis of Municipal Energy Companies that included Bristol and Nottingham conducted by Brinker and Satchwell (2020) was originally accepted for publication in October 2019 and thus is a usefully recent reference. However, whilst generally painting a picture of the risks involved in establishing such companies, they really gave no indication that the nature of the risks facing the Bristol and Nottingham business models were so high that they were facing imminent sale. Likewise, the extensive Bristol case study conducted by Brown, Hall and Davis (2020) was accepted for publication in February 2020 and includes Bristol Energy as one of its three foci in the study and also refers to the ongoing City Leap process and yet still gives no hint at the fragility of the business model. However, the data from Bristol in Round 2 reflects the sale of Bristol Energy and the consolidation of efforts into the City leap process.

10.1.3 'USA SPV Model'

The inclusion of the USA SPV Model in the data collection exercise was intended to capture opinions and intentions with regard to the highly evolved SPV Model prevalent in the USA and co-creational with the Municipal Bond market. Despite the origins of this Model in a uniquely US-based mechanism it is considered to be, on the whole, viable (Table 6). San Sebastián contribute a variation of the Model (Model 5a in Section 7.11.7) as a description of the dBus VCE, the public municipal company that manages urban public transport in the city[gg]. Further use of the Model is intended as the city intends to move to a 100% electric bus fleet by 2030[ooo]. Florence report that this Model captures the VCE for Publiacqua, the Municipal SPV that manages water supply in the city[hh,ppp]. Bristol comment that this Model might get explored post-City Leap[ii,qqq]. The Model is under active consideration by Essen as part of the EU funded SCORE project to finance PV on municipal building roofs and rented properties with implementation planned in 2021[jj,rrr]. The Model is rejected by Lausanne on much the same grounds as for the EU SPV Model, it is too complex legally to consider[j]. Likewise, the use of this Model by Nilüfer is rejected on the grounds of lack of fit to public administration culture[kk]. Emerging from the data is the recognition that the 'USA SPV Model' is widely indicated for its

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potential use in financing transport interventions – e-buses, e-taxis, and e-bikes, as well as district heating and smart lighting (Table 17).

Notwithstanding the possible evolution of the use of Municipal Bonds for financing 'green' interventions, for example the New York Metropolitan Transportation Authority (MTA) Green Bond Issues between 2016 and 2018 (Standard and Poor's, 2019), Green Bonds associated with this model are potentially quite different from those issued by the 'EU Municipal Green Model', which is firmly associated with the credit rating of the Municipality itself, whereas the 'USA SPV Model' was intended to describe the situation where the SPV was the issuer of the bond – green or otherwise.

10.2 Highly Viable Rejected Model

10.2.1 'EU Municipal Green Bond Model'

This Model, as exemplified in its use by the Gothenburg Municipality, can perhaps be regarded as lying on an alternative pathway to the SPV models i.e., the 'EU SPV Model', the 'US SPV Model' and the 'Transitional Model'. It is surmised here that the financial position of the Gothenburg Municipality was sufficiently strong in regard to its ability to service debt that it considered the process of undergoing credit rating, bond issuance, and debt servicing to be well within its capabilities. The more or less complete rejection of this Model by the REPLICATE Cities in favour of the leading contender models discussed above suggests an ongoing need to keep debt financing at arms-length from main Municipality financing and thus the preference, or necessity, of using an intermediate SPV[nn,oo]. Other reasons for its rejection are its complexity[mm] and mis-match to public administrative culture[pp].

10.3 Models with Specific Utility

10.3.1 'Transitional Model'

Originally presented to the REPLICATE Cities as a hypothetical and speculative intermediate stage between the 'EU SPV Model' (as Model 3 in Round 1 and Round 2) and the highly evolved 'USA SPV Model' (as Model 5) it nonetheless appears many times in the proposed mapping of interventions to financing mechanisms in Table 17. This is somewhat of a surprise. Given that the speculation was that the evolution of the 'EU SPV Model' would proceed via Municipalities placing a greater focus on the use of the model to finance infrastructure. In terms of its actual viability the picture is mixed. San Sebastián have contributed a variation of the Model (Model

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4a in Section 7.11.6) as a public/private finance model for the provision of public high-speed wireless connectivity in the city[ee]. Its use will be central to wide range of smart city projects across the city channelling €3.5M of investment over the next 5 years[kkk]. Both Essen and Nilüfer consider it to be a viable Model but unlikely to be taken up[cc,k].

10.3.2 'Crowdfunding Model'

The 'Crowdfunding Model' is only marginally viable (Table 6) and only Lausanne has indicated its relevance (Table 7) as a form of participatory budgeting mechanism where project promotors finance 50% of the necessary investment[p]. San Sebastián comment that the model does find use in the city[vvv], although it is clearly not relevant to the interventions covered here. Florence have indicated it may be used where other Models have failed[www] and Bristol have suggested its possible relevance for the R&D phase of projects[xxx]. The Model is not considered further in the following discussion.

10.4 Immediate Deployment

The analysis of intervention NPVs presented in Table 10 in Section 8.1 demonstrate a number of interventions highlighted in green that could be packaged-up into a straightforward business model i.e., the individual intervention is NPV positive or a combination of interventions into a portfolio would result in an overall positive NPV position. For example, based on the financial data provided by Florence, whilst the building retrofitting and district heating interventions combined show a negative NPV if combined with smart public lighting would result in an overall positive NPV. This could be achieved with elaborate value engineering. However, in this example, the smart public lighting is already part of the SILFI SPV i.e., within a portfolio under the 'EU SPV Model'. However, Municipal ownership of SILFI, and therefore any surpluses, does not preclude cross subsidy from SILFI to other interventions funded by the Municipality or indeed into other SPVs established by the Municipality. This has not been explicitly modelled in Section 7 although it is reasonably simple to conceptualise.

10.5 Problematic Interventions

Interventions 1-6 in Table 17 and Table 18 are clearly covered by the 'leading contender' Models presented above in Section 10.1, i.e., the 'EU SPV Model' and the 'ESCO Model' are both applicable to raising finance for all 6 interventions for both Pilot and Follower Cities. Domestic building retrofitting could also be covered by the 'USA SPV Model' too.

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However, The joining of data presented in Table 7 in Section 7.14, "Intention to use a Model", with data presented in Table 17 or Table 18 in Section 9.7, "Mapping of Interventions to Models", highlights interventions that might struggle to find a route to financing. In the Pilot Cities, e-taxis seem to be only amenable to the 'Grant Funding Model' or the 'Direct Model', although perhaps they could be financed under the 'USA SPV Model' as suggested from a Follower City perspective i.e., through a more arms-length SPV model with perhaps limited Municipal ownership and control. Also, from a Follower City perspective, both App development and public wifi/high speed wireless connectivity seem problematic to finance, with the 'Crowdfunding Model' being suggested for App development and the 'Transitional Model' being suggested for public wifi/high speed wireless connectivity.

10.6 Value of the VCE Approach

Emerging VCE models in Round 2, as presented in Section 7.11, demonstrate the expressiveness of the Value Creation Ecosystem technique and thus its general utility for explanation and communication. However, notwithstanding its widespread use in REPLICATE and publications emerging from the project e.g. (Pardo-Bosch, Cervera & Ysa, 2019), there was little comparable use in the literature reviewed in Section 6, with the notable exceptions of Hannon and Bolton (2015); Shang et al. (2017) on ESCO models as shown in Appendix D.

10.7 Reflections

The findings discussed above do not present an entirely consistent picture that would provide a definitive conclusion to the search for replicable business models. Whilst some avenues of pursuit are clearly identified there remain a number of uncertainties that require further research to resolve. These are discussed in the Lessons Learned in Section 13.

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11. Gap Analysis

11.1 Putting Some Numbers to the Scale of the Problem

Finding concrete data about the scale of investments required by a specific city to achieve its climate change targets is difficult. However, three indicative examples are reviewed here, a Pilot City (Bristol) and Follower City (Essen) in the REPLICATE project, and a pioneering city in the use of green bonds (Gothenburg) to finance interventions.

11.1.1 Bristol

The City Leap prospectus from Bristol identifies £875M (approximately €1.0 Billion) of investment opportunities between 2020 and 2030 in the energy system alone (Bristol City Council, 2018).

11.1.2 Essen

The recently published Essen 'Klimastadtplan' (Essen City Council, 2020) sets out the details for the city to achieve a position of 'klimaneutral' by 2030[22]. The bottom line, financially, is stated boldly as

> "*Essen nimmt die Klimawende ernst und schiebt 4.100 Mio. € kommunale und 30.884 Mio. € Gesamtinvestitionen bis 2030 an.*"

The figures highlight the difference between the total investment required and the amount expected to be flowing through the municipality. This latter and lower figure of €4.1Billion is useful for comparison purposes here. It also illustrates the necessity for a municipality to have some clear idea about the total required.

11.1.3 Gothenburg

To date, the City of Gothenburg has raised SEK4.36 Billion (approximately €0.4 Billion) between 2013 and 2016 through the issuance of Green Bonds (Climate Bonds Initiative, 2018) with a total debt load projected to reach SEK63,068 Billion by the end of 2022 (approximately €6.1 Billion) (City of Gothenburg, 2020). The schedule of recent Euro Medium Term Notes

[22] See https://klimaentscheid-essen.de

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(EMTN) issued by Gothenburg is reproduced in Appendix A to provide some indication of the frequency and size of these green bond issues.

11.2 Overall Situation

Whilst these numbers are useful, they are presented here as being more representative of exemplary positions rather than quotidian European city experience. Gothenburg as the first city to issue Green Bonds, Bristol as an innovator in developing novel financing mechanisms appropriate for the UK situation, and Essen in publishing clear guidance on the municipal investments required and estimates of the total investment required.

However, rather than undertaking further research to obtain detailed numbers from other cities, there are sources of aggregate data at the global and EU level that are sufficient for the purposes of this work of establishing estimates of targets, and therefore indications for the *scale* at which the Models presented in Section 7 will have to work.

Estimates of the scale of *annual* investment required at the global level have been supplied by the IPCC who state that

> "*Additional annual average energy-related investments for the period 2016 to 2050 in pathways limiting warming to 1.5°C compared to pathways without new climate policies beyond those in place today are estimated to be around 830 billion USD2010 (range of 150 billion to 1700 billion USD2010 across six models)*" (IPCC, 2018, p. 16)

As part of the European Green New Deal the European Commission (2020b) has identified that between €175 to €290 Billion of *additional* yearly investment is required to make the EU climate neutral by 2050[23] (European Commission, 2020a). In the UK, an estimate by HM Treasury in 2019 put the total cost of achieving 'net zero' by 2050 in excess of £1 Trillion (Pickard, 2019).

A simple pro-rata estimate based on population size and assuming the same 30-year period as for the European Commission figures suggests total additional investments required are; San Sebastián €2.2 – €3.6 Billion, Florence €4.5 – €7.5 Billion, Bristol €5.4 – €9.0 Billion, and Essen would be €6.8 – €11.3 Billion. Whilst these are only estimated figures, the lower end is realistic and consistent with the City Leap process data from Bristol and Green Bond issues from Gothenburg. The figure of €4.1 Billion of municipal investment stated in the

[23] For triangulation, D7.6 p23 has this as €177 Billion for the period 2021-2030.

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Klimastadtplan for Essen is consistent with the pro-rata estimate. The estimate for the overall city investment required of €30.1 Billion in Essen is perhaps not unreasonable. The estimate for San Sebastián should be compared with the economic analysis carried out by the Basque regional government (Administration of the Basque Country Autonomous Community, 2015, pp. 57-59), which shows an indicative budget for the region of €440M over the 5 year period 2016-2020. The figures for Florence should be contextualised by the budgets indicated by the municipality's Sustainable Energy Action Plan (SEAP) developed in 2010, which itemised costs of specific actions to a total of €2.16 Billion over the period 2010-2020, and which were subsequently revised in the monitoring process carried out in 2017 to a total of €3.13 Billion (Comune di Firenze, 2017).

To add further weight to the apparent problem in the UK is the lack of scale of the UK Government's financial commitment towards its "Green Industrial Revolution" announced in November 2020[24].

Whatever the exact figures are for any municipality, it is certainly clear that the Models identified in Section 7 *must* be capable of operating at the scale of Billions of Euros to tens of Billions of Euros, and as an absolute minimum the *additional* investments to be raised via these Models as required by each of the municipalities in the REPLICATE project to achieve their climate change targets is *certainly in excess of €1 Billion.* This burden sits clearly on the shoulders of the 'leading contender' Models discussed in Section 10.1 i.e., the 'EU SPV Model', the 'ESCO Model', and the 'USA SPV Model' – they have some heavy lifting to do.

11.3 Speed of Investment

Whilst cumulative numbers are helpful to communicate the magnitude of the financing gap faced by municipalities, it also useful to consider the annual *rates* of investment that are required. These provide some in-progress estimate of whether the actual investment rates being achieved approach the idealised slope of the required investment rate. Even if only done linearly it does emphasise the problem that cities face. That is, gap, target deadline, and rate of investment are *all* necessary to communicate the sense of urgency required. In terms of the systems model presented in Figure 1 at the introduction to this deliverable and the scale-up

[24] UK Government Press Release 18th November 2020 https://www.gov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-250000-jobs

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model in Figure 4, it is the rate of investment that provides a ready feedback signal into the Municipality to stimulate action.

The concept of a funding or investment gap, between current rates of funding and the those required to achieve targets, has not been widely discussed. Here, in this Deliverable, it has been made explicit in the 'EU SPV Model' by reference to the numbers cited in Bristol's City Leap Process tendering documents. This gap was also discussed in Deliverable D2.3, "*Internal Report on Findings*", as was the concept of *diverging trajectories* – in effect the difference between the current *rate* of financing interventions compared to the estimated gap divided by the number of years remaining in which to achieve the target.

11.4 Alternative Perspectives

Whilst the rate of investment against total investment required presents a quantitative feedback signal to create a sense of urgency and stimulate action it is not very visual. Numbers like this can easily get lost in reports, even if, as in the case of Essen's Klimastadtplan, they are called out in large, bold fonts (Figure 6).

Figure 6. Quantitative financial targets for Essen's Klimastadtplan (Essen City Council, 2020, p. 19).

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Here, we present two graphical techniques that might also contribute to communicating these total investment figures in ways that are more accessible to municipal audiences, especially elected representatives, to help focus decision making. These are marginal abatement cost curve diagrams and Sankey diagrams.

11.4.1 Marginal Abatement Curves

Marginal abatement cost curves are an economic tool and when used to present investment options in merit order, graphically indicate the amount of emission reduction that can be achieved for a given level of investment. The Net Present Value calculations presented in Table 10 in Section 8.1 could be combined with monitoring data defined by Deliverables 10.4, "*Monitoring programme for San Sebastian*", 10.5 "*Monitoring programme for Florence*", and 10.6 "*Monitoring programme for Bristol*" to begin to construct marginal abatement cost curves for the REPLICATE cities.

The municipality of Florence has already conducted the preliminary stages of analysis consistent with this approach for its recent SEAP (SPES Consulting, 2020), and as a reference guide, Ibrahim and Kennedy (2016) set out a well-defined methodology that can be used to construct marginal abatement cost curves to help decide investment decisions by municipalities. An example is reproduced in Appendix I – Example Marginal Abatement Cost Curve. This work is highlighted here to indicate a useful direction for future work.

11.4.2 Sankey Diagrams

The System Dynamics Model in Figure 5 was introduced as a conceptual device in this Work Package to structure the analysis of business models from across the entire project. However, the behaviour of System Dynamics Models is not intuitively easy to understand without going to the trouble of fully parameterising them and running them in simulation to produce graphs of variable and stock behaviour over time[25]. This was not a planned undertaking within the REPLICATE project, although it is flagged here as an area of future work. Based on the analysis carried out in this Task it is certain that detailed *dynamic* modelling will be an essential requirement for municipalities in order to manage their portfolios.

[25] The full methodology is explained in Sterman (2000).

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However, other techniques exist for visualising flows. The Sankey Diagram, originating in work by Mathew Sankey to visualise energy flows associated with steam engines at the end of the 19th Century, provides a simple flow language where the width of the 'arrows' is proportional to flow rates and the 'bars' call-out specific names for individual flows or their combinations. We have repurposed the technique, as have many others, to visualise flows of money rather than energy but the principle behind the technique is the same.

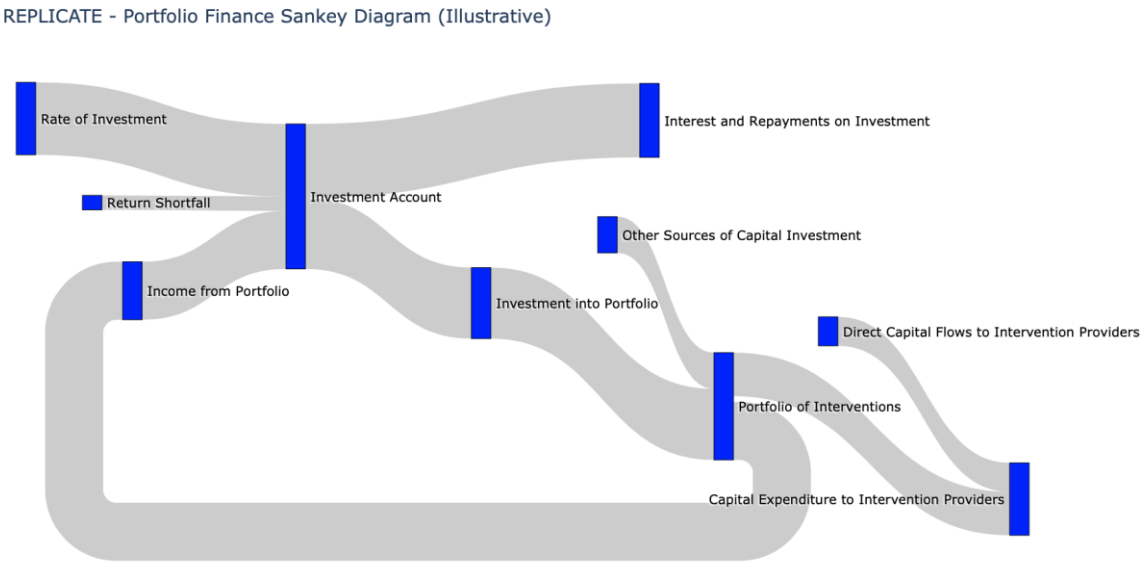

Figure 7. Sankey diagram of capital flows[26]. A re-interpretation of the System Dynamics model shown in Figure 5.

The System Dynamics Model of the portfolio shown in Figure 5 can be represented at a particular moment in time[27] by a Sankey diagram that shows the financial flows through the portfolio system and is shown in Figure 7. The names of the flows correspond exactly to the labelled flows in the System Dynamics Model as indicated by the following symbol:

[26] The plot was generated using the Sankey function in the Python package plotly (see https://pypi.org/project/plotly/).

[27] In practice over a measurement period that matches the flow rate measurement units in the System Dynamics Model. For example, these will be either in units of €/Month or €/Year.

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From this diagram it is intuitively obvious that if the <Income from Portfolio> should reduce, then all other things being equal (ceteris paribus), especially the <Rate of Investment> and <Interest and Repayments on Investment>, that there will be a corresponding need to increase <Return on Shortfall>. This is not immediately apparent from the System Dynamics Model in Figure 5. Again, thinking in terms of capabilities associated with this system we could attempt to associate a figure of merit to the efficiency of this system to leverage financial flows *out* of the system in the form of <Interest and Repayments on Investments> into <Capital Investment to Intervention Providers> as a simple climate investment gain index as shown in Equation 1.

$$GainIndex = \frac{<Capital\ Investment\ to\ Intervention\ Providers>}{<Interest\ and\ Repayments\ on\ Investments>} \quad (1)$$

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12. Discussion – Prospects for Replication

The prospects for achieving a single, unifying replicable business model approach to solving the problem of financing city-led smart city interventions have been shown to be questionable, although there are some leading contender Models, elicited in this Deliverable, that could find fairly widespread use.

Across the REPLICATE cities we see quite distinct differences between country contexts. We have the example of Bristol in a country that is in the (chaotic) process of leaving the EU and potentially adopting a model of financing via the City-Leap process that appears to be taking it on a trajectory that is closer to the municipal bond approach in the USA (i.e., the 'USA SPV Model'), or perhaps as found in some other freely entrepreneurial jurisdictions such as in countries like Singapore[28]. This is despite the fact that the perception reflected in the data collection is that it has more in common with the 'EU SPV Model' e.g., SILFI in Florence.

San Sebastian, Florence and Essen are clearly representative of a more unified EU picture, but even then, with significant differences in perceptions of the use of SPVs to achieve objectives as highlighted in Section 10.1.1. With Nilüfer and Lausanne we see two quite distinct contexts in Turkey and Switzerland that are both very much different from each other as well as from the EU and the UK.

The likely effects of new initiatives such as the EU's Green New Deal remain uncertain (European Commission, 2020b). If some of the more radical macroeconomic theorists manage to gain influence, for example, such as proponents of Modern Monetary Theory (MMT), then it may be the case that fiat currency-issuing jurisdictions will literally just 'print' the money that is required to finance all the interventions required to meet climate change targets (Kelton, 2020, p. 182)[29]. We have seen that the response to the Covid-19 pandemic has

[28] It will take some time before the wider consequences of the recently negotiated deal with the EU are known. The uncertainty is very high at the time of finalising this Deliverable [January 2021] and it is not possible to anticipate what sort of dominant financing regime may emerge; although recent news reports lend support to a Singaporean model e.g. "*Boris Johnson consults businesses on plan to become Europe's Singapore*" https://www.thetimes.co.uk/article/boris-johnson-consults-businesses-on-plan-to-become-europes-singapore-mktg5mtx2

[29] Quoting Alan Greenspan, Chair of the Federal Reserve in the USA (1987-2006), on being questioned about Social Security liabilities – "…*there's nothing to prevent the federal government from printing as much money as it wants and paying it to somebody*."

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presented an even more urgent case for Governments to do just this, although under the more acceptable labelling of Quantitative Easing (FT Editorial Board, 2020a).

In this section we review some of the approaches that have emerged through the duration of the REPLICATE project and discuss their prospects. We conclude the section with our reflection on whether we have fulfilled the challenge that was set before us by the European Innovation Partnership on Smart Cities and Communities (2016) where

> *"…The evolving nature of city financing further highlights the need for smart cities to diversify their sources of finance and create innovative new incentivised business models. With member states operating in a challenging fiscal environment, the ability of the public sector to finance mainstream scale-up is limited. European smart cities must work together to find diverse sources of long-term finance if they are to grow and thrive."*

12.1 Sustainability of the ESCO Model in the UK

The sale of the Bristol Energy customer base to Together Energy and transfer of the frontline staff was announced on the 8th September 2020[30]. Following the decision by Bristol City Council to put Bristol Energy up for sale Nottingham City Council, a partner in the REMOURBAN project, announced a similar decision for the sale of its own Robin Hood Energy Company to British Gas[31]. Clearly the 'ESCO Model' for these two pioneering municipalities in the UK is proving untenable and indicates the challenging financial conditions under which energy initiatives are operating and raises question marks over the sustainability of the 'ESCO Model' in the UK. However, the idea of 're-municipalisation' of infrastructures is still emerging, see Section 12.6 below.

12.2 The United States of America Municipal Bond Model

The issuance of municipal bonds into a thriving market has long been a means for US cities to raise capital finance for their infrastructure projects. Re-purposing this mechanism toward 'green' infrastructure is largely a question of the *labelling* applied to these bonds and whether there are specific regulations and/or guidelines that govern such labelling. The "*changing*

[30] https://news.bristol.gov.uk/news/together-energy-acquires-bristol-energys-residential-customers-and-brand

[31] See https://www.nottinghampost.com/news/local-news/sad-day-robin-hood-energy-4483913

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value of the 'green' label on the US municipal bond market" (Karpf & Mandel, 2018) highlights the transformation. However, there is little published research that might be parlayed into an understanding of either the evolution of Bristol's City Leap process i.e., the 'EU SPV Model' and variations discussed in Section 10.1.1, to an understanding whether green municipal bonds in the USA, i.e., 'USA SPV Model' and variations discussed in Section 10.1.3, are significantly different in character to what Gothenburg have been doing with their green bond issues. Whether any of these developments play into the new green bond standard that the EU are trying to establish is considered below.

12.3 Is Gothenburg's Green Bond Model the Way Forward?

The pressure exerted by sources of capital to find 'green' investments has certainly has been matched by a significant green premium or "greenium" as found in recent research by Partridge and Medda (2020), who have been charting the evolution of the pricing performance of green municipal bonds compared to their more traditional municipal bond forebears. The fact that this premium is real is welcome news to institutional investors, who can label their funds as green and also generate higher rates of return. This has also generated considerable pressure to certify green bonds – see for example the recent report by the Climate Bonds Initiative (2020) – such that they maintain their investment credibility and do not degenerate into "greenwash" and a vehicle for hiding away projects with poor green credentials and worse, poor investment performance (Karpf & Mandel, 2018). Where the market for green bonds is not yet mature there exists some riskiness for investors, as in the case of Italy discussed by Padovani, Rescigno and Ceccatelli (2018).

Credit rating agencies will need to take care too so that their ratings for municipal Green Bonds preserve credibility and protect investors. The emerging EU Green Bond Standard discussed next is likely to provide an umbrella answer to the question posed in this section for all European Municipalities.

12.4 The EU Green Bond Standard

The establishment of an EU Green Bond Standard (GBS) is seen as building on the EU Green New Deal and a necessary step towards re-orienting capital flows towards sustainable investments, managing financial risks associated with climate change, and achieving better transparency and longer-term thinking in investment decision making (European Commission, 2020e). The European Commission established a Technical Expert Group (TEG) in 2018 to

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research best practice, engage stakeholders and make recommendations[32]. The issue of the most recent report on the GBS by the EU Technical Expert Group on Sustainable Finance (2020b) has prompted the European Commission to consult widely before taking recommendations forward for possible legislation.

The consultation period has only recently closed[33] so the outcome is currently unknown (European Commission, 2020d). The questions asked in the consultation document (European Commission, 2020e) have been generated from the perspective of the *barriers* to introduction of an EU Green Bond standard and thus reflect not just investor concerns but also the accountability issues associated with the 'use of proceeds' (allocation reporting) and the effects the spending of the proceeds achieved (impact reporting), which have to be addressed by the controllers[34] of that spending.

From the perspective of researching replicable business models, it is clear that neither impact reporting nor allocation reporting require *visibility* into the replicability (or otherwise) of business models. The *rating* of any bond is fundamentally grounded in the expert opinion of the relevant credit rating agency about the ability of the issuer of the bond to sustain the coupon, that is, in effect pronouncing on the riskiness of the investment from the bond holders' perspective that the issuer of the bond will meet its payment obligations. The rating process is thus the fundamental determinant of how much interest a bond issuer pays for its debt.

Assuming for now an approach for issuing green bonds as shown by the 'EU Municipal Green Bond Model' discussed in Section 10.2.1, where the municipality itself is the issuer of the bonds and as based on the example of the City of Gothenburg (2015, 2016, 2017a, 2018b), then the question of the replicability of business models associated with interventions that will attract investment through the 'use of proceeds' *is only material as part of this rating process*. In keeping with the strong process ontology established throughout Work Package 2 and the use of the STEEP Methodology (European Innovation Partnership on Smart Cities and Communities, 2019; Yearworth, 2013; Yearworth, Schien & Burger, 2014), the credit rating that is established by a rating agency and then published to investors is the result of an

[32] Also see the analysis of the TEG from Work Package 7 (D7.6, pp27-29).
[33] The deadline for the end of the consultation was 2nd October 2020.
[34] i.e., the decision-makers who decide how the proceeds are used. For example, in Model N on Page xxx this would be the Municipality.

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ongoing process to measure and evaluate the credit worthiness of the bond issuer. Part of that process will be a close look at the relationship between intended uses of the proceeds for specific interventions (allocations) and the impact these will have on the overall finances of the bond issuer. It is only at this point that the question of business models will arise. Therefore, there is a *decoupling* of the specific uses of proceeds from the overall financial performance of the bond issuer and thus provides a mechanism to finance interventions with no meaningful business model, that is, one that would not be considered to be replicable. A good example of this is the investment of 14 MSEK for tree planting in Gothenburg in 2014 and 2015, paid for from the use of proceeds account (allocation reporting) and contributing to the overall carbon performance of the city (impact reporting) (City of Gothenburg, 2015, p. 5).

Empirical research into the performance and/or issues associated with the 'EU Municipal Green Bond Model' specifically or European municipal bonds generally is thin on the ground, both forms of bond are rare in Europe and the market is thus not sufficiently mature to analyse. However, a hypothesis that emerges here and grounded in the smart city strategy index work reported in D2.3, "*Internal Report on Findings*", is that a municipal credit rating may well depend on network effects arising from the relationship between the municipality and special purpose vehicles/joint ventures, local businesses, institutions such as Universities, and the third-sector. This suggests a rich seam of research that is required to fully make sense of this rapidly developing area of finance. For example, the study of the relationship between credit risk and network effects in the Municipal Bond Market (Li, Tang & Jaggi, 2018), or the question of the relationship between local government type and municipal bond ratings (Dove, 2017).

12.5 What of the EU Green New Deal?

The EU Green New Deal is still an emerging idea (European Commission, 2020b) and apart from high level communications about a Sustainable Europe Investment Plan (e.g. (European Commission, 2020c)) there has not been enough in-depth detail published or time to fully research the possible impact this will have on the question of replicability of business models, or indeed how easy these new instruments will be to use (EU Technical Expert Group on Sustainable Finance, 2020a).

Possibly, the establishment of Green Bond Investment instruments at the EU Central Bank (ECB) level, similar to the recent announcement by the UK Government concerning the issue of Green Gilts in 2021 (FT Editorial Board, 2020b), will raise significant sums that could be distributed

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to municipalities as funding rather than debt, which would contribute significantly to municipalities being able to pay for interventions that do not have replicable business models.

12.6 The Possible Re-Municipalisation of Infrastructures

The trend of the dismantling of Public Administration and the transition to the era New Public Management (Diefenbach, 2009; Hood, 1991) seems unstoppable, at least in the UK with the reversals suffered by Bristol and Nottingham in the sale of their energy companies. However, the idea of public ownership of essential infrastructure is enduring. For example, the original ownership of the first water companies in the UK was essentially private, but became part or wholly publicly owned towards the latter part of the 19th Century and remained in public ownership for roughly 100 years before sweeping rounds of privatisations[35]. Models of public ownership that show the entanglement of New Public Management with financialisation as seen in US infrastructures, such as public energy companies, aligns with recent calls for 'Energy Democracy'[36].

However, this form of public ownership, with financing of capital projects through municipal bonds, is not without the problems discussed in D2.3, "*Internal Report on Findings*" and e.g. (Kirkpatrick & Smith, 2011). The combinations of ownership and finance and path dependencies (i.e., history matters) seem too complex to distil into recommendations. Where an infrastructure is firmly in public ownership and can be steered towards meeting climate change targets[37] it should probably remain there. Infrastructure that is joint public/private ownership in the US style, that is, through a JV and financed through municipal bonds, presents a problematic position for a municipality that wants to steer the operation towards meeting (social) policy objectives.

There seems to be an emerging paradox. The 'EU SPV Model' and variants as discussed in Section 10.1.1, whilst seeming to offer a municipality a way of moving forwards towards meeting policy objectives and, as recognised across the board by the REPLICATE Pilot Cities, is certainly a viable funding mechanism to use, could in the longer term actually place

[35] Historical account of the development of the City of Exeter water supply http://www.exetermemories.co.uk/em/water_supply.php
[36] https://thenextsystem.org/learn/stories/public-ownership-energy-democracy
[37] And other objectives such as social policies aligned with the SDGs.

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infrastructure beyond the control of the municipality, or at least in a position where democratic control is problematic.

Despite the apparent attractiveness of public/private partnership the ownership structure and financialisation that goes with the EU SPV Model means that the outcome could be a form of backdoor privatisation (Kirkpatrick & Smith, 2011). This argument was quite well rehearsed in Toronto (Mann, Mitchell, Foth, & Anastasiu, 2020; Morgan & Webb, 2020), such that it led to the eventual demise of the deal with Sidewalk Labs. Note that this type of ownership is quite different from the 'Teckal Exempt' JV structures explored in D2.3, and seemingly[38] as exemplified in publicly held companies such as SILFI in Florence, dBus in San Sebastián and Bristol Waste in Bristol and therefore not subject to this seeming paradox.

12.7 Will There Be Winners and Losers?

The issues raised by use of elaborate engineering of Value Creation Ecosystems and the history of municipal bond financing in the USA highlight the critical importance of strategic decision making in Municipalities. Of course, a key aspect of strategy making is the recognition that the impact of decisions is such that there will be both (financial) winners and losers. Li, Pye and Strachan (2016) discuss this point concerning future UK energy system transitions. Of particular note in their conclusions is that the research needed to support policy making at this messy and complex strategic level requires a pragmatic and interdisciplinary approach. The viability of the all the 'leading contender' models i.e., the 'EU SPV Model', the 'ESCO Model', and the 'USA SPV Model', as well as the possibility of further adoption of the 'EU Municipal Green Bond Model' means that there is a fluid landscape emerging of value engineering centred on Municipalities that requires urgent attention from policy makers and scholars alike to ensure that the proliferation of SPVs created to address these financial challenges does not in fact create a further problem, exemplified in the USA, of loss or weakening of democratic accountability.

12.8 The Possible Impact of Heterodox Macroeconomics

Heterodox[39] Macroeconomic theories emerging from some economists – such as Modern Monetary Theory (MMT) as proposed by Kelton (2020) and Keen (2011), Mission Oriented

[38] The exact ownership and control characteristics with respect to a precise determination of Teckel Exempt status has not been carried out.
[39] And therefore contested

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Budgeting proposed by Mazzucato (2018) and Doughnut Economics proposed by Raworth (2017) – present an entirely new way of viewing public debt in the light of the power of governments to issue currency (i.e. literally print money) to pay for anything it requires. This challenges the conventional notion that government spending must be bounded by the revenue it obtains through taxation. Kelton (2020) argues forcibly that this orthodox understanding of how economies function is in fact completely backwards.

Whilst these theories remain controversial and outside mainstream economics they are unlikely to have a serious impact on how cities finance future interventions. However, should they become mainstream[40] then most of what is written here becomes irrelevant, as the chief source of finance required by municipalities would then become Governments and would be supplied as funding, not debt. The only limit to spending would be the productive capacity of the overall economy (*ibid*) and, as D9.3 "*Sectorial Business analysis / Exploitation potential in the field of low energy, ICT, Sustainable mobility and other remaining sectors included in REPLICATE*" has shown, there is already no shortage of the requisite technical solution capability that could readily be turned into additional profitable business should more finance become available to spend on such.

12.9 Have we 'solved' the EIP-SCC Challenge?

The challenge set out by the European Innovation Partnership on Smart Cities and Communities (2016) certainly placed a heavy burden on municipalities to find the means of bridging the gap between the investment required to meet climate targets and ready sources of capital. The instrumental means to achieve this was conceived as the replicable business model. However, what the work in this Work Package has demonstrated, supported by the empirical evidence provided by the municipalities about the REPLICATE project interventions and an extensive literature search, is that replicable business models as interpreted in a narrow firm-oriented sense and as exemplified by much of the Business Model Innovation (BMI) literature discussed in Section 4, are not by themselves a *sufficient* means of bridging this gap. Furthermore, the rapidly evolving fields of green finance through issuance of green bonds at the EU, National, or Municipal Level, coupled with innovative value engineering by

[40] One unlooked-for consequence of the Covid-19 Pandemic has been evidence of Governments directly injecting finance into the economy e.g., the original $2 Trillion stimulus package in the US in March 2020.

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municipalities of Value Creation Ecosystems, grounded in creative use of Special Purpose Vehicles and Joint Ventures, means that they may not even be *necessary*.

The emergent logic from the data collection and analysis conducted throughout this Work Package, not just in this Task (T2.4), is that for any city there exists a notional financial need that reflects the total inward capital investment required to pay for all the interventions required to achieve climate change targets. The 'Direct Model' highlights the fact that not all of this capital investment is, or should be, in the "gift of the municipality". However, the difference between the overall need and that which can be achieved through this direct means *is* the target amount of capital finance that the municipality needs to raise. What this amount might be is discussed in Section 11. What is not provided through funding, i.e., through the 'Funding Model' and its many variants, therefore remains the scope of either trivial business cases (i.e., interventions with straightforward positive NPV projects, or portfolios of them) or the 'leading contender' VCE Models discussed in Section 10.1.

The NPV analysis presented in Section 8.1 and discussed in Section 10.4 highlights some examples of interventions that have fairly straightforward business models associated with them (i.e., REPLICATE data has indicated a positive NPV) and there are also some examples of capital investments that have been covered by amortisation. The 'leading contenders' for raising the finance required are the 'EU SPV Model', the 'ESCO Model', and the 'USA SPV Model'. These models have some heavy financial lifting to do, as indicated by Bristol's City Leap tender documents and Essen's Klimastadtplan. However, there are also some doubts too about the future of the 'ESCO Model' in the UK, as both Bristol Energy and Robin Hood Energy (Nottingham) have recently been sold. Despite the clear viability of the 'EU Municipal Green Bond Model', it was largely rejected by the REPLICATE partners for possible use in the 2021–2025 and 2025+ timeframes (Table 8). This places even more reliance on the 'leading contender' Models. Therefore, whilst we believe the EIP-SCC challenge has been solved, it has only been done so by the reinterpretation of the instrumental replicable business model at a different, much larger, scale. There is also a sense that whilst the 'EU SPV Model', the 'ESCO Model' could be used to address the totality of the remaining financing gap that a Municipality is facing they also seem potentially fragile, either resulting in exit (i.e., examples of the demise of the 'ESCO Model' in the UK) or the possible migration to the 'USA SPV Model'.

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13. Lessons Learned

The main lessons learned from the work in this Task and generally for the Work Package were threefold.

The first is that the financial environment in which the replicable city business model was to be investigated is undergoing considerable development and that the landscape that existed at the time of the REPLICATE project proposal (REPLICATE Project Consortium, 2015) is considerably different from the time of writing this Deliverable. The literature reviews in both D2.3, "*Internal Report on Findings*" and this Deliverable are mostly based on sources that were published after the start of the REPLICATE project. Developments such as the emerging EU Green Bond Standard and the EU Green New Deal are both likely to play an increasingly important role in enabling municipalities obtain the financing they require for interventions in their cities.

The second lesson is that the empirical basis for searching for validation for replicable business models in the REPLICATE project is not ideal. The data from the interventions analysed were from interventions that were ostensibly funded, to a large extent, from EU grant funding (Model 1 in Section 7). Inferring from these funded interventions to their potential replicability 'beyond SCC' funding has been an exercise in extrapolation and interpretation. The question would have been better answered by reference to interventions, current and planned, that were outside the REPLICATE project funding.

Finally, the third lesson is that research is never ended. Delving into the question of replicability of business models has inevitably raised even more questions. Some of these are emerging research questions with some promise of rich dividends if pursued with appropriate funding. They are offered here in the following Sections 13.1, 13.2 and 13.3 as suggestions for further work.

13.1 SPV Related Questions

The value of SPVs, as shown by their actual use or the declared intention to use the 'EU SPV Model', is an interesting finding that suggests a number of research questions that should be pursued. The value engineering implicit in the Model seems to be the *affordance* that a SPV offers Municipalities to creatively use a business entity for policy objectives, but at an arms-length distance. The SPV has none of the financial constraints of a municipality, especially in terms of access to the capital markets for debt finance, and can implement the objectives of the municipality as if it were an operating division so long as it confirms to the ownership and

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control parameters defined by the precedent set by the ECJ ruling on the Teckal Exemption (Yearworth, 2020, p. 32). However, with this financing freedom[41] the Model also introduces some serious concerns about democratic accountability, as discussed at various points in Section 12 below and also previously by Yearworth (2020, pp. 72-75).

Whilst there are some parallels between the 'EU SPV Model' and the 'ESCO Model', comparatively little research has been reported about the former, and none that specifically mentions Teckal Exemption[42]. Given the role that SPVs are likely to have to play in the future transition pathways for cities, especially in the UK, more attention needs to be given to their advantages and disadvantages, as well as full consideration given to their relationship with the 'ESCO Model' and use of EPCs, and the extensive experience in the USA of the use of SPVs (i.e., the 'USA SPV Model') and their relationship to the Municipal Bond market.

It is clear that there is an emerging tension centred on the role that SPVs are playing and will play in the future financing of climate change interventions in cities. We thus posit the Municipal SPV as a *pivotal entity* that can facilitate a wide degree of financial flexibility, i.e., movement in either direction – towards a closely aligned ownership relationship with the Municipality, or quite at 'arms-length'. We have data that pin-point precise positions on this continuum e.g., SILFI – Florence (Model 3a), City Leap – Bristol (Model 3), FSS – San Sebastián (Model 3B, Model 4a, Model 5a).

13.2 Pathways to Green Finance

The apparent convergence of the evolution of the 'EU SPV Model' to the 'USA SPV Model' via the 'Transitional Model' and the emergence in Europe of the 'EU Municipal Green Bond Model' represent two different pathways towards solving the financing problem ending up in the same market destination. However, despite both the 'USA SPV Model' and the 'EU Municipal Green Bond Model' both issuing Green Bonds (i.e., New York Metropolitan Transport Authority and Gothenburg) they represent fundamentally different evolutionary positions. The 'EU Municipal Green Bond Model' exemplifies the *centrality* of municipal ownership and control without the need to resort to elaborate mechanisms that involve creating SPVs. It is the Municipality itself that is the issuer of the Green Bond and the subject of rating. Whereas, the 'USA SPV Model' exemplifies the value engineering necessary in the USA to establish SPVs with arms-length

[41] And other freedoms, such as being able to offer different conditions of employment compared to those of a municipality.
[42] The search for TITLE-ABS-KEY ("Teckal Exemption") on Scopus returned zero documents.

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ownership and control. In REPLICATE we have examples of the 'EU SPV Model' in use in the case of SILFI in Florence and Bristol Waste/Goram Homes in Bristol, with the City Leap procurement process still ongoing. In San Sebastián we have the example of dBus as a variation on the 'USA SPV Model' (Model 5a in Section 7.11.7).

A further question emerges that cannot be answered in this work – how long will these municipalities be able to maintain ownership and control of their SPVs? This is raised in the light of points made in the discussion in Section 12.6. Is the trajectory via the 'Transitional Model' to the 'USA SPV Model' really only hypothetical? Is the 'USA SPV Model' just an example of path dependency unique to the USA (and similar countries) and something that is not necessary or can be avoided in Europe? On the other hand, in Section 12.6, the concept of re-municipalisation of infrastructures is introduced. Is it possible that the Teckal exempt SPV, as already used by municipalities, can be used as a vehicle or channel through which infrastructures currently outside of municipal control can be brought back into a form of public ownership? Only time, and the continuous monitoring and evaluation of the use of SPVs in Europe, will provide an answer.

13.3 Gap Analysis

The across-the-board applicability of the 'Direct Model' and the critical contribution it will make towards a city reaching its climate change targets should really stimulate further work by cities in trying to measure the amounts of capital finance flowing from Financial Institutions to Intervention Beneficiaries. It should also provoke scholarly activity into the relationship between the Municipality and the citizen, especially in regard to the 'gap in the gap' – that is, the difference between the Municipal-owned or Municipal-responsible targets and the overall target of the Municipality that the Direct Model, or variants, will have to address.

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14. Innovation Impacts and Scalability

The main objective of Work Package 2 was to develop an understanding of the relationship between strategic planning and the replicability of business models in the financing of the smart city. Specific objectives were i) transferring of the STEEP Methodology to the Follower Cities (Task 2.1), ii) developing business models in the Lighthouse Cities using the VCE and CMC Methodologies (Task 2.2), iii) analysing the learning from pilots' initial business plans for extension beyond SCC1 (Task 2.3), and iv) validating the replicability of city business models (Task 2.4). The innovation impacts and scalability of Tasks 2.1 to 2.3 have been reported already in Deliverables D2.1, "*Report on Follower City Workshops*", D2.2, "*Report on the Business Models of the Lighthouse Cities*", and D2.3, "*Internal report on findings*". The report on the replication potential of city business models, D2.4, is this Deliverable and for completeness the key innovation impacts and scalability for the whole Work Package are summarised in the sub-sections below.

Due to the research focus of this Work Package the main impacts are essentially

1. Methodological contributions that advance the start of the art across a range of approaches of importance to the smart city in progressing towards achieving climate change targets, and
2. Specific findings relating to the core question of replicable business models and the emergent question of their relationship to smart city finance

Furthermore, as highlighted in the Review of Purpose in Section 5.6, the impacts of the cross-cutting Work Packages are likely to be realised beyond the end of the REPLICATE project and not immediately measurable. Impact from publication of scientific results will take some time to be measurable by citation counts and downloads due to the relatively slow pace of peer review. Tracking of citation counts for the two main academic authors in this Work Package can be monitored via Google Scholar and Scopus

https://www.scopus.com/authid/detail.uri?authorId=56382542600 (Pardo-Bosch)
https://scholar.google.com/citations?user=WUktXHoAAAAJ (Yearworth)
https://www.scopus.com/authid/detail.uri?authorId=6602655577 (Yearworth)

14.1 Cooperation

The results obtained in this cross-cutting Work Package were only possible by the extensive cooperation achieved with the partners in the REPLICATE project and not least in the transfer of Work Package leadership from the University of Bristol to the University of Exeter in M8.

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The collaborating partner in the Work Package has been ESADE Business School, leading Task 2.2. Achieving successful delivery of Task 2.1 required close collaboration with the municipalities of Nilüfer, Lausanne, and Essen and their associated partners to transfer the STEEP Methodology for the development of smart city plans (SCPs). The data collection that formed the basis for Task 2.3 in the process of analysing the learning from pilots' initial business plans required collaboration with the municipalities of San Sebastián (WP3), Florence (WP4), and Bristol (WP5) and their associated project partners. The more extensive three rounds of data collection for Task 2.4 required, in addition to the existing cooperation of the Lighthouse Cities, collaboration with the Follower Cities too. Furthermore, there was close cooperation with SPES (WP7) to understand their analysis of Management Models (D7.5) and Replication Plans (D7.6).

14.2 Innovation solutions

The following innovation solutions have been developed in this Work Package

14.2.1 Refinement of the STEEP Methodology

The STEEP Methodology is a fully open-source methodology to enable multi-organisational stakeholder groups to create systems models of the transformations required to meet objectives in complex settings such as the smart city. In this methodology, systems are modelled using Hierarchical Process Models (HPM) (Yearworth, 2021). Originally developed for the STEEP project (Yearworth, 2013; Yearworth, Schien & Burger, 2014), the approach has been refined in the REPLICATE project and has been incorporated into the EIP-SCC Smart City Guidance Package (European Innovation Partnership on Smart Cities and Communities, 2019).

14.2.2 Development of the City Model Canvas (CMC) approach

The main output of Task 2.2 led by ESADE was the definition of City Model Canvas (CMC). Based on the Business Model Canvas for firms, the CMC is a graphical tool to analyse the elements of a city's business model holistically and visually. It shows the elements that city councils should consider during the design, delivery and assessment of smart services, including the smart service's expected economic, environmental and social impacts (Timeus, Vinaixa & Pardo-Bosch, 2020).

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14.2.3 Value Creation Ecosystem (VCE) modelling

Details of the contribution that the VCE modelling can make can be found in D9.2, "*Methodology review and methodological framework definition*". The value of the approach has been discussed above in Section 10.6.

14.2.4 Process Measurement Methodology with Uncertainty

This is an improvement of the original ad hoc 'Italian Flag' measurement technique for the evaluation of process performance in Hierarchical Process Models (HPM). This makes use of both expert judgement of process performance and an explicit assessment in the confidence in that judgement. Processes judged to be performing badly (mainly coloured red) and/or processes with a high degree of uncertainty in their assessment (mainly coloured white) become the focus for taking action (red → improve, white → investigate) (Lowe, Espinosa & Yearworth, 2020).

14.2.5 Smart City Strategy Index (SCSI) Methodology

A methodology for assessing the strategic capability of the smart city as a network of cooperating actors. Theoretically grounded in Strategy as Practice and based on the use of the REPLICATE strategy survey instrument, the technique derives a Smart City Strategy Index (SCSI) as a second order latent factor in a Structural Equation Model (SEM).

14.2.6 Capability Improvement Framework

The results of a qualitative analysis into the approaches taken by the Lighthouse cities in financing and managing smart city projects expressed as a Capability Improvement Framework. Each of the 9 processes can be used as the basis of a new transformation project using the STEEP methodology. The framework is summarised below in Figure 8.

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Figure 8. Capability Improvement Framework (summary view of the meta-level summary of a set of 9 processes that would be required to initiate any transformation in the smart city context (D2.3 p66)).

14.2.7 Mapping of Smart City Business Models to Generic VCE models

This final innovation is the subject of this deliverable and will be submitted for academic publication in an appropriate peer-reviewed journal in due course. Three "Leading Contender" VCE models have been identified that will likely form the mainstay of financial scale-up and replication efforts across EU municipalities. The "EU SPV Model" has been shown to be a *pivotal entity* that can facilitate a wide degree of financial flexibility for Municipalities, either towards a closely aligned ownership relationship or quite at 'arms-length'.

14.2.8 Summary of Innovation

The main innovations from this Work Package are methodological and this is reflected in the nature of the results presented in this Deliverable and across the whole Work Package. The STEEP Methodology was a development of a soft system methodology for multi-organisational groups working on smart city planning and has been further refined in REPLICATE. The Value Creation Ecosystem (VCE) methodology has been repurposed to represent generic value flows in a hybrid commercial/municipal ecosystem. The Process Measurement Methodology with Uncertainty has refined the original ad-hoc Italian Flag scoring mechanism to a defined dual five-point Likert scale measure making it simpler to use. The development of the Smart City

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Strategy Index (SCSI) is entirely *de novo* and is targeting both uptake by agencies responsible for measuring/assessing strategic capability (e.g., for rating and ranking purposes) and also being submitted for publication in a leading strategy journal. Even though the Capability Improvement Framework (from Task 2.3) and the Mapping of Smart City Business Models to Finance Mechanisms in this Deliverable represent summative results from the analyses carried out across this Work Package, they nonetheless illustrate the product from these methodological innovations and how they interrelate.

14.3 Replication and scalability potential

14.3.1 Refinement of the STEEP Methodology

In addition to the development of this Problem Structuring Method (PSM) in the STEEP project and refinement in the REPLICATE project it has already been widely used in consulting projects over a long period of time (Davis, MacDonald & White, 2010; Lowe, Espinosa & Yearworth, 2020; Marashi & Davis, 2006). The methodology was transferred to the Follower Cities through training workshops (T2.1, D2.1). Furthermore, the methodology is currently being used via an online Group Support System (GSS) in the EU CoME EASY Project[43]. Finally, the methodology is 'open source' and freely available in the public domain and is currently being written-up for publication as a book chapter (Yearworth, 2021).

14.3.2 Value Creation Ecosystem (VCE) modelling

The VCE modelling methodology used in D2.3, used extensively in Work Package 7, and central to the work in this Deliverable to model the possible financing models for smart city projects can be widely used. It is clearly applicable to academic publishing (Pardo-Bosch, Cervera & Ysa, 2019) and applied retrospectively to interpret previously published work (see

[43] https://www.come-easy.eu/welcome-to-the-european-energy-award

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Appendix D – Characteristics of ESCO and EPC Models).

14.3.3 Smart City Strategy Index (SCSI) Methodology

This is positioned for adoption by either the EIP-SCC, Eurostat, or could form part of an evaluation methodology by a credit rating agency in association with issuing green bonds. Beyond the REPLICATE project there is an ongoing activity that is currently setting up for further data collection; the Making City project[44] stakeholder maps are helping with identification of the correct stakeholders to survey. This work will be written-up for publication in a leading journal.

[44] https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/smart-cities-communities/making-city

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15. Conclusions

We have shown that achieving replicable business models is not the core problem to be solved in order to offer municipalities a way forward in their commitments to achieving climate change targets. We have argued at length for a change in focus to the question of financing the capital investments required and the range of financing models that municipalities can implement to raise the necessary finance. Therefore, to give this deliverable a figurative epitaph we can summarise our conclusions simply. The problem facing cities in scaling-up interventions to meet their climate change targets is not the absence of available capital in the world – in fact there seems to be a surplus that is enthusiastically looking for green investment opportunities (International Renewable Energy Association, 2020; Kidney, 2020; Smart Cities Marketplace, 2020), backed up by organisations willing to certify the label. Nor is there an absence of industries ready to sell technical solutions – market projections are strong; most of the technology needed is ready and firms are eagerly looking for customers. The problem is that to place the *burden* on municipalities to solve the business model problem that would connect these two willing constituencies together, the ostensible purpose of this project, would seem to be an abrogation of responsibility on the part of our Governments, who should really be providing the necessary capital investment at city level to bridge the financing gaps that municipalities are facing. As discussed in Section 10.4 the replicable business model problem, from a Net Present Value perspective, is only partially solved. Further effort to solve this problem in a definitive manner is probably not justified from an EU funding perspective, although business model innovation is obviously an ongoing and vibrant activity – at least in the pages of academic journals as we have shown in our review. However, time is running out and without a breakthrough in replicability, which in our opinion we believe is unlikely, Governments (National and/or Regional) need to act now and start making major investments. Without this, municipalities will struggle to bridge the financing gap they are currently facing and will be forced to resort to ever more elaborate forms of financialisation. On the one hand, in one example municipality we have studied – Gothenburg and their issue of Green Bonds – this seems to be an entirely manageable approach and therefore a positive development that can be repeated; but seemingly only by those cities equivalently endowed with the revenue-generating assets necessary to sustain the debt repayments. On the other hand, we have seen in the REPLICATE project evidence for a viable EU SPV model in a variety of guises with wide applicability. Whether this is a step towards the approach widely adopted by municipalities in the USA and the emergence of the municipal bond market and its evolution or absorption into a green bond market remains to be seen. Either way, these represent ways forward for securing

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immediate access to capital investment that can be implemented today, but perhaps at the significant cost of storing up problems for later.

"*If a problem cannot be solved, enlarge it*" – Eisenhower

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Appendix A – Bond Issues by the City of Gothenburg

Schedule of recent Euro Medium Term Notes (EMTN) issued by the City of Gothenburg[45].

Issues under EMTN			
Month/Year	**Amount**	**Tenor**	**Level**
Nov-19	1000 MSEK	6 years FIX	MS + 16 bp (kupong 0,455)
Nov-19	1000 MSEK	6 years FRN	STIBOR 3M + 16 bp
Sep-19	300 MSEK	6 years FRN	STIBOR 3M + 12 bp
Sep-19	1500 MSEK	6 years FIX	MS + 12 bp (coupon 0,214)
Jun-19	300 MSEK	5 years FIX	MS + 8 bp (coupon 0,27)
Jun-19	1200 MSEK	5 years FRN	MS + 8 bp
Feb-19	1800 MSEK	5 years FRN	MS + 17 bp
Oct-18	1000 MSEK	6 years FRN	MS + 21 bp
			MS + 21 bp
Oct-18	500 MSEK	6 years FIX	Coupon 1,00 %
			MS + 16 bp
Mar-18	400 MSEK	5 years FIX	Coupon 0,735 %
Mar-18	900 MSEK	5 years FRN	STIBOR 3M + 16 bp
Nov-17	750 MNOK	5,25 years FRN	NIBOR 3M + 19 bp
Oct-17	1500 MSEK	5 years FRN	STIBOR 3M + 26,5 bp
Oct-17	350 MSEK	5 years FIX	MS + 26,5 bp (coupon 0,75%)
Aug-17	500 MSEK	8 years FRN	STIBOR 3M + 36 bp
Aug-17	500 MSEK	7 years FRN	STIBOR 3M + 43 bp
Jun-17	1200 MSEK	6 years FIX	MS +26 bp (coupon 0.625 %)
Mar-17	700 MSEK	4 years FRN	STIBOR 3M +100 bp
Mar-17	500 MNOK	4 years FRN	NIBOR 3M +17 bp
Dec-16	320 MNOK	3 years FRN	NIBOR 3M +10 bp
Sep-16	650 MSEK	5 years FIX	MS +30 bp (coupon 0,25 %)
Sep-16	1350 MSEK	5 years FRN	STIBOR 3M +30 bp (issue price 103,572)
Jun-16	1000 MSEK	6 years FIX	MS +51 bp (coupon 0.885 %)
Apr-16	1350 MSEK	5 years FIX	MS +47 bp (coupon 0.83 %)
Feb-16	200 MSEK	20 years FIX	MS +80 bp (coupon 2.75 %)
Feb-16	700 MNOK	4 years FRN	NIBOR 3M +15 bp (expansion)
Feb-16	500 MNOK	3 years FRN	NIBOR 3M +25 bp (expansion)

The bonds have been issued in both Swedish Krona and Norwegian Krone. The total in this table is equivalent to €2.15 Billion.

Key:
EMTN – Euro Medium Term Notes. A Flexible source of medium-term debt
FRN – Floating interest rate (but only up to 5 years)
FIX – Fixed interest rate
STIBOR – Stockholm Interbank Offered Rate (3M – 3 months)

[45] See https://finans.goteborg.se/en/finance/most-recent-issues-2/

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NIBOR – Norwegian Interbank Offered Rate (3M – 3 months)
MS – Mid-swap
bp – Basis points (a difference of $^{1}/_{100}{}^{\text{th}}$ of one percent i.e. 0.01%)

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Appendix B – Bristol's City Leap Process

Update on Bristol's City Leap process presented to Cabinet on the 2nd June 2020 (Focus on evidence base details)[46].

[46] See https://democracy.bristol.gov.uk/documents/s49367/2020%2006%2002%20Cabinet%20Decision%20Pathway%20-%20City%20Leap%20Energy%20Partnership%20update.pdf

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Decision Pathway – Report

PURPOSE: For reference

MEETING: Cabinet

DATE: 2 June 2020

TITLE	**City Leap Energy Partnership - Update for Cabinet**	
Ward(s)	**All**	
Author: David White		**Job title: Head of Energy Services**
Cabinet lead: Cllr Kye Dudd		**Executive Director lead: Stephen Peacock**
Proposal origin: *BCC Staff*		
Decision maker: Cabinet Member **Decision forum:** *Cabinet*		
Timescales: Cabinet Approval 2nd April 2019 – Update 2 June 2020		
Purpose of Report: This report provides the Mayor and Cabinet with an update on the work undertaken for the procurement of the Strategic Partner for the City Leap Energy Partnership.		

Evidence Base:

Bristol City Council was the first local authority in the UK to declare a 'climate emergency' and has brought forward its internal and city-wide targets for carbon neutrality to better reflect the short window of opportunity that remains to reduce the city's carbon emissions to zero. Bristol enjoys a global reputation as a leading energy city and has made significant progress in reducing its carbon emissions; however, despite having invested over £50m in low-carbon energy infrastructure and projects over the last decade, the pace of delivery must increase significantly if we are to play our full part in addressing the climate emergency and meet our 2030 goal for carbon neutrality.

City Leap aims to build on the innovative leadership the council has shown in energy and sustainability over almost three decades to deliver a local interconnected, low carbon, smart energy system in Bristol that provides long-term social, environmental and economic benefits for its residents, communities and businesses.

This transformation will involve the build out of significant low carbon energy infrastructure, such as heat networks, renewable energy generation, battery storage and energy efficiency, which will require substantial levels of capital investment; levels that the council cannot deliver alone. Therefore, one of City Leap's main aims is to attract, facilitate and deliver at least £1bn of low carbon and smart energy infrastructure investment in Bristol's energy system.

To assist with attracting this investment, in May 2018, the council published the City Leap Prospectus, which set out the council's past successes, current programme of low carbon energy projects and future investment opportunities in relation to low carbon energy within the council's estate and across the city. The response to the City Leap Prospectus exceeded the council's expectations with 180 Expressions of Interest being submitted containing a wide range of proposals.

The council subsequently undertook an extensive soft market testing phase, meeting with organisations that submitted Expressions of Interest, and completing its own comprehensive options appraisal. This led to the council selecting a preferred model to deliver City Leap involving the setting up a joint venture with a Strategic Partner. Establishing this joint venture will merely be the start of the City Leap journey, as the partnership required to deliver Bristol's future low carbon, smart energy system will need to be flexible and inclusive in its approach, bringing in new projects, innovation and partners over time as Bristol progresses towards carbon neutrality.

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Following approval of the Cabinet Report, 'City Leap Energy Partnership', in April 2019, the council commenced the procurement of a Strategic Partner for the joint venture in September 2019, including hosting a Bidders' Day event at City Hall, which attracted over 70 organisations. Following the initial selection stage of the procurement, eight Bidders were selected to procced to the next stage. Due to the innovative nature of City Leap, this second stage was designed to obtain feedback from Bidders on key points of the procurement to ensure the market could provide the best response and consisted of three rounds of face-to-face meetings with Bidders held over a period of six weeks, finishing on 5 March 2020. This enabled the council to gain valuable and extensive feedback across a range of topics from Bidders, with strong interest being shown by all Bidders in the low carbon energy infrastructure investment opportunities available under City Leap. The feedback received from Bidders required consideration and discussion with Cabinet Members and senior officers to determine whether any changes should be made to the procurement. These discussions had to be delayed given the absolute priority for the council to fully focus on its response to the coronavirus pandemic. Accordingly, the decision was taken in mid-March to delay the third stage of the procurement, when Bidders would have been invited to submit initial bids, for an unspecified period of time. Separately to the City Leap procurement exercise, the Council has commissioned consultants EY to support Bristol Energy in determining the optimal business strategy for the company going forwards which will be presented to Cabinet on the 2nd June 2020. Irrespective of the outcome of this assessment, following the feedback received from Bidders the council is confident that there is strong interest in the low carbon energy infrastructure investment opportunities available under City Leap. Having now considered the feedback received from Bidders, the council intends to make a number of changes to the City Leap Energy Partnership procurement in order to deliver the best possible outcome for Bristol. Some of these changes materially affect the nature of the procurement and, following legal advice, the council therefore has decided to formally bring the current City Leap Energy Partnership procurement exercise to an end and to recommence with a revised and simplified procurement exercise. Cabinet approval for this revised approach to the City Leap Energy Partnership procurement will be sought at Cabinet on 14 July 2020 and the revised procurement will commence as soon as practicably possible thereafter.
Cabinet Member / Officer Recommendations: 1. To note the decision to bring the current procurement to an end and to restart a revised procurement process subject to a further Cabinet Decision in July.
Corporate Strategy alignment: 1. The City Leap Energy Partnership is intended to deliver the £800m to £1bn investment referenced under the second Wellbeing Key Commitment in the Corporate Strategy 2018-23, which was approved by Full Council in February 2018, 'Keep Bristol on course to be run entirely on clean energy by 2050 whilst improving our environment to ensure people enjoy cleaner air, cleaner streets and access to parks and green spaces.'
City Benefits: 1. Keep Bristol on course to be run entirely on clean energy by 2050 by delivering £800m to £1bn of investment in the city's low carbon, smart energy system. 2. Improve our environment to ensure people enjoy cleaner air through supporting the further deployment of renewable energy generation and electric vehicles. 3. Improve physical and mental health and wellbeing by making residents' homes warmer and cheaper to heat, reducing inequalities and the demand for acute services. 4. Tackle food and fuel poverty by reducing energy bills. 5. Create jobs, contributing to a diverse economy that offers opportunity to all and makes quality work experience and apprenticeships available to every young person.
Consultation Details: 50+ briefings provided to the Mayor, Cabinet Member Briefings, Oversight & Scrutiny Management Board, Growth

2

Version May 2019

Status of the City Leap Process as at January 2021

The City Leap team provided an update to Cabinet on the 2nd of June 2020.

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> "*Earlier this week, Cabinet took the decision to sell Bristol Energy after carefully reviewing a number of options.*
>
> *You might be wondering what this means for our internal Energy Service and the City Leap initiative; The council's Energy Service is entirely separate to Bristol Energy and will continue to deliver projects to decarbonise the city including renewable energy, energy efficiency, electric vehicle charging and Bristol's low carbon heat network in support of the Mayor's ambition for Bristol to be carbon neutral by 2030.*
>
> *The City Leap initiative will also continue, but without Bristol Energy as a partner. City Leap is an ambitious project which seeks to greatly increase the number of low carbon projects, initiatives and opportunities across the whole city. The ultimate goal of City Leap is to support the delivery of a carbon neutral Bristol by 2030 by attracting up to £1 billion of investment in different low carbon energy infrastructure opportunities on the council's estate and across the city."*[47]

Following from this renewed scrutiny into the process, the City Leap procurement was re-launched publicly on the 7th August 2020 with a Concession Notice for Services (373755-2020) published in the Official Journal of the EU (Bristol City Council, 2020a) and is summarised in Appendix C – Bristol City Leap Process Tender Document (Extract). There appears to be no significant differences with the first notice published in September 2019 – apart from the almost one year delay (Bristol City Council, 2019b).

A further update about the City Leap process was presented to Cabinet on the 1st December (Bristol City Council, 2020b) and revealed that the following bidders were through to the next round to be selected as the City's Strategic Partner

- Ameresco Limited, with Vattenfall Heat UK Limited as an Essential Sub-Contractor
- E.ON UK PLC and Marubeni Corporation (acting as a consortium)
- ENGIE Services Holding UK Ltd and Sumitomo Corporation (acting as a consortium), with Abundance Investment Ltd as an Essential Sub-Contractor

[47] https://news.bristol.gov.uk/news/cabinet-agrees-sale-of-bristol-energy

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Appendix C – Bristol City Leap Process Tender Document (Extract)

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United Kingdom-Bristol: Energy and related services

2020/S 152-373755

Concession notice

Services

Legal Basis:
Directive 2014/23/EU

Section I: Contracting authority/entity

I.1) **Name and addresses**
Official name: Bristol City Council
Postal address: PO Box 3399
Town: Bristol
NUTS code: UKK SOUTH WEST (ENGLAND)
Postal code: BS1 9NE
Country: United Kingdom
Contact person: Ade Bakare
E-mail: ade.bakare@bristol.gov.uk
Telephone: +44 1179222000
Internet address(es):
Main address: www.bristol.gov.uk
Address of the buyer profile: www.bristol.gov.uk

I.3) **Communication**
The procurement documents are available for unrestricted and full direct access, free of charge, at: https://procontract.due-north.com/
Additional information can be obtained from the abovementioned address
Applications or, where applicable, tenders must be submitted electronically via: https://procontract.due-north.com/

I.4) **Type of the contracting authority**
Regional or local authority

I.5) **Main activity**
General public services

Section II: Object

II.1) **Scope of the procurement**

II.1.1) **Title:**
City Leap Energy Partnership
Reference number: DN484211

II.1.2) **Main CPV code**
71314000 Energy and related services - KA16

II.1.3) **Type of contract**
Services

II.1.4) **Short description:**
Bristol City Council is seeking to appoint a strategic partner to form a long term corporate joint venture with the Council, the City Leap Energy Partnership, to provide and secure low-carbon energy-related investment and expertise to deliver City Leap's Strategic Objectives. The City Leap Energy Partnership will provide opportunities for the development, construction, and financing of low-carbon energy-related projects and delivery of associated services to assist with meeting Bristol's carbon neutrality targets. It will also afford the opportunity to provide certain services (detailed below) to other public bodies in the South West region.
The procurement will be governed by Concession Contracts Regulations 2016 (including any amendments/variations /transitional provisions that apply to this procurement).

II.1.5) **Estimated total value**
Value excluding VAT: 12 000 000 000.00 GBP

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City Leap Energy Partnership

Main contract details

Opportunity Id	DN484211
Title	City Leap Energy Partnership
Categories	66122000-1 - Corporate finance and venture capital services 71314000-2 - Energy and related services
Description	Bristol City Council is seeking to appoint a Strategic Partner to form a long term corporate joint venture with the Council, the City Leap Energy Partnership, to provide and secure low-carbon energy-related investment and expertise to deliver City Leap's Strategic Objectives. The City Leap Energy Partnership will provide opportunities for the development and construction of low-carbon energy-related projects and delivery of associated services to assist with meeting Bristol's carbon neutrality targets and potentially those of other Local Authorities in the South West region.
Region(s) of supply	UNITED KINGDOM
Estimated value	£12,000,000,000.00
Keywords	Low carbon energy, Low carbon infrastructure, Smart energy system, Low carbon energy investment, Affordable clean energy, Energy efficienies

Key dates

Estimated contract dates

Start date 07/07/2021 **End date** 05/07/2041

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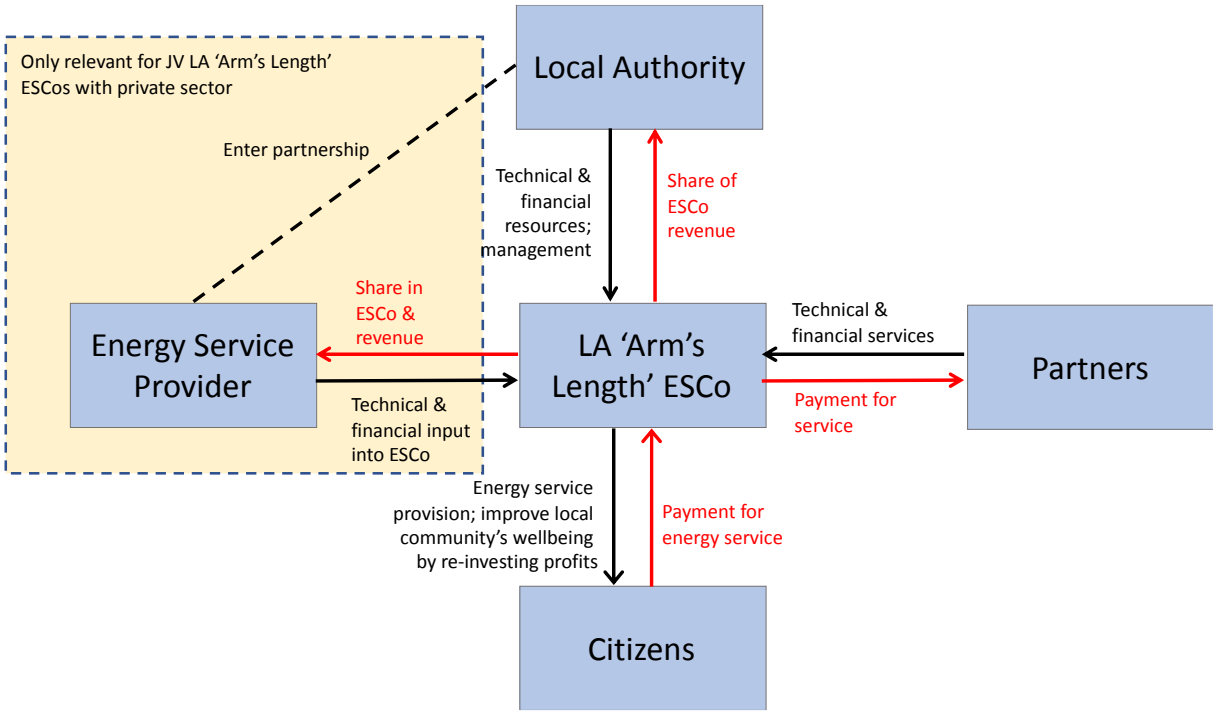
Appendix D – Characteristics of ESCO and EPC Models

The following Figure and Table are adapted from Hannon and Bolton (2015). The Figure has been re-drawn in the in the style of the VCE models shown in Section 7. Note that in the original, Citizens were identified as 'Customer Base'. The change has been made here to reflect a consistent naming of actors established in Table 4.



Characteristics	Rationale for engagement	Potential limitations	Examples
• Wholly owned by the LA, unless a joint-venture with a private sector partner • 'Not-for-profit' financial model where profits are recycled into future LA initiatives	• All profit generated fed back into other LA 'common good' activities • Activities are specifically tailored to help LA deliver on its political objectives • ESCo is a separate legal entity thus insulating LA from	• Still exposed to some financial and technical risk • LA may lack necessary resources, experience, expertise and/or political will to 'start up' and operate an ESCo • Unsuccessful projects could undermine the	• Aberdeen Heat & Power (owned by Aberdeen City Council) • Enviroenergy (owned by Nottingham City Council) • Pimlico District Heating Under-taking (owned by

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• Operations typically limited to the local area	majority of risk associated with its operations • Can develop long term energy strategies • Finance can be raised from public and private sectors • Successful projects provide LA with greater legitimacy as energy governance actor	LA's legitimacy, especially on managing key energy issues • Lack of political will and central government pressure to take a lead on local energy issues	Westminster City Council) • Thameswey Energy (owned by Woking Borough Council

The following table is reproduced from Carbonara and Pellegrino (2018).

EPC models	Risk allocation		Provision of finance		Contract duration	ESCO's remuneration
	ESCO	Customer	ESCO	Customer		
Shared Savings	Performance risk Financial/ credit risk	Part of performance risk	X		fixed period	Pre-arranged percentage of savings
Guaranteed Savings	Performance risk	Financial/credit risk		X	fixed period	Based on demonstrated performance; if the savings are less than expected the ESCO covers the shortfall
First Out	Performance risk Credit risk		X		variable period	ESCO receives 100% of energy savings each year, until it has recovered its original capital and the rate of return

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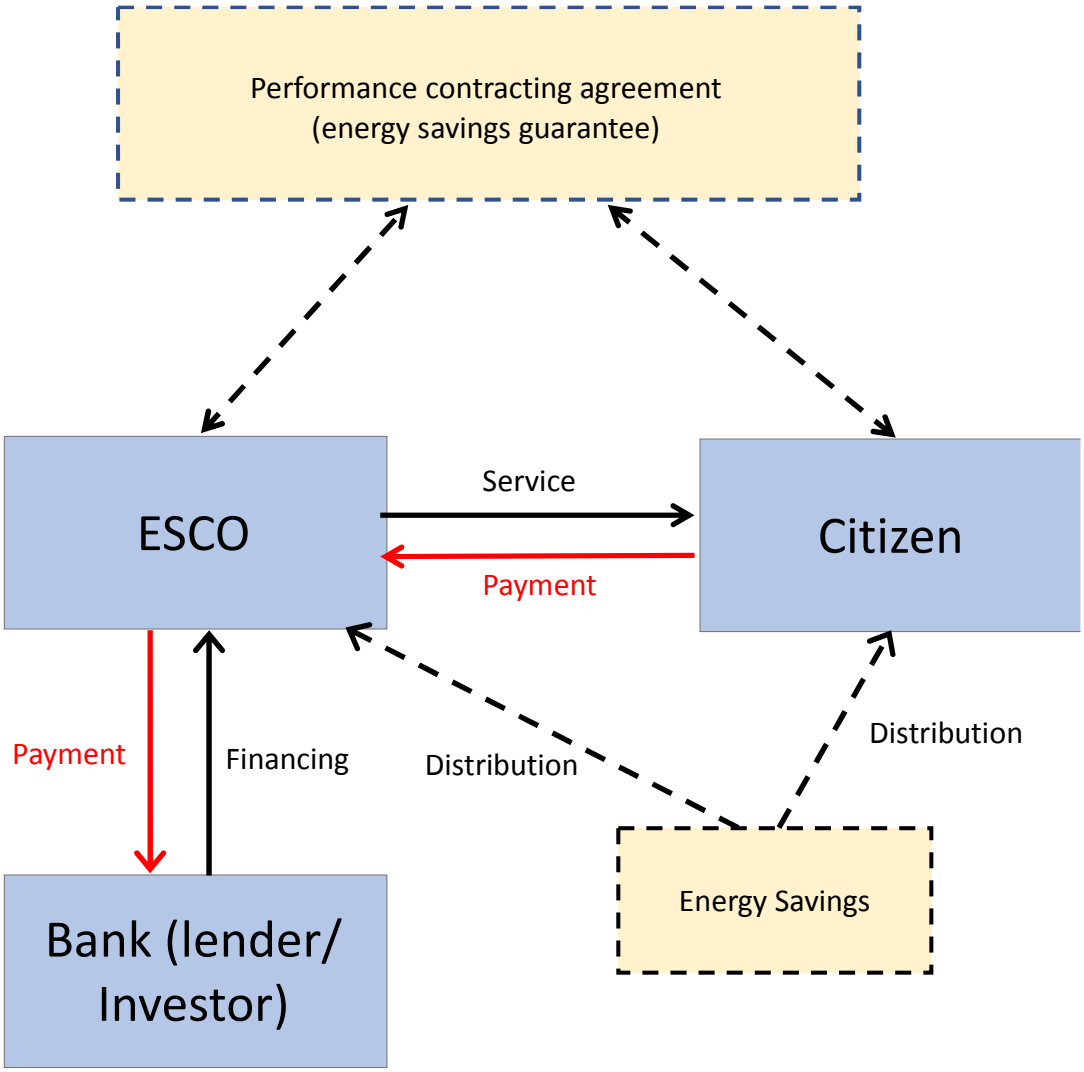
The following models are adapted from Shang et al. (2017) and re-drawn to reflect the VCE Model style adopted in Section 7 and where Client in the original has been re-labelled as Citizen to reflect the consistent actor naming established in Table 4.



Shared Savings Model

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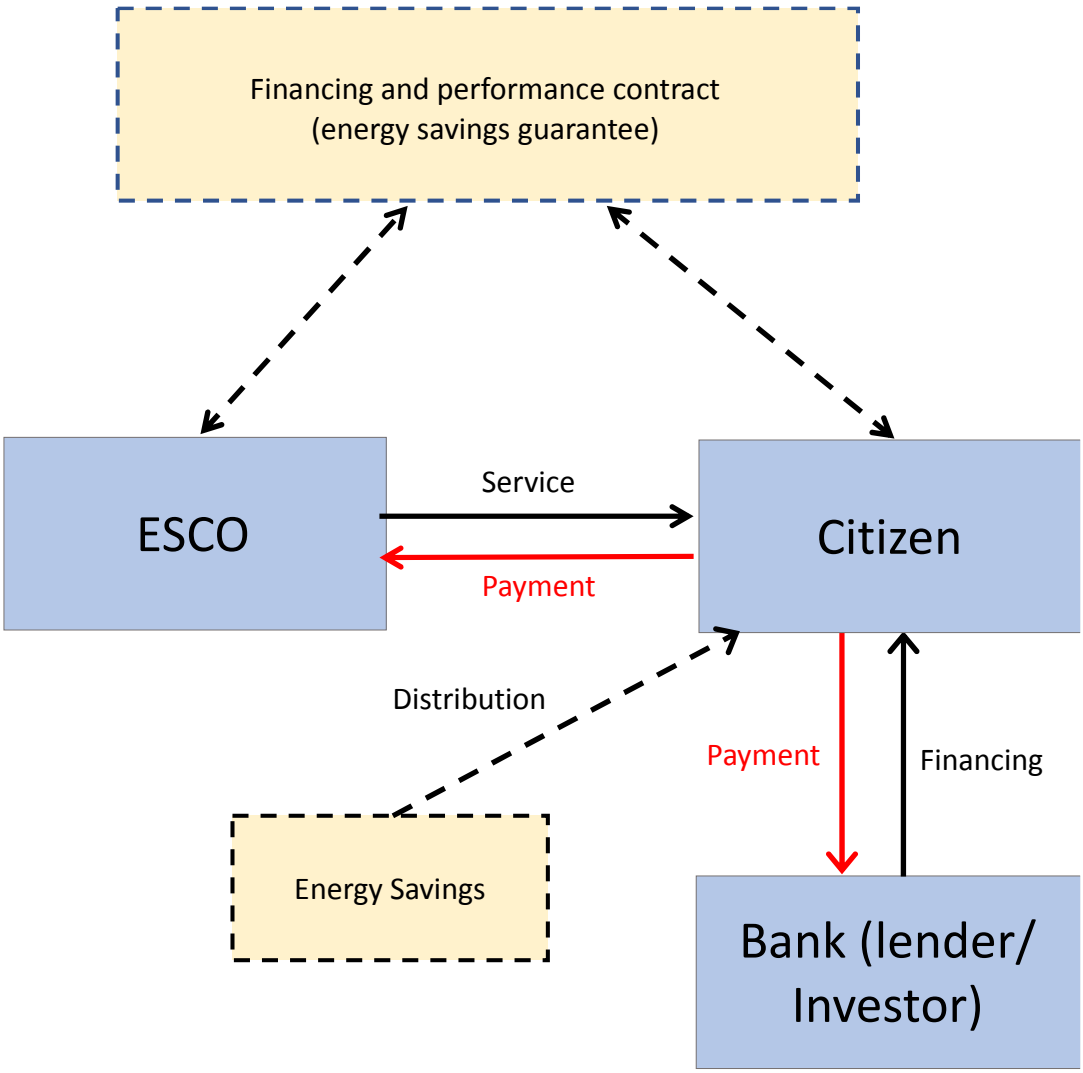

Guaranteed Savings Model

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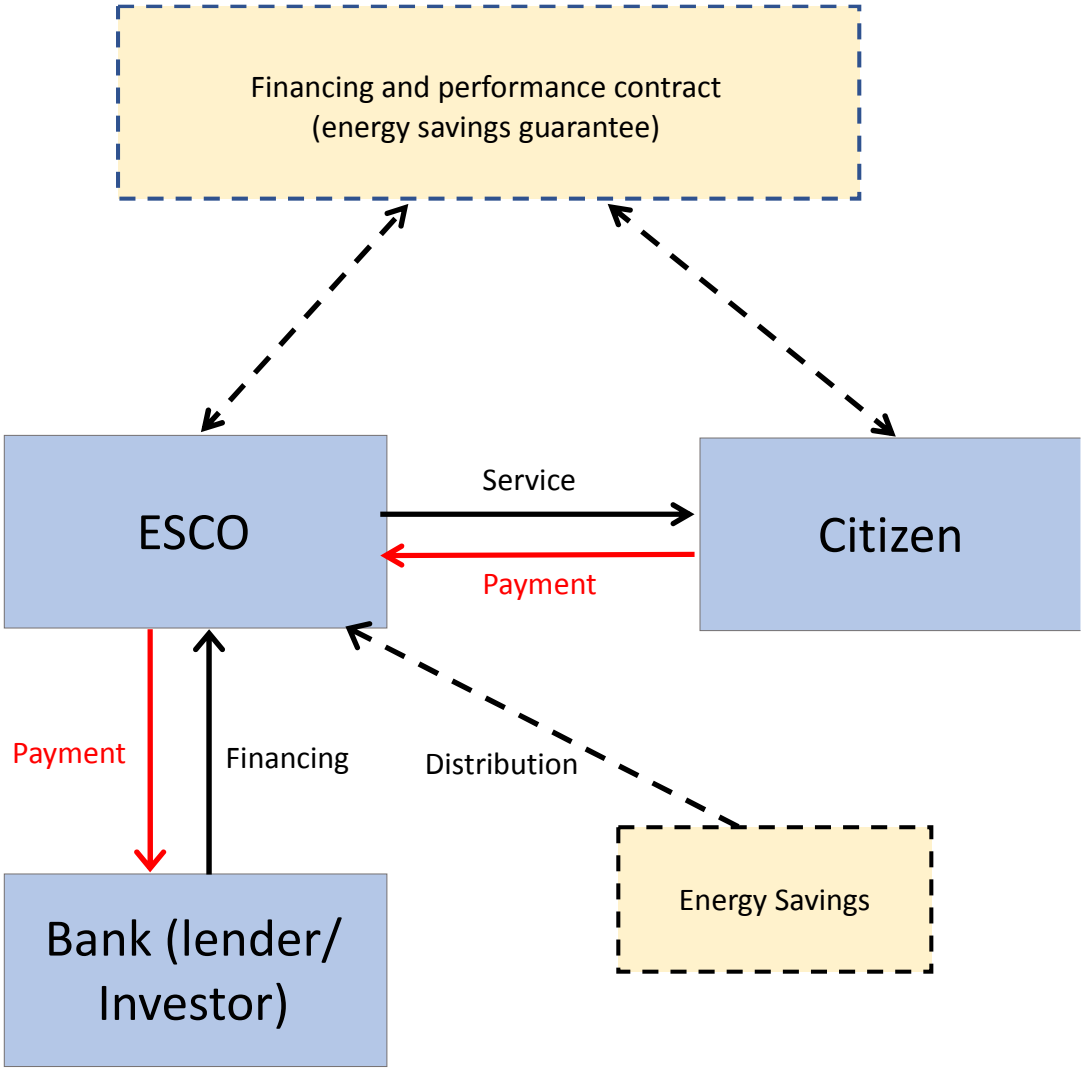

Chaffee Model

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Appendix E – Emerging Energy Efficiency Business Models

The following table is reproduced from Nolden and Sorrell (2016, p. 1415).

Emerging models for energy efficiency investment in the commercial office sector
• On-bill finance (OBF): More of a collection mechanism than a type of financing, with the repayment of capital (from utilities, the state or third parties) taken from electricity and gas bills. The total post-retrofit utility bill should not exceed the pre-retrofit bill, and repayment obligations are tied to the property and not the owner. This mechanism has proved successful in the USA, but the UK Green Deal policy—which was modelled on the US experience—proved unsuccessful and was withdrawn in 2015.
• Property Assessed Clean Energy financing (PACE): A means of financing building renovations through the use of bonds offered by local governments to investors. The funds raised are used to finance energy efficiency investments that are then repaid via annual assessments on property taxes. The loan is secured to the building and not to the owner or tenant.
• Green leases: Leases that give the landlord and tenant responsibilities with regard to the sustainable operation of a property—for example, energy efficiency measures, waste reduction/management and water efficiency. 'Darker green' provisions include energy efficiency targets with penalties for non-compliance, such as increased rents or rent reductions.
• Measured Energy Efficiency Transaction Structure (MEETS): Developed by Energy RM and used in Seattle, this relies upon a 'dynamic' metering system that provides estimates of energy savings that have been approved by the local utility. The client pays an agreed price per unit saved (MWh) on a 20-year agreement similar to a power purchase agreement. Repayment is linked to the building rather than the occupier.

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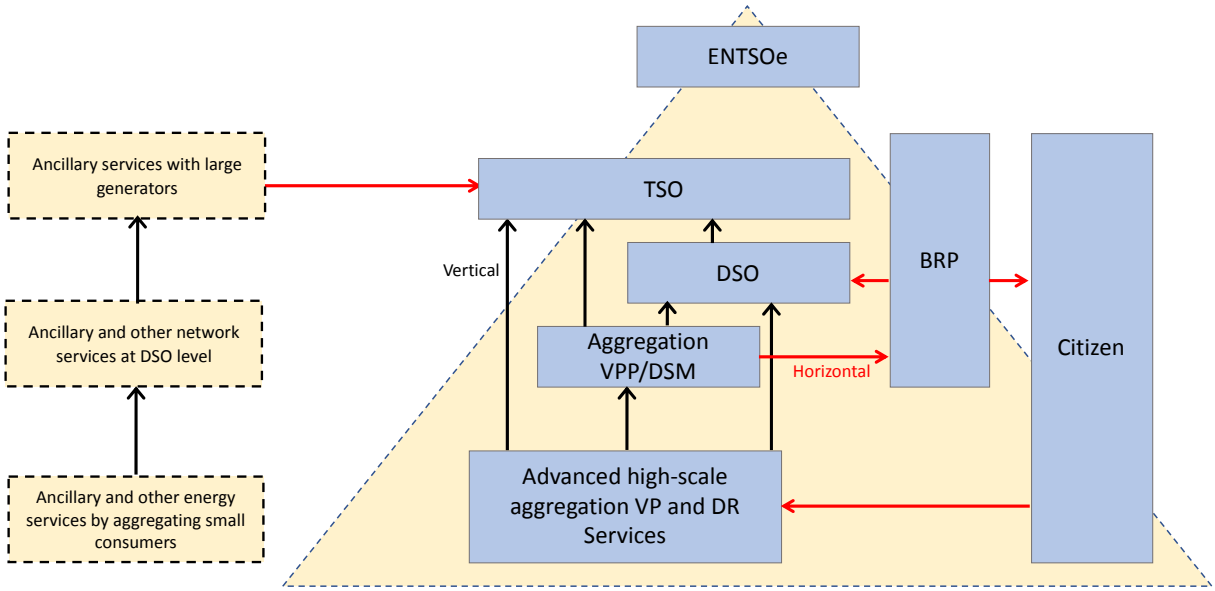
Appendix F – Demand Aggregation Model

The following is reproduced from (Lu et al., 2020).



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Appendix G – e-Vehicle Business Models

The following Table is reproduced from Funke and Burgert (2020).

NUMBER OF TAXI CHARGING SITES THAT COULD BE REFINANCED ONLY BY TAXI USE – AND THE CORRESPONDING ELECTRIFIED KM SHARE. CHARGING ONLY AT TAXI STANDS

Parameter	2020	2025	2030
No CP	1	15	20
Km share BEV	3%	56%	62%

The following is reproduced from Li et al. (2020).

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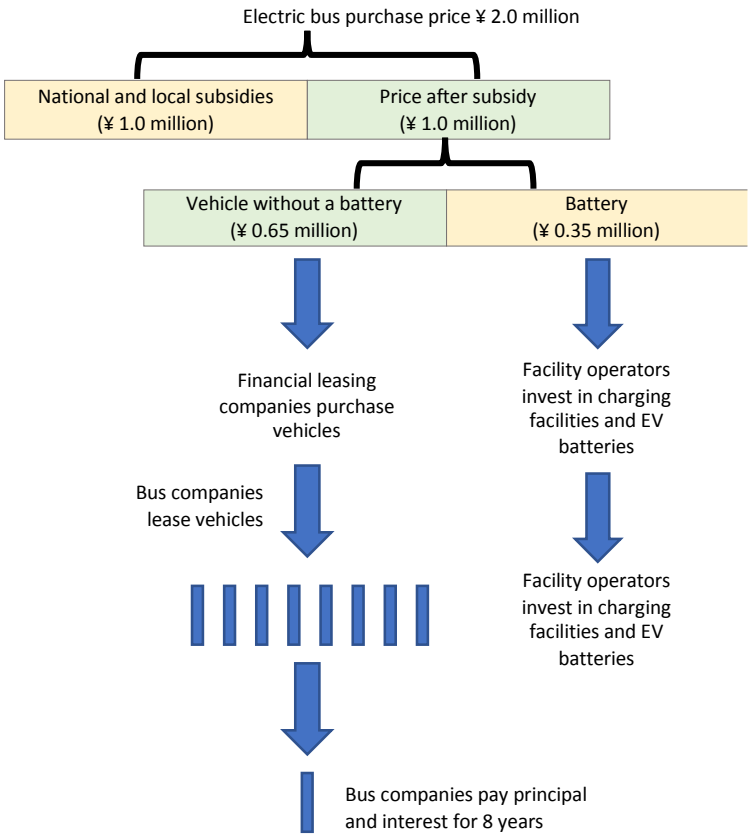

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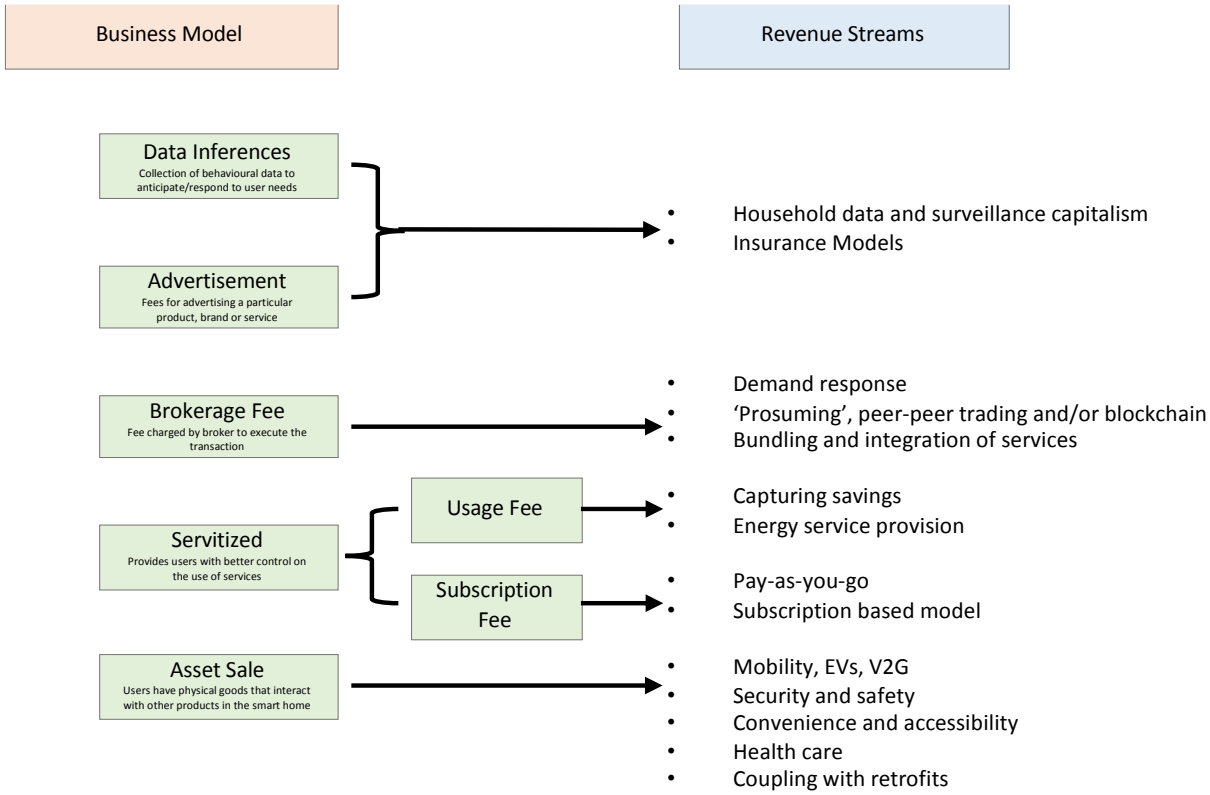
Appendix H – Smart Home Business Models

The following is adapted from Furszyfer Del Rio et al. (2020).



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Appendix I – Example Marginal Abatement Cost Curve

The following is reproduced from Ibrahim and Kennedy (2016).

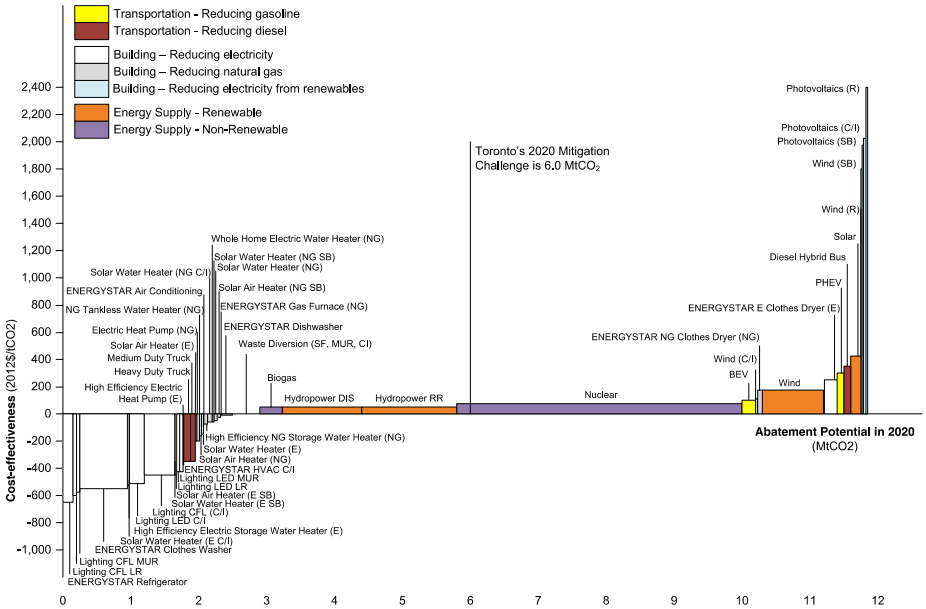

Figure 1. Toronto 2020 marginal abatement cost (MAC) curve showing mitigation measures by sector and a marginal abatement cost of 70 $/tCO$_2$ for the city's 2020 target (R = Residential, LR = Low-rise, MUR = Multi-unit residential, SF = Single-family, SB = Small Business, C/I = Commercial/Institutional, NG = Natural gas, E = Electricity).

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