D1.2: Report on the Architecture for the ICT Ecosystem

+CityxChange | Work Package 1, Task 1.1

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Authors	Sobah Abbas Petersen (NTNU), Anthony Junior Bokolo (NTNU), Dirk Ahlers (NTNU), Armin Shams (UL, Lero), Markus Helfert (UL), Iyas Alloush (Lero), Zohreh Pourzolfaghar (Lero)
Contributors	Nick Purshouse (IES), Mamdouh Eljoudi (FourC), Tor Erlend Fægri, Bjørn Ove Berthelsen & Leendert Wienhofen (TK)

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25.01.21	13.0	NTNU (Sobah Abbas Petersen, Anthony Junior Bokolo, Dirk Ahlers), Nick Purshouse (IES)).	Final refinement, formatting, and proof reading, ensuring linkage to other documents, QA.

List of Acronyms

API	Application Programming Interface
BPMN	Business Process Modelling Notation
DOA	Description of Activities
DoDAF	Department of Defence Architecture Framework
DP	Demonstration projects
FEAF	Federal Enterprise Architecture Framework
EA	Enterprise Architecture
EAF	Enterprise Architecture Framework
eMaaS	eMobility-as-a-Service
EMS	Energy Management System
EU	European Union
EV	Electrical Vehicles
GDPR	General Data Protection Regulation
GERAM	Generalised Enterprise Reference Architecture and Methodology
GIS	Geographical Information System
IDS	Industrial Data Spaces
IDS-RAM	Industrial Data Spaces Reference Architecture Model
IoT	Internet of Things
ITS	Intelligent Transport Systems
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
LCCC	Limerick City Council
OADP	Oracle Enterprise Architecture Development Process
ORM	Object Relational Mapping
PED	Positive Energy Districts
PEB	Positive Energy Block
REST	Representational State Transfer
SCIS	Smart Cities Information System
SOAP	Simple Object Access Protocol
TK	Trondheim Kommune
TOGAF	The Open Group Architecture Framework
TOGAF-ADM	TOGAF Architecture Development Method
VE	Virtual Enterprise
WG	Working Group
WP	Work Package

Executive Summary

This deliverable presents the +CityxChange Enterprise Architecture Framework for describing the project's Information and Communications Technology (ICT) ecosystem. This work has been conducted within tasks T1.1 and T1.2. The main objectives of this work are to create an overall ICT architecture and service-based ecosystem to ensure that service providers of the +CityxChange project will develop, deploy, and test their services through integrated and interconnected approaches.

The main ideas of the +CityxChange Enterprise Architecture Framework (EAF) is inspired by Enterprise Architecture approaches and anchors around a data space called the +CityxChange Data Space and value added services provided through collaborations among several partners. The approach is to provide a consistent architecture with clear separation of concerns and a strong integration and interoperability support, following requirements of the cities. This deliverable provides a description of the Enterprise Architecture Framework and provides guidelines on how to apply it.

The +CityxChange Enterprise Architecture Framework has been presented to the partners in WP1, WP2, WP3, WP4, WP5, and WP7 and has been applied to describe various services. Descriptions of use cases have been included in the deliverable to illustrate how the developed EAF has been applied. Also, a step by step set of guidelines on how to apply the EAF has also been provided to support Followers Cities in replication of the services from WP1, WP2, WP3, WP4, WP5, and WP7.

This Deliverable is linked with parallel work on data and API integration within the Ecosystem described here, described in D1.3: Report and catalogue on the ICT data integration and interoperability.

This current deliverable is a final version of D1.2 due on M24. The content presented in this deliverable is based on the modelled use cases which are mainly based on feedback from partners involved in WP1, WP2, WP3, WP4, WP5, and WP7. The use cases involve high level user stories of the demonstration projects (DP1-DP11). Additionally, general feedback from partners, recommendations, roadmap, and reflections are presented.

1 Introduction

This deliverable presents the +CityxChange Enterprise Architecture Framework (EAF) for describing the project's ICT ecosystem. The main ideas of the EAF anchors around a data space which supports DataxChange and value-added services provided through collaborations among several partners.

The software development, system deployment, and Lighthouse City Work Packages, where the developed framework was applied to describe the various services. Modeled sketches of the examples have been included in the deliverable to illustrate how the EAF is being applied and a step by step description of the set of guidelines is provided on how to apply the EAF.

This deliverable is a final version of D1.2 due M24. This deliverable includes a description of use cases which includes high level user stories of the demonstration projects. Besides, a list of use cases stories is presented based on case identification, model creation, feedback collection, and final validation from partners involved in the case. Additionally, general feedback from +CityxChange partners as regards to the EAF, recommendations, roadmap, and reflections are presented.

This deliverable is linked with parallel work on data and API integration as an important topic within the Ecosystem described here, described in detail in D1.3: Report and catalogue on the ICT data integration and interoperability.

1.1 Objectives

The main objective of task T1.1 - Development of the ICT Service Based Ecosystem Architecture and Roadmap is stated in the Grant Agreement as follows:

"O1.2 - Create an overall ICT architecture and service-based ecosystem to ensure that service providers of the +CityxChange project will develop, deploy, and test their services through integrated and interconnected approaches."

Furthermore, the task is described as follows:

"This task will design and iteratively develop the architecture and roadmap of the ICT service-based ecosystem for +CityxChange. Since there will not be a central ICT platform in the project, this task will orchestrate the development

and evolution of the ICT service-based ecosystem. It follows a distributed sustainable Smart City approach that uses loose coupling and stronger integration where necessary in line with Enterprise Architecture (EA) methodologies. The ICT ecosystem will give partners a better overview of +CityxChange for integration and allows ongoing gap analyses of the state of development.

An initial version of the ICT architecture was developed in M6. This included the overall architecture concepts and diagrams, a set of data and security principles in line with the General Data Protection Regulation (GDPR), data models, a set of guidelines for iterative service life-cycle development in the demonstration projects. Also, this deliverable captures APIs used by partners in providing services. The API specifications are further described in D1.3 which provides an online repository for maintaining the API catalogue (D1.3) and use case catalogue. The API catalogue is initiated with the cities' and partners' existing APIs needed in the project and the use case catalogue were initiated with high level user stories of the demonstration projects. Principles and guidelines were provided at M6; architecture development, ongoing mapping of demo states, and use case catalogue was iteratively updated [M7-M24] as the ICT ecosystem evolved with the development of demonstration projects and +CityxChange integration.

Participant Roles: NTNU lead the task with strong collaboration with UL, TK, and LCCC ICT departments. IESRD and POW contributed input and requirements for the Decision Support Tool (T1.3 and T1.4) and with ABB and MPOWER on the grid optimization and balancing (T2.2). FourC, Powel, and IOTA provided requirements for e-mobility (T2.4). IOTA further collaborated on micro-payments, crypto-currencies, and energy trading (T2.5).

Innovation Applied to Demonstration Project: "DP01 – DP11".

The Deliverable is derived from the above task description and will describe

"The +CityxChange ICT ecosystem architecture including overall architecture concepts and diagrams, principles and guidelines, use cases, and roadmap. It includes the report and repository of architecture elements and presented APIs (discussed in D1.3) used within the DP use cases. (Connected to task 1.1)".

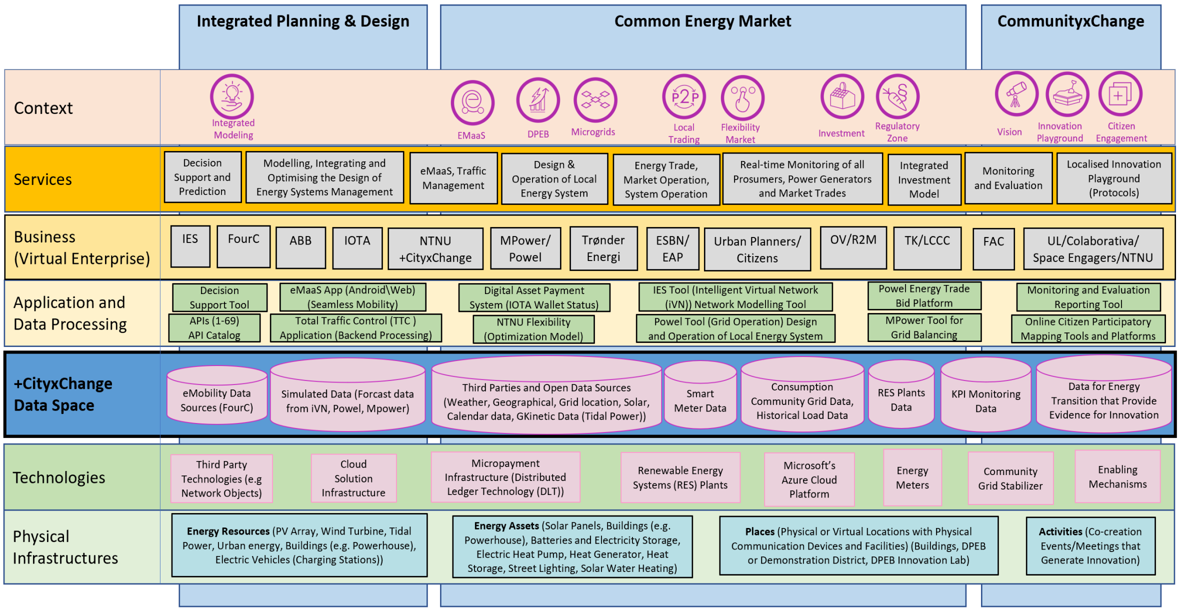


Fig. 1.1: Overall ICT Eco-system for the +CityxChange project

The overall ICT Eco-system for the +CityxChange project is shown in Figure 1.1. As such, the main objective of this deliverable is to orchestrate the development and evolution of the ICT ecosystem for the +CityxChange project and to help partners by providing an ICT-based project overview for integration, interconnection, and gap analyses of Demonstration Projects (as presented in section 6, 7, 8, and 9). This work was inspired by the following research domains and approaches:

- Enterprise architecture methodologies and approaches.
- Service design and development approaches, with the user in focus.
- Distributed systems and digital ecosystems.
- Open data and data-centric approaches.

In particular, this document aims to include the following information:

- Overall architecture concepts and diagrams.
- Data and security principles (linked with GDPR).
- Guidelines for iterative service life-cycle development in the Demonstration Projects (DPs).
- A use case catalogue linked to an online API catalogue maintained by D1.3.
- A roadmap on what and how the Followers Cities can use the developed +CityxChange Enterprise Architecture.

1.2 Context within the project

The work in this deliverable is the result of close collaboration between tasks T1.1 and T1.2 (D1.2 and D1.3). In addition, the work and the contents have been influenced by the interactions with the Lighthouse Cities, Trondheim and Limerick. The task leader of T1.1, NTNU, has been mostly in contact with Trondheim Municipality (TK) while UL has had most contact with Limerick City Council (LCCC). In addition, there have been collaboration with the other tasks in WP1, WP2, WP3, WP4, WP5, and WP7 and dialogue with several of the partners, in particular technology providers, in the project. An overview of how the D1.2 and D1.3 relate to the Demonstration Projects (DPs) and other WPs in the project are shown in Figure 1.1.

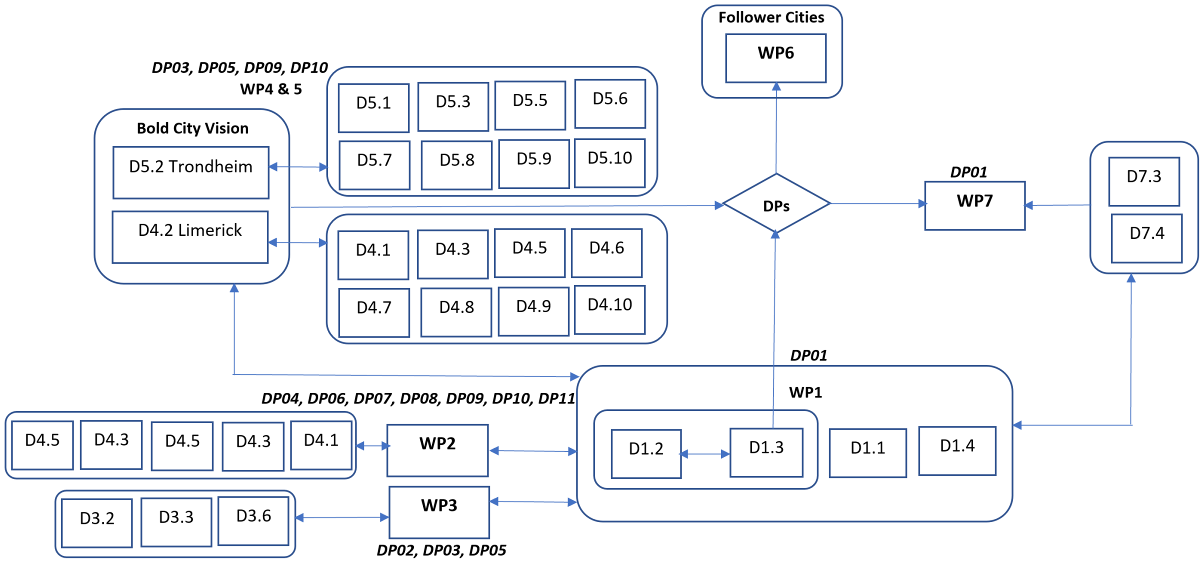


Fig. 1.1: Overview of deliverable D1.2 and D1.3 in relation to the DPs, and WPs

Figure 1.1 presents an overview of deliverable D1.2 and D1.3 in relation to the DPs, and WPs, In the CityxChange project

- “DP01, Model” aims to collecting data and providing integrated decision support to the cities.
- “DP02, Vision” focuses to Co-creating a Bold City Vision to plan, implement, replicate and scale-up to positive Energy Districts and Cities.
- “DP03, Engage” aims to Co-creating Distributed Positive Energy Blocks through citizen participation.
- “DP04, Regulatory Zone” attempts to Enabling innovation through regulation mechanisms.
- “DP05, Playground” focuses at Accelerating change and disruptive solutions through innovation playgrounds.
- “DP06, DPEB” aims at Creating DPEBs through improved energy performance and integration with the energy system.

- "DP07, Microgrids" focuses at Creating the +CityxChange approach to community grids.
- "DP08, eMaaS" aims at Integrating seamless eMobility within the DPEB.
- "DP09, Local Trading" aims at Enabling local energy trading within the DPEB.
- "DP10, Flexibility Market" focuses at Enabling a fair deal to all consumers through a local flexibility market.
- "DP11, Sustainable Investments" aims at Enabling public and private stakeholders to invest in their buildings.

The links to the DPs, and WPs (deliverable and tasks) are summarized in Table 6.1. It should be noted that deliverable D1.2 and D1.3 are indirectly related to most WPs in the project as the EA is an overview of the various services and systems developed within the project are documented using the +CityxChange EAF.

1.3 Work process

This work has been conducted within tasks T1.1 and T1.2 and the EAF has been presented to the partners in the tasks and some of the partners within the project. Based on the original task description, the API catalogue was supposed to be addressed in T1.1 but has now been moved to D1.3 because it fits better with the interoperability work being addressed in D1.3.
The contents in this deliverable are the outcomes of the work that has been conducted within the following tasks in WP1:

- Task T1.1 - Development of the ICT Service Based Ecosystem Architecture and Roadmap
- Task T1.2 - Data Integration and Interoperability for the ICT Ecosystem

The main activities within these tasks have included the following:

- Weekly online meetings between the two task leaders, from NTNU and UL. Additional researchers and the project manager have participated in some of these.
- Several meetings with the technical staff and others from Trondheim Municipality (TK), mostly by NTNU.
- Several meetings with the technical staff and others from Limerick City and County Council (LCCC), mostly by UL.
- Meetings with the partners in the tasks and participation in various meetings and workshops, including consortium meetings, where +CityxChange scenarios and solutions were discussed.

- Meetings with specific partners to exchange ideas and gather data (e.g. ABB, FourC and IOTA).
- A face to face meeting between the two task leaders and researchers in the task, in April, in Dublin.
- Online meeting with LCCC's technical staff.
- Several workshops with developer partners in Trondheim to start applying the EAF to identify specific scenarios and use cases.
- In the second year of the project more meetings were held online with partners at UL, NTNU, MPower, Powel, IES, FAC, Colaborativa, and Space Engagers.
- Individual meetings with the partners responsible for the specific use cases and corresponding deliverables were carried out to obtain the input described in the use cases modelled in Section 6 and 7.

1.4 Structure of Deliverable

The structure of this deliverable is described in Table 1.1.

Section(s)	Description	Target audience
1	Introduction, objectives, context and task description	All
2.2	What is Enterprise Architecture and why we need such an approach for the +CityxChange ICT ecosystem	All
3	Methodology and approach for service design	All, most relevant for cities and service designers.
4	A description of the +CityxChange Enterprise Architecture Framework (+CxC EAF). How it can be applied and an illustrative example	All
5	Guidelines and steps to apply the +CityxChange Enterprise Architecture Framework to describe services and ICT ecosystem for services. Examples of services described in collaboration with other partners are provided for the different steps. The Principles and Guidelines for the +CityxChange ICT ecosystem is based on literature, best practices,	All, most relevant for service developers and providers and technology developers.

	guidelines from consultancy companies and experience.	
6	Overall ICT Eco-system showing a summary of all DPs, applications and data captured in the developed CityxChange Enterprise Architecture Framework. This is presented in relation to Integrated Planning and Design, Common Energy Market, and CommunityxChange.	All, most relevant for data providers, owners and users and service and technology developers. As well as for FCs.
7	Description of use cases (high level user stories of the demonstration projects).	All, most relevant for FCs
8	Present general feedback received via survey questionnaires from +CityxChange partners as regards to the EAF, reflections and lesson learned.	All
9	Guidelines and roadmap for Follower Cities	All
10	Conclusion and future works	All
Appendix		All

Table 1.1: Structure of this deliverable

2 Background and Literature Review

2.1 Overview of Enterprise Architecture

This section aims to describe what is Enterprise Architecture (EA) and why it was adopted in the +CityxChange project in developing the ICT Eco-system. The Open Group defines that EA is about understanding all of the different components that connects to make up the enterprise and how those components interrelate. Institute for Enterprise Architecture Developments (IFEAD) defines EA as "a complete expression of the enterprise; a master plan which "acts as a collaboration force" between aspects of business planning such as goals, visions, strategies and governance principles; aspects of business operations such as business terms, organization structures, processes and data; aspects of automation such as information systems and databases; and the enabling technological infrastructure of the business such as computers, operating systems and networks." EA provides the overall architectural vision for an enterprise.

Why do we consider the city as an enterprise?

A city can be considered similar to a complex organisation or an enterprise where a number of services are offered and that uses a variety of ICT systems. The +CityxChange project considers the city as a central entity that may play a vital role in the engagement of its citizens and in fostering new and innovative services to support Positive Energy Buildings (PEBs) and Positive Energy Districts (PED). The visions of the project outline city-wide services and ICT systems that might require a structured approach to design and maintain and to share data, information and knowledge among the partners in the project.

This is similar to large enterprises that maintain a wide landscape of internal systems and interact with a large number of external systems, stakeholders, and networks.

EA and EAFs provide a structured approach to do this. Furthermore, a city or indeed the +CityxChange project consists of a diverse set of stakeholders, each with their specific domain interests, expectations and needs; see Figure 2.1. EA also provides a structured approach to cater to the diverse needs of the different stakeholders.

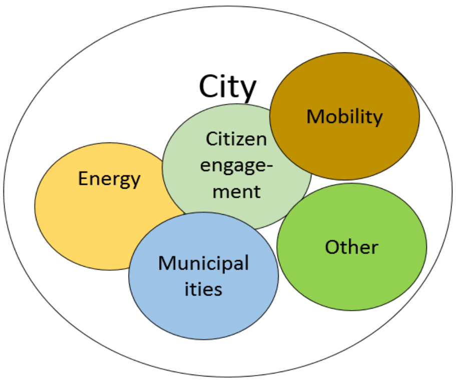


Fig. 2.1: Diverse set of stakeholders in a smart city

It is broadly accepted that the origins of the modern Enterprise Architecture (EA) lie with the publication of "A Framework for information systems architecture"[1]. This framework was inspired by the construction industry, where they identified that there were several stakeholders who had diverse information needs. For each stakeholder (e.g. a planner, or a building owner or a builder), depending on which aspect of information they required (e.g. what, why, how, etc.), the specific view of that information would differ. The levels of abstraction and detail of the specific information would differ for each case. But the strength of an approach such as EAs can help to tailor to the diverse needs of the stakeholders in a city.

What are the benefits of using EA?

The benefits of using EA for the +CityxChange project can be considered as follows:

- EA bridges the value added services to the ICT ecosystem.
- EA provides a structured approach to co-creating and describing services and ICT systems, which can facilitate dialogue and a common understanding among the project partners.
- EA provides a structured approach to designing and developing services and ICT systems.
- EA can support better access to information, data, services, and potential business collaboration partners.
- EA can support innovative services and business models.
- An EA approach can support blueprinting of services, which can act as reference architectures to support replication of services across cities.

What is the added value by using EA?

The added value from an EA approach can be considered from the perspective of different stakeholders within the project and some external stakeholders.

Stakeholder	Examples	Added Value
Cities	Trondheim, Limerick, follower cities, other cities	Reference architectures, documentation of services, knowledge sharing across cities, enhanced transparency of service provision, support for data governance, overview of policies and regulations.
Citizens	Users of mobility services. Participants in City Labs	Potential for new value added services, overview of available information and data, information about the details of the service.
Services and utility providers	Trønderenergy, ESB, Powel, AtB, MPower, Colaborativa, Space Engagers	Structured approach to service descriptions, overview of available data and potential business partners, access to reference models, overview of relevant policies and regulations, support for dialogue and common understanding among partners.

ICT developers	Powel, MPower, FourC, IES, IOTA, FAC	Structured approach to service descriptions, overview of available data and other ICT systems and how to access them, overview of scenarios and use cases, overview of APIs, standards, data models and other metadata.
Researchers	NTNU, UL	Structured approach, overview of scenarios and use cases for research.
Service providers, external to the project	A startup company who wants to provide eMaaS services. Contributors in Innovation Labs.	Structured approach to service descriptions, overview of available data and potential business partners, access to reference models,

Table 2.1: Added value to stakeholders by using EA

It should be noted that within the stakeholder groups identified in Table 2.1, there may be different needs and expectations. For example, there may be stakeholders with one partner, such as the cities, that have different needs and expectations as identified below:

- Strategic focus - who expect higher level information of strategic relevance, e.g., potential business opportunities, policies.
- Operations focus - who expect information relevant to the operation of a service or a system, e.g., information that may impact their service, APIs, standards.
- Technical focus - who may be interested in the components of the systems and their links to data sources, protocols.

2.2 Existing Enterprise Architecture Approaches

This section provides a theoretical background around approaches of Enterprise Architecture. It is broadly accepted that the origins of the modern Enterprise Architecture (EA) lie with the publication of "A Framework for information systems architecture" by [1]. Since then, several EA and Architecture frameworks have emerged and there are several definitions of EA.

An EA is a plan of record, a blueprint of the permitted structure, arrangement, configuration, functional groupings/partitioning, interfaces, data, protocols, logical functionality, integration, technology, of IT resources needed to support a corporate or organizational business function or mission [2]. For example, [3] explained that in EA, focus is on the human element, and the way to "architect" and plan the enterprise to have the best human performance and output. All the other elements in the EA are secondary, meaning that they exist to facilitate the best outcomes for the human operations. The Open Group defines that EA is about understanding all of the different components that go to make up the enterprise and how those components interrelate. Institute for Enterprise Architecture Developments (IFEAD) defines EA as “a complete expression of the enterprise; a master plan which “acts as a collaboration force” between aspects of business planning such as goals, visions, strategies and governance principles; aspects of business operations such as business terms, organization structures, processes and data; aspects of automation such as information systems and databases; and the enabling technological infrastructure of the business such as computers, operating systems, and networks”[4]

The field of EA initially originated to support enterprises overcome the challenge of aligning and bridging their business and IT strategies. An important contribution was made by John Zachman in 1987, by drawing attention to the different stakeholders in an enterprise and their perspectives of the enterprise and the Information Systems within an enterprise. Zachman presented the first EA, the Zachman Framework, as a taxonomy, identifying the different stakeholders’ perspectives or views and the different aspects of the entity they may be interested in.

Over the years, many EA frameworks and modelling concepts have been proposed. An overview of the main EA approaches that are relevant for the work in this deliverable are provided in this section. They include the Zachman Framework [1], The Open Group Architecture Framework (TOGAF) [5] and the Industrial Data Space Reference Architecture Model (IDS-RAM) [6].
Common to these frameworks is reducing enterprise complexities by considering disparate viewpoints and organizing various aspects in ways that make an enterprise understandable. The main ideas and concepts that defined EA, i.e. perspectives of different stakeholders and aligning the ICT developments with the needs of non-IT stakeholders are equally important for all kinds of enterprises. Taking a broader interpretation of an enterprise, a city can be viewed as an enterprise, with a broader set of stakeholders and the aim to meet the needs of its citizens. Thus, it is no surprise that EA has been adopted for supporting cities and municipalities [7]. Thus, this section will also provide an example of how EA approaches have been adopted for cities.

2.2.1 Zachman Framework

The first EA, the Zachman Framework [1] with the main goal to use logical constructs to address the management of ever-increasing complexity of information systems within the organisations. Zachman [1] framework is a two-dimensional matrix representing the viewpoints on the Y axis, and the views on the X axis. In this framework, viewpoints are represented by the different stakeholders with clearly defined deliverables towards the end system; see Figure 2.2. While the Zachman Framework provides a taxonomy for understanding and describing enterprises, it lacks guidance for the creation of an EA. Nevertheless, it continues to provide support and provide inspiration for enterprise architects even today.

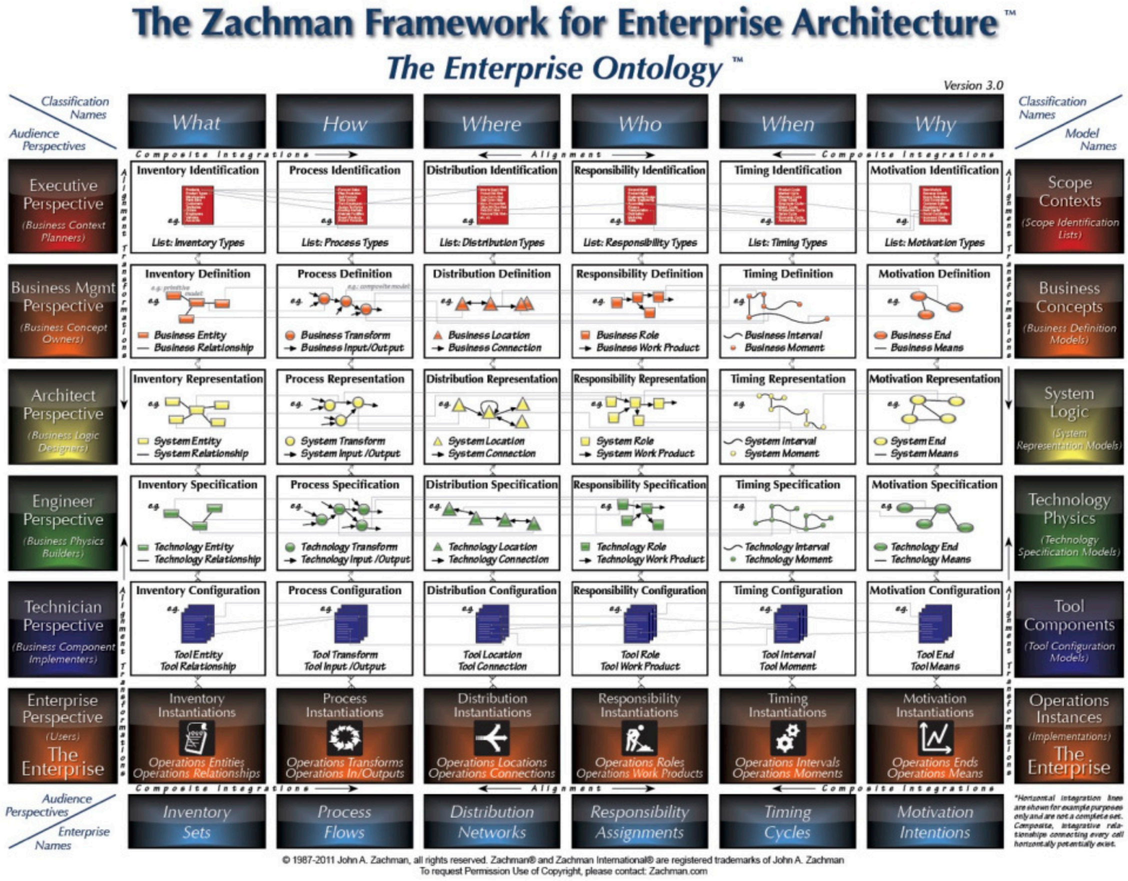


Fig. 2.2: The Zachman framework 3.0[1][1]

2.2.2 TOGAF - The Open Group Architecture Framework

The Open Group has defined The Open Group Architecture Framework (TOGAF) which is a layered EA governing framework [5]. One of the most significant parts of the TOGAF is the Architecture Development Method (ADM) which is a process for developing the EA of an enterprise. ADM specifically addresses three distinct types of architectures; see Figure 2.3:

[1] https://www.zachman.com/about-the-zachman-framework

1. Business Architecture,
2. Information Systems (Application and Data) Architecture,
3. Technology Architecture.

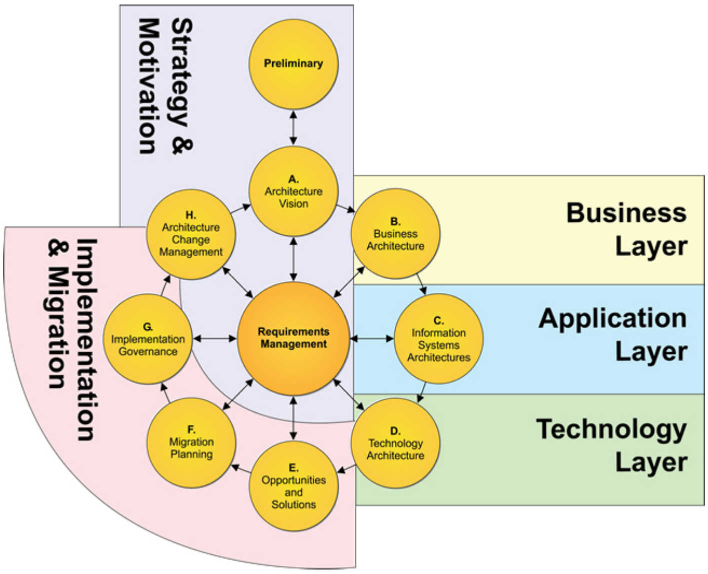


Fig. 2.3: The Zachman framework TOGAF framework [5]

Each of the architecture types (Business, Information Systems and Technology) defined in ADM address different concerns of an enterprise. The Business Architecture describes the processes the business or the enterprise uses to meet its goals. Information Systems Architecture contains two subtypes - the Applications Architecture which addresses the architecture of the application systems within the enterprise, and the Data Architecture which addresses the data types and data flows within the enterprise TOGAF. The Technology Architecture addresses the physical infrastructure of an enterprise such as computer hardware, mobile devices, and communications networks. Furthermore, TOGAF includes a layer to model the strategy and motivation that drives the business strategy.

The ADM guides an enterprise to start the EA activity by identifying their vision, referred to as strategy and motivation, and the Business architecture before addressing the Information Systems and Technology architectures. The different architectures are defined for the current situation and a future, desired situation. Once the different architectures and the gaps have been identified, ADM provides guidance for the implementation and migration to the future architectures.
TOGAF's layered architecture has influenced several EA frameworks, in particular, the architectural frameworks that have been adopted by some Smart City projects such as ESPRESSO [8].

2.2.4 Data Centered EA

The EAs described in the earlier subsections are designed to support the information architecture. With the increase in the availability and access to data (e.g. from sensors and other sources), and Big Data, the traditional approach of defining a data schema first before processing data may not be the only way to go. In such scenarios, data can be captured and processed without a pre-defined schema. This is a paradigm shift in the way enterprises think about data and how to leverage on the data that is available. By "bringing the analytical capabilities to the data" versus the traditional processes of "bringing the data to the analytical capabilities through staging, extracting, transforming and loading," can contribute to reducing the cost of moving data [9].

Similar to TOGAF, the ORACLE EA incorporates a business architecture, an application architecture, an information architecture and a technology architecture. The Oracle EA framework consists of seven components as shown in Figure 2.4. In addition to the architectural layers, it includes:

- EA repository for all the architecture artefacts and deliverables that are captured and developed throughout the lifecycle of an EA.
- EA governance which provides the structure and processes for implementing an organization's businesses strategy and objectives through an EA
- People, processes, and tools used to define the EA and architecture solutions.

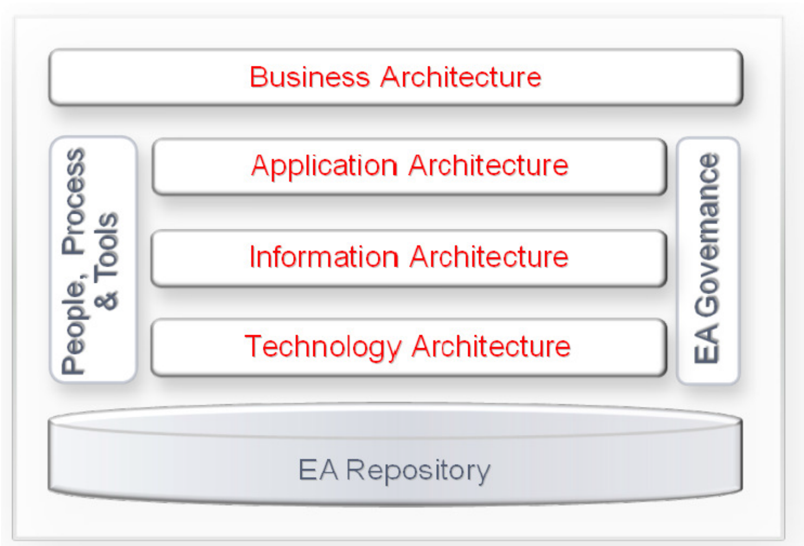


Fig. 2.4: The Oracle EA framework [9]

Similar to TOGAF's ADM process, the Oracle Enterprise Architecture Development Process (OADP) was designed to be a flexible and a "just-in-time" architecture development approach to support the development of a big data focused EA incrementally and

iteratively. The OADP includes a six-step process to support the development of data-focussed enterprise architectures.
Another EA that is focussed on the abundance of available data is IDS-RAM, a Reference Architecture Model for data spaces, proposed by the German Fraunhofer Institute and the International Data Spaces Initiative [9]. This is the result of a collaboration among several German universities, research institutes and industry. IDS-RAM brings to focus Industry 4.0, the current digitization trend and the data-centric landscape.
The Industrial Data Space is defined as a "virtual data space leveraging existing standards and technologies as well as accepted governance models for the data economy, to facilitate the secure and standardized exchange and easy linkage of data in a trusted business ecosystem. It thereby provides a basis for smart service scenarios and innovative cross-company business processes, while at the same time making sure that data sovereignty is guaranteed for participating data owners [6]."

Similar to several other EA approaches, IDS-RAM also takes a layered approach. However, a few things distinguish it from the other frameworks and methodologies; e.g. it focuses on the industrial data space and it takes a data-centric approach and thus supports both top-down and bottom-up approaches than some of the other EA approaches.

The general structure of IDS-RAM is shown in Figure 2.5. The model is made up of five layers: Business, Functional, Process, Information, and System layers. Directly related to the five layers are three cross-sectional Perspectives: Security, Certification, and Governance. These are an integral part of the RAM in order to make sure that these three major core concepts of the IDS are implemented across all five layers.

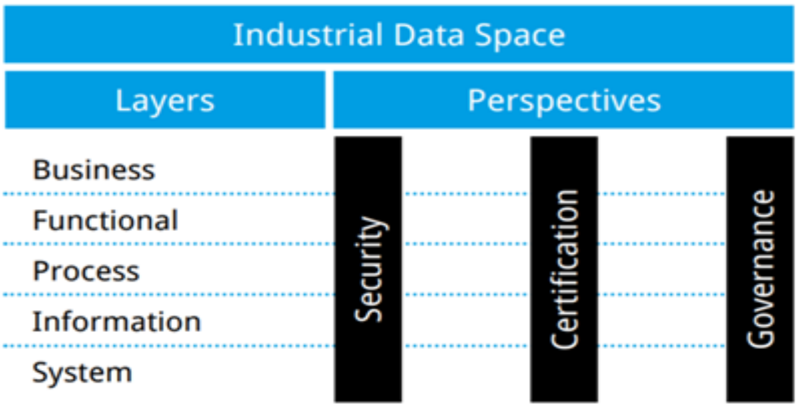
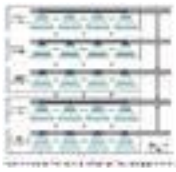
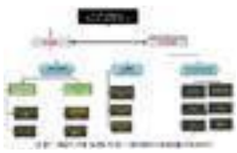
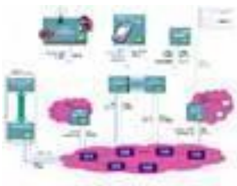


Fig. 2.5: The general structure of IDS-RAM [6]

IDS-RAM contributes to the design of enterprise architectures in commercial and industrial digitization scenarios by proposing an architecture for secure data exchange and trusted data sharing. It provides a framework that supports the design of scenarios and services as envisaged in the +CityxChange project, where data is shared across businesses and involves a number of organisations and stakeholders.

2.2.5 Smart City EA Frameworks

Several EA approaches have been proposed for supporting smart cities, some of which have adopted a layered approach. An overview of the different smart city frameworks/ architectures is summarised in Table 2.2.

Framework/Architecture	Ability - Author & Year
	Open Service Architecture - define an information city as one enabled with services that are web-accessible [10].
	Enterprise architecture- as a cross layer view of aggregate artefacts [11].
	Multi-layer structure of smart city- the authors proposed a layered framework, and articulate principles for smart city development through the demonstrated case [12].
	Smart city Unites: applications, business processes, processes management and communication protocols [13].
	Smart city infrastructure development and monitoring framework [13].
	Smart city high level architecture - to gather data about occurring events, analyse the data, make decisions, and communicating those decisions to the devices located in public spaces [14].

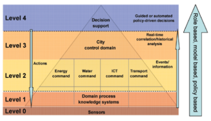
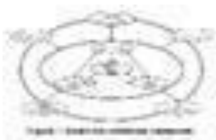
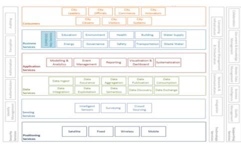
	Proposed a hierarchical model of the interconnection [15].
	Designed a multi-tier architecture of digital city [16].
	Urban Information model- a layered view on the resources of the city and classifying the different types of information that can be generated, produced, or consumed [15].
	Smart City initiative framework, [17] based on 8 critical factors of smart city initiatives
	Conceptual Architectural framework solution architecture for smart city sensors interconnection with the organization [18].
	Smart city architecture from the perspective of data that underpin all the functionalities [19].
	The smart city's layers to urban planning dimensions [16].
	ESPRESSO's aims to identify a collection of open conceptual standards that work well together to support smart cities [8].

Table 2.2: Overview of Smart City Enterprise Architectures

Table 2.2 depicts an overview of prior smart city enterprise architecture; further discussions on the reviewed studies in Table 2.2 are provided in appendix C2. Over the years there have been a few EU sponsored smart city project as discussed in appendix D. Of particular interest to the +CityxChange project is the layered EA proposed by the EU ESPRESSO project (as discussed in appendix D.1). One of the most important motivations of a Smart

City is to meet the needs of its citizens and the aspect of services that are offered to the citizens. Thus, an important Smart City EA is the one proposed in [7], where a layer dedicated for the design of services has been added to the EA; see Figure 2.6. The Services layer brings focus to the stakeholders such as citizens and other users and receivers of the services on offer in cities, perhaps offered by municipalities and/or in collaboration with other actors.

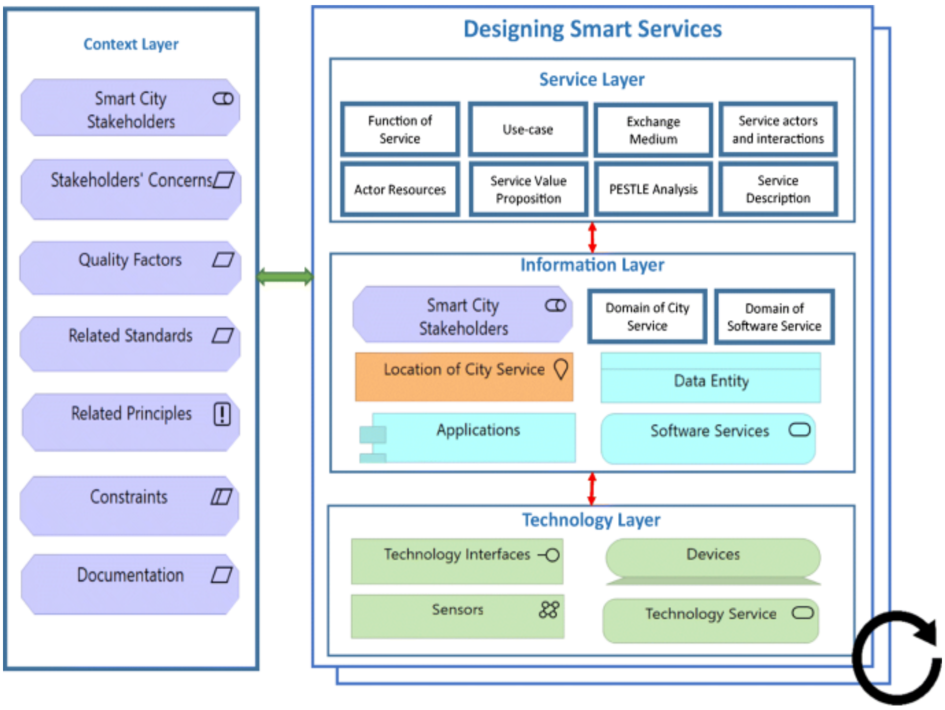


Fig. 2.6: Smart City EA to support design of services [7]

2.3 Synthesis from the Literature

Based on the review of smart city architectures from the literature (SC Reference Architecture Concepts and Smart City Architectures from Literature as discussed in appendix C), as well as smart city architectures from relevant EU smart city projects (ESPRESSO, SmartEnCity, Sharing Cities, RUGGEDISED, REPLICATE, mySMARTLife, IRIS, MAtchUP as discussed in appendix D). Emphases were made on the relevance and preference of the relevance of layered architecture for both traditional enterprises as well as smart cities. The layers are primarily influenced by EA approaches (see section 2.2), such as TOGAF; i.e. Business, Information, and Data. More recently, the smart city focused EA approaches identify services as an important component of an EA and add a service and a context layer to the EA.

A layered architecture, a process to guide the EA activities and reference models appear to be core elements of almost all the EA approaches (see section 2.2).

Most of the traditional EA approaches (e.g. TOGAF) prescribe a top-down approach, from the services or business strategy to data. However, with the emergence of new technologies such as Big Data and IoT, the newer architectural frameworks (e.g. IDS-RAM) lend more emphasis on the Data layer and make that a central component of the EA approach. This stimulates both top-down and bottom-up approaches to EA, where data-driven value added services could be created. This is illustrated in Figure 2.7.

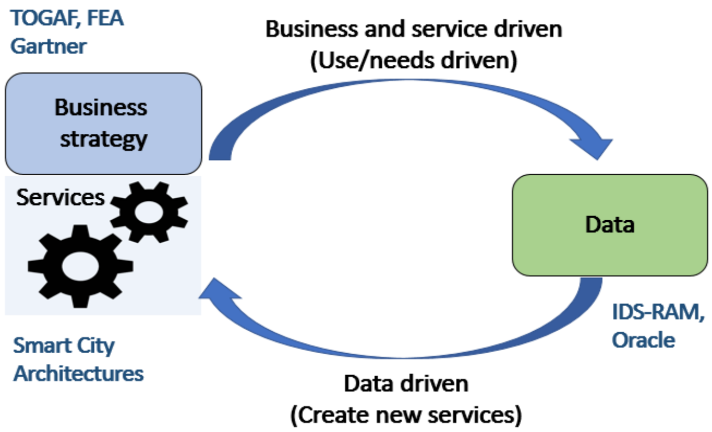


Fig. 2.7: Top-down and bottom-up approaches to EA

3 Method and Work Process

This section describes the work process that has been followed in developing the +CityxChange EAF and the use case models that have been described in this deliverable. The overall work process is described in Figure 3.1. One of the most important activities that have been quite central to this work has been the dialogue with the lighthouse cities and the different partners in the project. So, from the very beginning, there has been dialogues and interaction with the cities and all partners. In parallel, a literature review on EA in general and EA approaches for Smart Cities was conducted to inform the design of the +CityxChange Enterprise Architecture Framework (+CityxChange EAF). As drafts of deliverables from the project became available, they were also studied to complement the dialogue with the partners and inform the design of the +CityxChange EAF. Once the +CityxChange EAF was developed, it was then used to model and visually describe the use cases in the project.
A use case, in this context, is defined as a service that is offered to the citizens or any stakeholder, which is developed through the collaboration of two or more partners in the project and utilizes one or more applications and data sources.

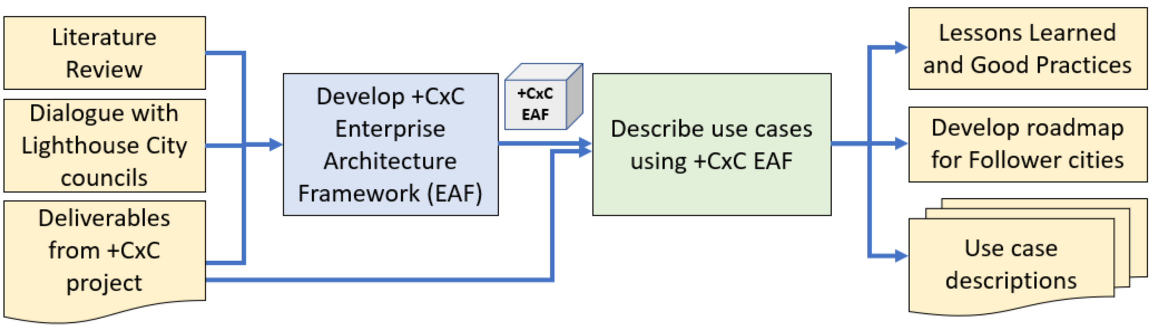


Fig. 3.1: Overall work process

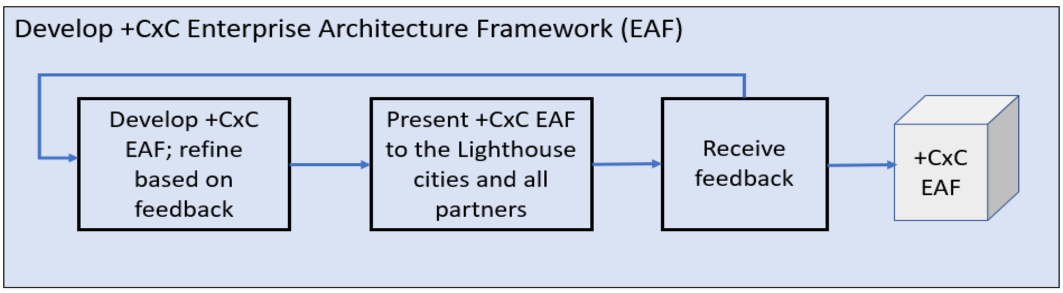


Fig. 3.2: Iterative development process for +CityxChange EAF

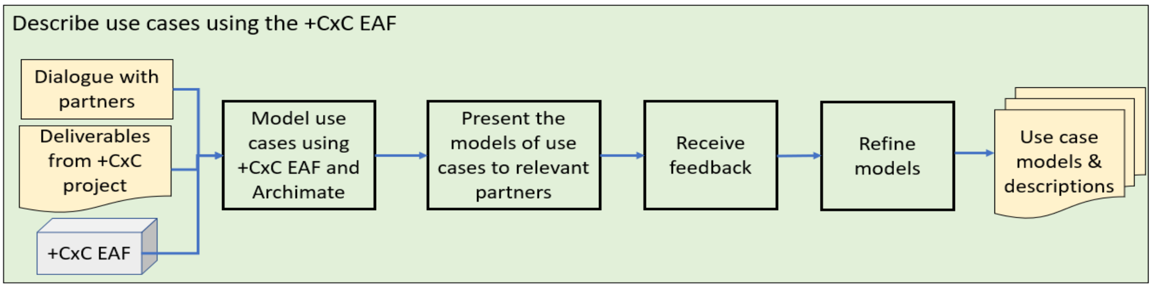


Fig. 3.3*: Process for modelling and describing Use Cases*

The development of the +CityxChange EAF was an iterative process as shown in Fig. 3.*2*: Iterative development process for +CityxChange EAF

.

Early components were already developed in the proposal phase of the project, to understand and develop the relation of partners to jointly develop the demo projects, initially understand the necessary system interactions, and facilitate the partners' co-creation activities. The initial ideas for the framework were developed based on the literature, previous experiences with EA and in dialogue with the lighthouse cities. The first version of the +CityxChange EAF was presented to the lighthouse cities and some of the technical partners for feedback. A few examples of the use cases, e.g. the Energy exchange use case with Powel and the eMaaS with FourC, were modelled in brainstorming meetings with the respective partners (see section 5).

The first versions of the example models were developed using a drawing/sketching application such as Microsoft Visio. In addition, the draft +CityxChange EAF was presented to other partners for feedback. The feedback was then used to refine the EAF. A few iterations were done before the +CityxChange EAF, described in Section 4.2 of this deliverable, was finalised.
As the +CityxChange EAF became accepted by the partners in the consortium and the details of the use cases became clearer, the models were reproduced using the Archimate Enterprise Modelling language2 and the Archi tool3. Archi is an Open Source modelling tool that supports the Archimate language, which although did not support all the modelling needs, seemed adequate for the purpose. The models were then presented to the relevant partners and refined based on the feedback, as shown in Fig. *3.3*: Process for modelling and describing Use Cases

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[2] https://www.archimatetool.com/blog/2020/04/18/c4-model-architecture-viewpoint-and-archi-4-7/
[3] https://www.archimatetool.com/

.3. At times, some of the use case models went through a few iterations.

Obtaining the input for the models was challenging at times as not all developers of the services were familiar with EA or Information Systems (IS) modelling. At times, the complete knowledge about the use case did not reside with a single individual or a partner either. This was particularly visible in the complex cross-cutting Demo Projects (DP). Here the EA approach was also supposed to directly reflect back into the partners' joint development processes. Hence, as the deliverables became available, they served as complementary knowledge sources for the use cases.
In addition, a template was developed to assist partners and use case developers to describe the knowledge for the use case models. This template is included in appendix B. The template was not used much during the descriptions of the use cases. However, they can serve as a valuable input for the Follower Cities, when they start using the +CityxChange EAF for describing their use cases.
The experience of working closely with several partners and the dialogue, to explain the EA approach and the +CityxChange EAF to them while trying to understand the Information Systems and the technological landscape and the details of the use cases provided valuable insights. The feedback, the lessons learned and the good practices that have been identified from the work are thus summarised and presented in Section 8 and 9. These form the basis of the roadmap for the Follower Cities.

3.1 Methodology for Service Design

As stated in the +CityxChange Grant Agreement and Description of Actions, this part of D1.2, T1.1 deliverable aim to present a set of guidelines for iterative service life-cycle development in the demonstration projects. Also, the APIs used within the DP use cases are presented in the developed EAF to depict the evolution and development of demonstration projects for +CityxChange integration. The iterative service life-cycle development adopted based on Figure 3.3 is shown in Figure 3.4.

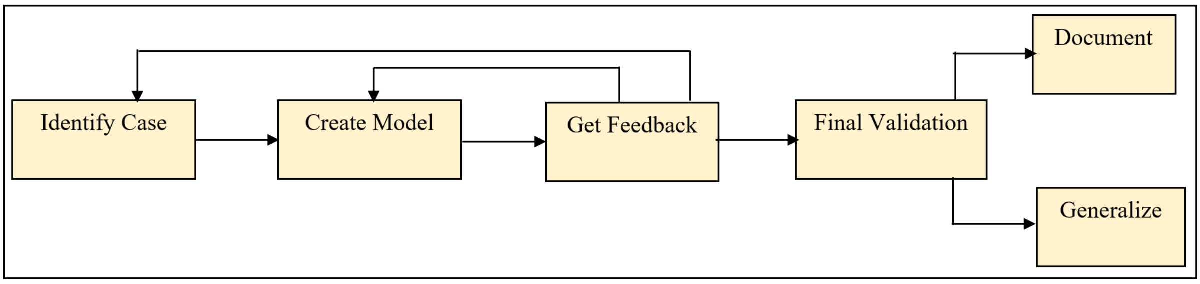

Fig. 3.4: Iterative service life-cycle development

Accordingly, Table 3.1 summaries the guidelines for iterative service life-cycle development adopted in T1.1 as previously discussed.

Phase	Capturing and Discussion	Stakeholders (Who Were Involved)	Method Employed (What Was Used)
1	Identify case ● Discuss the need for the developed EAF. ● Identify the services and stakeholders involved. ● Identify the work package and demonstration project (s) involved. ● Also employ the methodology and approach for service design described in Section 3.1 which comprises information gathering, service description and overall process.	● Dialogue with relevant stakeholders using information gathering approaches e.g workshops with partners e.g FourC, Powel, TK, etc.	● Employ open ended interview discussion with relevant partners. ● Use the use case template document (see appendix B) for service requirement gathering. ● Adopt the developed EAF.
2	Create model ● Capture the model requirements using the developed EAF. ● Design the model using the developed EAF layers (context, service, business, application and data processing, data space, technologies, and physical infrastructures), and perspectives (stakeholder and data if available). ● Follow the guidelines for using the +CityxChange EAF as discussed in Section 5 of this report.	● Carryout discussion with partners either in the partners organization or at the Department of Computer Science (IDI) premise at NTNU to get feedback and suggestion to improve the ongoing use case modelled in the developed EAF.	● Use of the use case template document. ● Collect information from deliverables of other work pages in the project. ● Documentation of task progress. ● Use of requirement table designed in D1.3 to specify the requirements of other project partners. ● Use of API repository

	✓ Step 1: Identify Components ✓ Step 2: Identify Relationships ✓ Step 3: Identify additional information ✓ Step 4: Iterate and detail ✓ Step 5: Identify Views		(http://apicatalog.cityxchange.lero.ie/api_catalog.php) to map APIs in the modelled use cases.
3	Get feedback ● Iterations based on feedback.	● Carryout follow-up meetings with partners either online via e-meetings using email, Microsoft Teams, Skype for Business, or Google Hangout or physical if needed to confirm the case modelled from prior meetings. ● Update prior information in the use case template.	● Use case modelled in the developed EAF.
4	Final Validation ● Document findings about the modelled use case. ● Identify and distinguish specific and generic use case.	● Discuss with partners to model a specific and generic use case to aid replication for follower cities.	● Use models in developed EAF.

Table 3.1: Guidelines for iterative service life-cycle development

3.2. Feedback Collection and Final Validation

To identify use cases, a discussion meeting was held with partners from 17th June 2019 with partners such as FourC to identify the services, data and APIs required. During these discussions the participants designed a sketch of the envisioned services such as the seamless eMobility system to be developed in Trondheim as discussed in Section 5.1-5.5 (Figure 5.1-5.5). During the course of development of the use cases as seen in Table 6.1 several discussion meetings were carried out from 2019 to 2020 by researchers in T1.1 with +CityxChange partners to model the first version of the use cases. The discussion took

place online and also in the partners organization such as FourC premise (17th October 2019).
Also, feedback was collected from partners to get more insights on eMobility, energy trading, and other related services needed in the LHCs Limerick and Trondheim. Additional feedback was received from subsequent meetings with partners via email that helped to refine and update the use cases. Lastly, more feedback was retrieved from available deliverables to finally validate the use cases. Also, other feedback from partners that helped in modeling the use cases are shown in the appendix B of this report.

4 +CityxChange Enterprise Architecture

This section will describe the high-level principles for a city-wide EA and the proposed +CityxChange EA, including its structure and details, supporting the distributed ICT ecosystem approach. The end of this section shows an example of how to apply the EA to the instance of a use case.

4.1 High-level Principles for an EA

A number of principles, guidelines, considerations, and challenges have been identified that should be addressed by an Enterprise Architecture for the +CityxChange project. This report is an ongoing development, which needs input from all partners to ensure usefulness for all ICT-related development tasks. Parts have been published already [20, 21]. The main ones that serve as high-level principles for the +CityxChange EA are described below:

- Take into account the view of the whole city rather than a single enterprise.
- Different stakeholders need to be engaged, joint benefits need to be made clear, conflicts between stakeholders on integration and coupling need to be addressed in a way that best supports the city needs and long-term strategies. Modeling the architecture this way points to strong stakeholder participation, so for example regular updates of architecture sketches and interfaces between different tasks was facilitated from partners in this report and +CityxChange partners.
- The architecture tasks support other tasks and demonstration projects to integrate their specific architectures into the larger ecosystem view, to provide a birds-eye view and enable better connection and integration between tasks/demos.
- Individual partners/demos should connect their own architectures with the ecosystem tasks to enable it to map out the project.
- Loose coupling of components to support independent components, well-defined interfaces, encapsulation and information hiding of internal structures of other components. It offers flexibility and reusability around adding, replacing, changing, and evolving components and a reduction in system-wide effects.
- Support Open Innovation as a guiding principle to enable meaningful connections and contributions from city and citizens, industry, academia, and other stakeholders.
- Solutions services across multiple domains to open up for sharing of data, information, applications, services, and collaborations.
- Sustainability of the technical solutions for long-term use and to support migration options after the completion of the +CityxChange project.
- Sustainable use of ICT for effectivity and environmental sustainability.

- Reuse of knowledge, information, applications, services, and data, such as standards and solutions, from previous Smart City projects and other relevant experiences.
- Support digital transformation of the city, where the city could act as a stimulant and facilitator for change.
- Support agile transformation of the services.
- Support migration and replication of the whole or parts of the EA.

4.2 +CityxChange EA

Based on the literature and the smart city EAs developed in the relevant EU projects, such as SmartEnCity [22] and ESPRESSO [8], this project propose a layered EA for the +CityxChange project, as illustrated in Figure 4.1. The main driver for the EA is the "service-based ecosystem" as identified in the objective for Task T1.1. The scenarios envisaged for the +CityxChange project span over the three focus areas of the city: Integrated Planning and Design, Common Energy Market, and CommunityxChange, and many application domains such as energy, transport, IoT, built environment, and governance. These often pose the silo problem with domains or departments separated from the organisation and data integration perspective; and the ecosystem and interoperability approach is expected to help solve this for the complex demonstration projects. Furthermore, +CityxChange extends beyond the traditional single enterprise boundary and includes many actors from the private and public sector as well as citizens.

The highest layer of the EA is the context layer which describes the needs of the citizens and the drivers for the services, which may also be the KPIs of the +CityxChange project. The second highest layer is the service layer, which both offers services to and uses data and applications from different application domains and involves one or more actors. The value added services layer will be driven by the project's objectives and the Key Performance Indicators (KPIs); i.e. services will be designed to contribute to one or more KPIs defined for the project; e.g. reduce Green House Gases (GHC), reduce energy consumption and energy waste and increase the uptake of Electric Mobility-as-a-Service (eMaaS); or the overall objectives such as the deployment of Positive Energy Blocks and localising the European Energy Transition into Urban Transitions.

Several horizontal layers are defined to support the services, which utilise data and are provided by collaborations among two or more enterprises; i.e. by a Virtual Enterprises (VE) [23]. The thinking behind the layered approach is that each layer supports the layer above it. Thus, the services are supported by one or more businesses or a VE, which are supported by one or many applications, which use data from the +CityxChange Data Space.

The +CityxChange Data Space is supported by technologies and finally, the data is obtained from data sources.

Related to the horizontal layers, two perspectives were proposed: (i) Stakeholder perspective to highlight the different stakeholders, their roles and perspectives; and (ii) Data perspective to address the specific principles and guidelines that are relevant in data-rich environments. These perspectives apply to all or most levels of the EA as shown in the Figure 4.1. More importantly, these perspectives help to identify contextualized principles and guidelines for designing EAs for the cities in the project and other PEDS. The proposed EA for +CityxChange project has also published [21],[24].

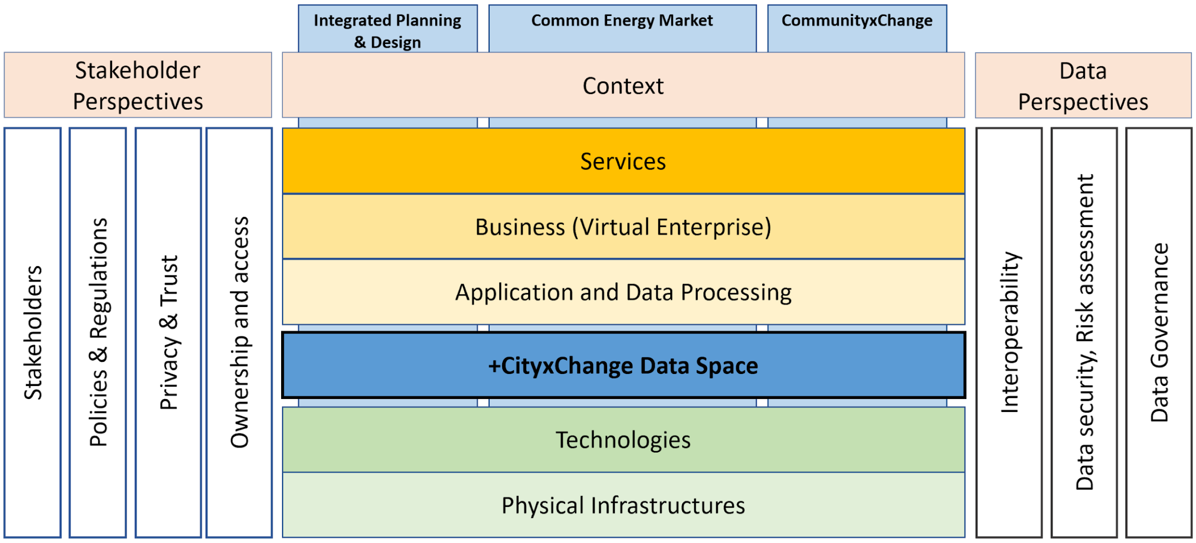

Fig. 4.1: Proposed layered EA for the +CityxChange project

The main elements that distinguish this EA from others are the following:

- At the heart of the +CityxChange EA lies the +CityxChange Data Space, which provides an overview and access to useful and relevant data that could be used in applications and by applications, by organisations, to provide value added service in the +CityxChange project. This layer will facilitate enhancing the data space from a collection of data to include additional support for leveraging on available data such as meta-data, opening up for data markets and contracts for using data.
- The concept of VEs in the business layer and the +CityxChange Data Space. The business layer is envisaged to include one or more actors or organisations that work together to provide a value added service to citizens or an organisation. While this may include the entities that are included in the business layers of other EAs, such as processes and actors, in the +CityxChange project, for each service, this layer include a VE, which is composed of two or more organisational entities that come

together to achieve a specific goal [23]; which in this case is to provide a specific service. This will facilitate new constellations of VEs, easy creation of new services, evolution of existing services and innovative collaborative business models.

The layers and the perspectives are described in the following subsections.

4.3 +CityxChange Architectural Layers

As in many EAs reported in the literature (see section 2.2.5), the CityxChange EA takes a layered approach, where the lower layers support the higher layers; see Figure 4.2. At the heart of this EA lies the +CityxChange Data Space which connects the higher layers with the lower layers. The higher layers correspond to what has been identified as the business and processing layers and the lower layers correspond more to the technological layers (e.g. [6]).

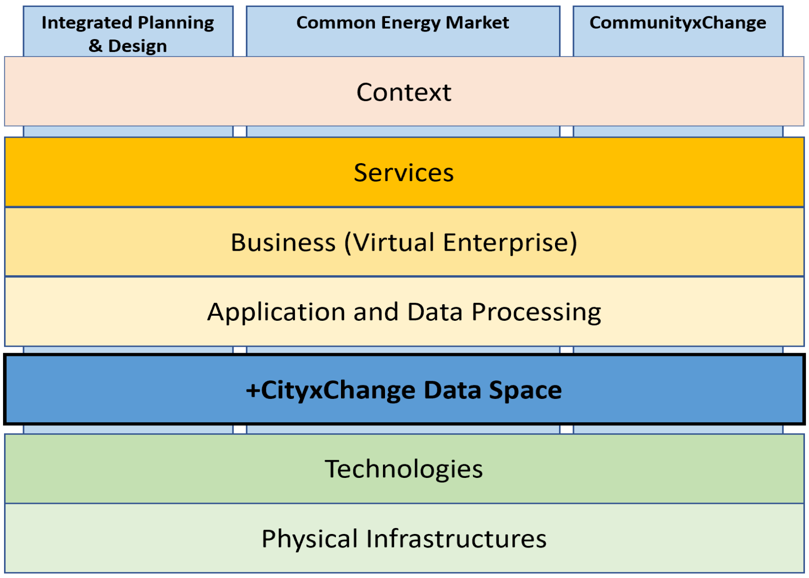

Fig. 4.2: EA layered approach for CityxChange

The horizontal layers of the CityxChange EA are described below:

- Context layer describes the needs of the citizens and the drivers for the services, which may also be the KPIs of the +CityxChange project.
- Service layer describes the value added services that are offered to users and customers, that bring together a number of service providers, data and applications.
- Business layer describes the different actors and processes that are involved in providing the service. Here the actors would typically be organisational units that need to collaborate to provide the service, referred to as a VE. As the example services show in Section 5, the service-based ecosystem envisaged for the

+CityxChange project are most likely to involve more than one entity and thus this layer is relevant for the +CityxChange EA.

- Application and Data Processing layer describes the different applications that support the services. Applications may support processing or analytics of data that are relevant for the service or other purposes such as searching and navigating the information space, visualisation of information or others.
- +CityxChange Data Space provides a means to bridge the lower levels of the EA, such as supporting technologies, and the higher levels of the EA, such as the (data-based) services. Furthermore, this layer will also serve as a common "platform" for the lower layers to facilitate access to data for the higher layers. This layer can be used to describe the data that is available in the +CityxChange or a PEB/PED space, that could be used by various entities to provide services. This layer is envisaged as serving a purpose that is greater than the data layer supported by EA frameworks such as TOGAF. Together with the Business layer, this layer is designed to support concepts such as data markets and data as a commodity.
- Technologies layer describes the different technologies that support the +CityxChange Data Space and the higher layers of the EA. Technologies include hardware (e.g. servers and community grid), applications such as databases and trust enabling infrastructure such as the IOTA platform for data integrity and transactions.
- Physical Infrastructures layer identifies the sources that provide the data, such as energy sensors, metering devices, IoT devices, mobile phones and social media. This layer is important for supporting transparency and integrity of data, and for adhering to regulatory frameworks such as GDPR.

It is important to note that these layers can be split into several layers within themselves; e.g. the technology layer could be split into software, hardware and infrastructure layers. Similarly, the business layer could be split into separate layers for each business entity, e.g. as Swimlanes in BPMN. Detailed descriptions of these layers are presented in Section 6 and 7 which shows the use of this layered EA illustrated through the services that are developed in the +CityxChange project.

4.4 Stakeholder Perspectives

The +CityxChange project has a citizen focused approach with several tasks dedicated to citizen engagement through innovation playgrounds, in WP3. Similarly, the service-based ecosystem and the participation of several public and private entities call for close attention to the diverse stakeholders that are a part of the city-wide or +CityxChange-wide EA space;

see Figure 4.3. Furthermore, based on the objectives of the +CityxChange project, relevance on the policies and regulations related to the application areas of the project are anticipated.

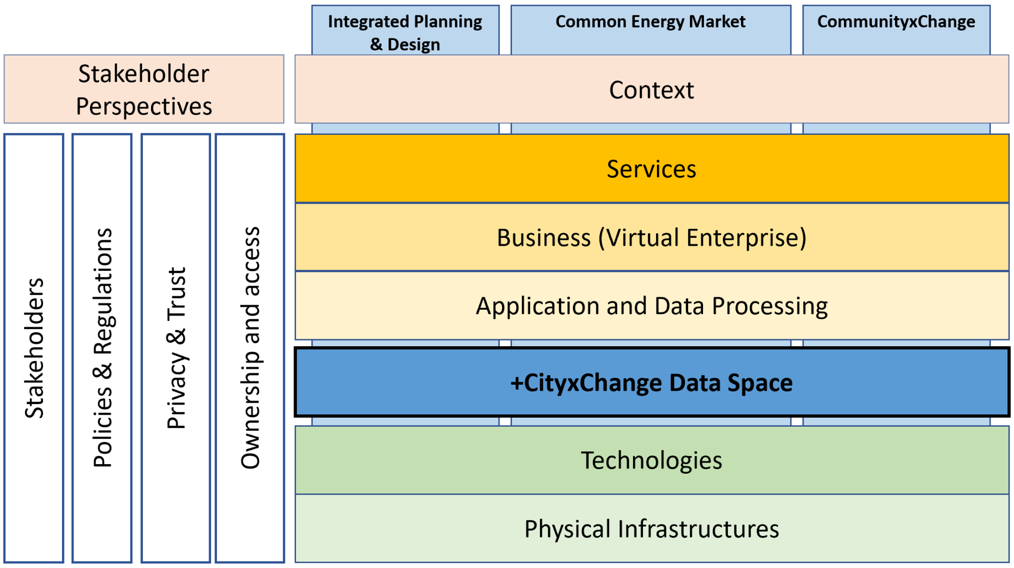

Fig. 4.3: Stakeholder perspective in the +CityxChange EA

The different perspectives within the stakeholder perspective are described below.

- Stakeholders describe the various entities involved in the city-wide or +CityxChange-wide EA space [25], which include citizens, service providers and consumers, who may be the end users of a service or users who build upon the service to create added value. Stakeholders also include data owners, providers, processors and consumers of data, public authorities, private enterprises, researchers and various communities (e.g. a local housing complex).
- Policies and regulations describe the regulatory stakeholders that are involved in the project, the influencers and stakeholders and services that are affected by the specific policies and regulations. Additionally, it identifies the policies and regulations that are relevant for meeting the objectives of the project. The policies and regulations apply to all the levels of the +CityxChange EA [20]; e.g. for business collaborations, data sharing and technologies.
- Privacy and Trust describes the relevant principles and guidelines that need to be followed not only to respect and protect the privacy of individual people and organisations, but also support a network of trust among the various stakeholders of the +CityxChange Data Space and services. Given the focus on stakeholders and the protection of individuals through the recent EU GDPR regulations, we have chosen to separate privacy and trust from data security (although they are

dependent on one another). The principles related to Privacy and Trust are discussed in Section 4.6.3.

- Ownership and Access describes the relationships between the stakeholders and the entities that will be represented in the layers of the EA. The data sources used by partner cities, shown in Figure 7.1, highlight that the relationships between the data and other entities or the ownership or accessibility for data used for providing services. This is evident from the example services identified in section 5.2 and 5.4. Similarly, the ownership and accessibility of services also require consideration. The issues, principles and guidelines related to ownership and accessibility is discussed in section 4.6.4.

4.5 Data Perspectives

The +CityxChange project envisages value added services that leverage on data that is available through the +CityxChange Data Space or indeed Open Data as further discussed in D1.3. Thus, there is a data perspective related to all layers of the EA, from the data sources to the value added services; see Figure 4.4.

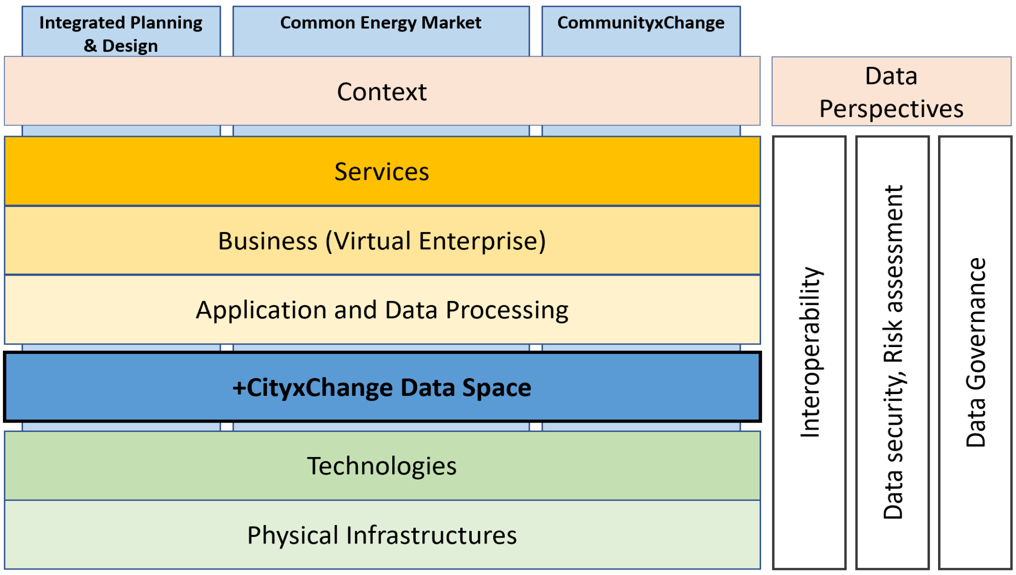

Fig. 4.4: Data perspective in the +CityxChange EA

This raises a need to address the data perspectives, and these are described below:

- Interoperability addresses how entities, through all the layers in the EA, could be brought together in a cohesive way to provide the value added services. Interoperability applies to all the levels of the EA; syntactic, semantic and business interoperability among technologies, businesses (Described in detail in section 4.7.1). APIs are employed in this project to achieve interoperability as discussed in D1.3 which provides and describes the API catalogue.

- Data security and risk assessment apply to all the layers of the EA to ensure that the data is handled in a secure and reliable manner. The security of data is not a static state; i.e. data that is secure at any time may not be secure at a future time, and thus requires regular assessments of risks and threats to the security of the data. Principles and guidelines for data security and risk assessments are discussed in section 4.7.2.
- Data Governance ensures key data management processes and encompasses people, organisations and processes. Data governance also ensures that data is consistent, available and usable. Principles and guidelines for data governance are discussed in section 4.7.3.

The +CityxChange EAF has been continuously developed over the first 2 years of the project. Apart from internal testing, use, and iteration, it has also been published in scientific avenues, for example in [24, 26, 27].

4.6 Principles and Guidelines for Stakeholder Perspectives

The stakeholder and data perspectives from the +CityxChange EA has been adopted as a framework for discussing the principles and guidelines relevant for the EA. In this section, each of the different stakeholders' perspectives are addressed in detail. The content is based on literature, guidelines from several consultancy companies and experience using EA frameworks. Also, the principles and guidelines are refined based on the feedback and user experience, to support the cities and developer partners.

4.6.1 Stakeholders

Stakeholders describe the various entities involved in the city-wide or +CityxChange-wide EA space, which include citizens, service providers and consumers, who may be the end users of a service or users who build upon the service to create added value. Stakeholders also include data owners, providers, processors and analysts and consumers of data, public authorities, private enterprises, researchers and various communities (e.g. a local housing complex). The principles for ensuring the broad perspectives of the diverse set of stakeholders and their need for support are outlined below:

- Participation of diverse stakeholders across one or many organizational entities, to collaborate, coordinate and communicate and perform one or more activities, e.g. provide +CityxChange value added services.

- Discover potential collaboration partners in the +CityxChange ecosystem that could collaborate to create a new VE and value added service(s).
- Integration of contributions from any stakeholder, such as services, applications and data, in an agile manner to ensure a dynamic service-based ecosystem.
- Citizen engagement through value added services, e.g. information dashboards, or virtual and physical meeting places or playgrounds.
- Separation of concerns from the stakeholders' perspectives so that each stakeholder is able to be an active member of the ecosystem, while experiencing a degree of freedom or decentralization as desired.

4.6.2 Policies and Regulations

The objectives of the +CityxChange project challenge existing policies, regulations and challenges on many dimensions such as the common market for energy and building codes. A regulatory environment is normally understood as the laws, rules, and regulations put in place by federal, state, or other government entities and civilian organisations to control the behaviour and actions of business activities. The regulatory environment impacts both enabling factors and barriers to the successful implementation of the solutions planned in the project [28]. Appropriate policies and regulations across cities and borders are relevant for replicability of Smart City approaches and solutions. The main principles relevant for policies and regulations are:

- Comply with policies and regulations at the local, national, European and international levels, at all times.
- Collaborate with public authorities (e.g. municipalities and city councils) and other regulatory authorities (e.g. standardization bodies) as relevant to introduce new policies and regulations and update and adapt them as relevant.
- Communicate the need for new or revised policies and regulations to the relevant stakeholders and provide the necessary input and feedback [29].
- Share knowledge and experience about relevant policies and regulations with project partners.
- Strive to comply with locally and globally agreed objectives and goals (e.g. the UN Sustainable Development Goals, UNSDG), wherever possible. Ensure alignment with city strategies and transformation processes [30].
- Leverage on common standards, best practices and performance metrics (or KPIs) and experiences from other projects; e.g. the CityKeys project [31], or the current EU SCIS (Smart City Information System).

4.6.3 Privacy and Trust

Recent EU regulations on data protection, GDPR [32], [33], has increased the attention of IT developers to practice Privacy by Design, rather than privacy as an afterthought. GDPR is central in the Stakeholder perspective to protect individuals and it applies to personal data, which is defined as "any information relating to an identified or identifiable natural person (data subject)". GDPR provides new rights to the data subject, (individuals about whom data is held), where they now have control of their data, improving data transparency and empowerment of the data subjects. It also draws attention to the distinction between the protection of personal data and the privacy of personal data; data protection is about securing the data against unauthorized access while privacy of data is about authorized access, such as who has it and who defines it. Data protection is a technical issue while data privacy is a legal issue.

In addition to the overall principle of Privacy by Design, the Article 5 of the GDPR sets out key principles and compliance with these key principles is essential for good data protection practice. Failure to comply with the principles may lead to fines; Article 83(5)(a) states that infringements of the basic principles for processing personal data are subject to the highest tier of administrative fines. This could mean a fine of up to €20 million, or 4% of an organisations' total worldwide annual turnover, whichever is higher. It is important to note that each organisation is itself responsible for compliance with GDPR, this also holds when data is exchanged between organisations, mandating specific care also in these cases [34].

The key principles of GDPR are described below:

- Privacy by Design, which calls for the inclusion of data protection from the onset of the designing of systems. This implies considering privacy of users and data protection to ensure privacy and trust as a part of the design, along with other design aspects such as the functionality, performance and user interface. It also emphasizes the importance of considering it throughout the life cycle of the system from conception to the design, development, deployment, and maintenance.
- Lawfulness, fairness, and transparency requires that personal data shall be processed lawfully, fairly and in a transparent manner in relation to individuals.
- Purpose limitation requires that personal data shall be collected for specified, explicit and legitimate purposes and not further processed in a manner that is incompatible with those purposes.

- Data minimization requires that personal data shall be adequate, relevant, and limited to what is necessary in relation to the purposes for which they are processed.
- Accuracy requires that personal data shall be accurate and, where necessary, kept up to date; every reasonable step must be taken to ensure that personal data that are inaccurate, having regard to the purposes for which they are processed, are erased or rectified without delay.
- Storage limitation requires that personal data shall be kept in a form which permits identification of data subjects for no longer than is necessary for the purposes for which the personal data are processed.
- Integrity and confidentiality require that personal data shall be processed in a manner that ensures appropriate security of the personal data.

Literature on Privacy identify that trust in relationships between two parties could be affected or violated, e.g. due to breach of confidentiality or the disclosure of information. Relationships are often founded on trust and confidentiality. Privacy and trust are dependent on the context in which they apply and indeed the relationship between privacy and trust are also context dependent. The context sensitivity is influenced by another important concept identified in the literature, the sensitivity of the information, e.g. a person's personal identification number is a more sensitive piece of information about the person than some other information. Thus, trust is an antecedent to disclosing private information in online and other environments. Privacy by Design foster trust in the system and the designers of systems and services and compliance to the key principles of GDPR foster trust in relationships among the entities that collaborate to provide the value added services. Principles for fostering trust among users when collecting data are listed below; some of these correspond to principles of privacy also.

- Increase transparency by informing the data subject of data collection.
- Comply with consent requirements by asking for permission, not forgiveness.
- Give control of the personal data to the data subjects.
- Communicate the benefits to data subjects by sharing their data and the value of their data.
- Do not ask for more information than necessary.
- Protect the data adequately and make this clear to the data subjects.

Regarding GDPR the +CityxChange project relies on trust networks among its partners, and perhaps beyond the project community in the future, for providing value added services. Thus, principles that facilitate and foster the different kinds of trust among the actors or organisations in the +CityxChange ecosystem are adopted. Some guiding principles to foster trust networks include the following:

- Relational trust - trust each other with mutual respect and comply with agreements (e.g. share data models or use Open Standards) to build trust over time (literature shows that trust between two parties is built over time).
- Functional trust - trust relates to how to get things done together such as collaborate to deliver a service. This requires open communication and reliability in the work to be done.
- Flow-of-Value trust is about reciprocity, where it is important to ensure that both or all parties in the trust network benefit mutually and that actors (and or their services and data) are not exploited.

4.6.4 Ownership and Access

Data ownership is the act of having legal rights and complete control over a single piece or set of data elements. It defines and provides information about the rightful owner of data assets and the acquisition, use and distribution policy implemented by the data owner. Ownership and access are relevant not only within the +CityxChange project, but whenever third-party data, applications, information or technologies are used. This is very likely the case for several +CityxChange relevant scenarios and services. For example, data may be saved on third party owned cloud-based storage and data may be collected and provided by third parties. This was evident also from the small sample of data gathered during the proposal stage. Principles for managing ownership and access rights to data, applications, information or technologies that are relevant for the implementation of value-added services are listed below:

- Individual systems and data responsibility - enable individual ownership of single components in the +CityxChange EA or parts of the EA, rather than a centrally owned single platform.
- Individual actors must be able to determine and exercise access rights to their own parts of the +CityxChange EA.
- Clarify ownership of data, applications, information and services and share this information with all.
- Define and describe assess models and rights for the components in the +CityxChange EA and share this information with all.
- Clarify the terms and conditions for granting access to privately owned data and other components.

4.7 Principles and Guidelines for Data Perspectives

The data perspectives from the +CityxChange EA are similarly discussed in this section, each of the different data perspectives are addressed in detail.

4.7.1 Interoperability

Interoperability is defined as a property of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, without any restricted access or implementation. Discussion on how interoperability is achieved in the +CityxChange project is discussed in detail in D1.3 where a catalogue of APIs are presented and data models are presented to show data is integrated and made interoperable by partners in the consortium in providing services. Also, to ensure GDPR is adhered to in D1.2, there is no personal identifiable data shared publicly (since it will go against GDPR rules and regulations).

Additionally, general principles for ensuring interoperability are described below:

- Ensure interoperability at many levels as often the exchange of data or information is not adequate for two or more actors to work together, e.g. to provide the value-added services in the +CityxChange project.
    - Syntactic Interoperability - two or more systems are capable of communicating and exchanging data. This could be supported through specified data formats and communication protocol.
    - Semantic Interoperability - to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of both systems; e.g. through the use of a common information exchange reference model or ontologies.
    - Business Interoperability – for diverse actors and business processes to work together seamlessly, as in the case of VEs that provide value added services.
    - Legal or regulatory interoperability at the policy level to achieve business interoperability across countries.
- Enabling and facilitation of systems open for everyone to ensure not only access to data, but also to the applications, systems, services and infrastructure, as much as possible.
- Use Open Standards as much as possible to enable sharing of data. An open standard is defined as a standard that is publicly available and has various rights to use associated with it.

- Comply with EU standards for easy discovery and sharing of data; e.g. EU INSPIRE legislation for spatial data [33] and URBAN ITS standards for transport data [35]. Use such standards as much as possible and adapt and extend them as relevant.
- Ensure updated standards and easy access to relevant standards.
- Share and publish APIs for connecting across applications and accessing data.
- Ensure updated APIs and easy access to available APIs.
- Use Open Data Models [36] as much as possible.
- Share and update data models.

4.7.2 Data Security and Risk Assessment

The main data security principles are based on the CIA (Confidence, Integrity, Availability) model and focus primarily on the data, which for the most part are managed within a single organization [37]. In a service based ecosystem, such as that envisaged in the +CityxChange project, security principles must extend to the different technologies such as data collection hardware and applications, third party technologies and infrastructure as any of these can fail security and are exposed to risks and threats to security breaches. Risk assessment is considered an important part of data security. The main principles for data security and risk assessment are:

- Confidentiality requires a set of rules that limits access to information. Measures must be taken to ensure confidentiality and to prevent sensitive information from reaching the wrong people, while making sure that the right people can in fact get it. Methods to ensure data confidentiality include encryption, authentication, authorization, and detection of identity fraud.
- Integrity is the assurance that the data is trustworthy and accurate and involves maintaining the consistency, accuracy, and trustworthiness of data over its entire life cycle. Data must not be changed in transit, and steps must be taken to ensure that data cannot be altered by unauthorized people (for example, in a breach of confidentiality). These measures include file permissions and user access controls. Good practices for ensuring data integrity include backup of data, version control and store of immutable data hashes (e.g. using distributed ledger, such as IOTA (see Section 6.2).
- Availability is a guarantee of reliable access to the information by authorized people. This requires ensuring that all hardware is maintained and upgraded as necessary. To achieve availability at all times, a disaster recovery process is essential.
- Risk assessment - data security needs to be a continuous process of assessing the risks and threats to data security. Thus, risk assessment must be conducted regularly, and relevant steps need to be taken to identify risks and threats and to

mitigate risks. Processes to deal with risks and threats need to be defined and adhered to.

  - Identify potential harm to data, systems, activities.
  - Assess the likelihood and severity of risks.
  - Determine actions to mitigate risk.

4.7.3 Data Governance

Data governance can be defined as an overall management of quality, usability, availability, security and consistency of an organization's data. This is important for +CityxChange to ensure project-wide consistency and joint understanding of data management and to ensure the quality of the data. The project's Data Management Plan (DMP) as discussed in D11.16 is focused on data governance from the management view of the project and complements the items discussed here. It also regularly updates that view, with a specific focus on open data, research data management and access, personal data, data security, licenses, open standards, and general requirements of the project in line with H2020 principles.

The core principles of data governance are described below:

- Open Data - aim to have Open Data as much as possible, which should be available to everyone to access, use, reuse and share, without licenses, copyright, or patents.
- Open Data in line with FAIR (Findable, Affordable, Interoperable, Reusable) - when data cannot be Open Data, aim to align with FAIR, which means to make data accessible by appropriate people, at an appropriate time, in an appropriate way. This is relevant where data may be private or if the data owner wishes to share their data only with specific parties or under specific conditions.
- Open Data Models should be developed and encouraged to facilitate the sharing of data and replication of solutions.
- Manage data quality consistently from the very beginning and on a periodic basis against the defined quality standards.
- Recognize data as an asset. Data has real, tangible and measurable value, and it must be recognized as a valued enterprise asset. It is important to ensure that the data assets are defined, controlled, and accessed in a careful and process-driven way.
- Data ownership and accountability must be clearly defined and it should be accessed through authorized processes only.
- Standardized rules, regulations and guidelines for the data governance process must be defined to avoid risks and noncompliance. This includes proper rules and

guidelines for things such as data access, data definition, privacy policies and security standards.

- Change management guidelines to track the data changes over the time. This is relevant for ensuring updated and correct data and to maintain data integrity, which facilitates trust building among data users.
- Data audit process to support a transparent audit policy.
- Well defined roles for data governance at all levels of the enterprise [38]. For the +CityxChange project, this is at the project level to ensure data governance within the project.

4.8 Applying the +CityxChange EA

This section describes a few examples to illustrate how the proposed +CityxChange EAF will be used in the project. The main idea is that one or more value added services (e.g. PEB Operations, eMaaS or a Service X) could be created by using data available from the +CityxChange Data Space, as shown in Figure 4.5. Each of these services are likely delivered by collaboration among one or more organisations; any organization may participate in the delivery of one or more services and participate in one or more VEs. The same organisations may be involved in providing several services, e.g. a utility company or technology developer may be a part of a Virtual Enterprise (VE) that provides several services. Similarly, an application and/or data sets may be used by more than one service.

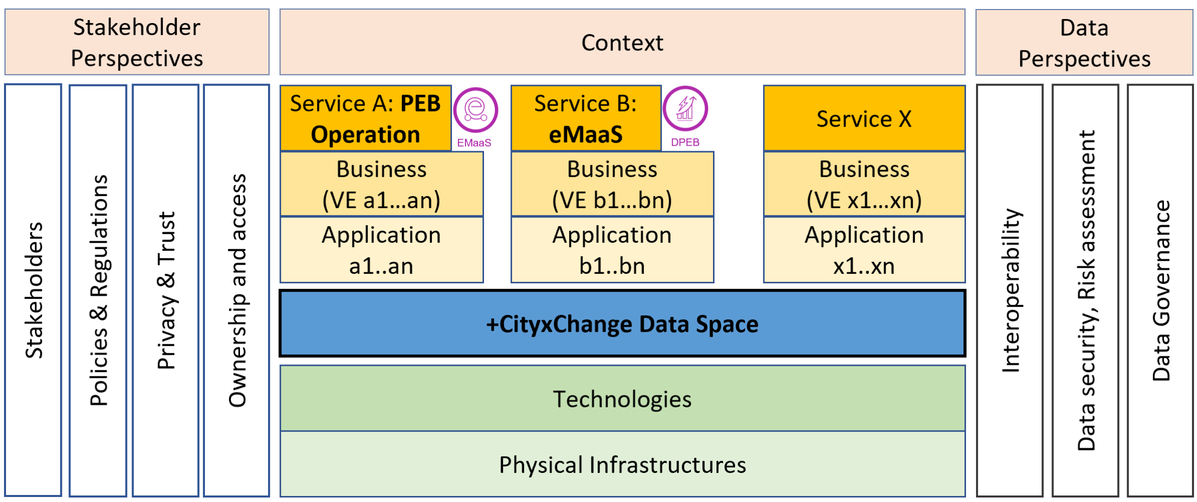

Fig. 4.5: Service creation in the proposed +CityxChange EAF

Two preliminary example scenarios are described using the +CityxChange EAF, in Figure 4.6. Note that this Figure is created for illustrative purposes only and is by no means an accurate or the final version of the services (final versions for eMaaS and trading platform are shown in section A.1 and A.11 respectively). The eMaaS is a service that is developed by partners in the lighthouse city Trondheim. The eMaaS service is provided by a VE; i.e. through a business collaboration among several partners with the goal to provide the specific service to specific target groups as seen in Figure 4.6. It is possible that one organisations can take part in one or more VEs; in this case, the partner FourC collaborates with other partners such as IOTA to form a VE which provide eMaaS to citizens.

As illustrated in Figure 4.6 the energy trade operation and eMaaS service includes applications such as trade platform, Total Traffic Control (TTC) (backend processing) and eMaaS application frontend application. The TTC uses data from different sources such as 3rd party weather data, etc. which is also used by the trade platform for energy trading in the energy market. The trade platform and eMaaS also use the same technological components, such as the V2G chargers or Micropayment Infrastructure (IOTA Distributed Ledger Technology (DLT)) that ensures data integrity.

The simple example (see Figure 4.6) also illustrates that several elements from the +CityxChange Data Space are used by one or more services. Or indeed, the data generated by one service may serve as a key data source in another service; e.g. the data related to EV chargers and energy consumption may play a significant role in services related to the energy exchange or transportation planning.

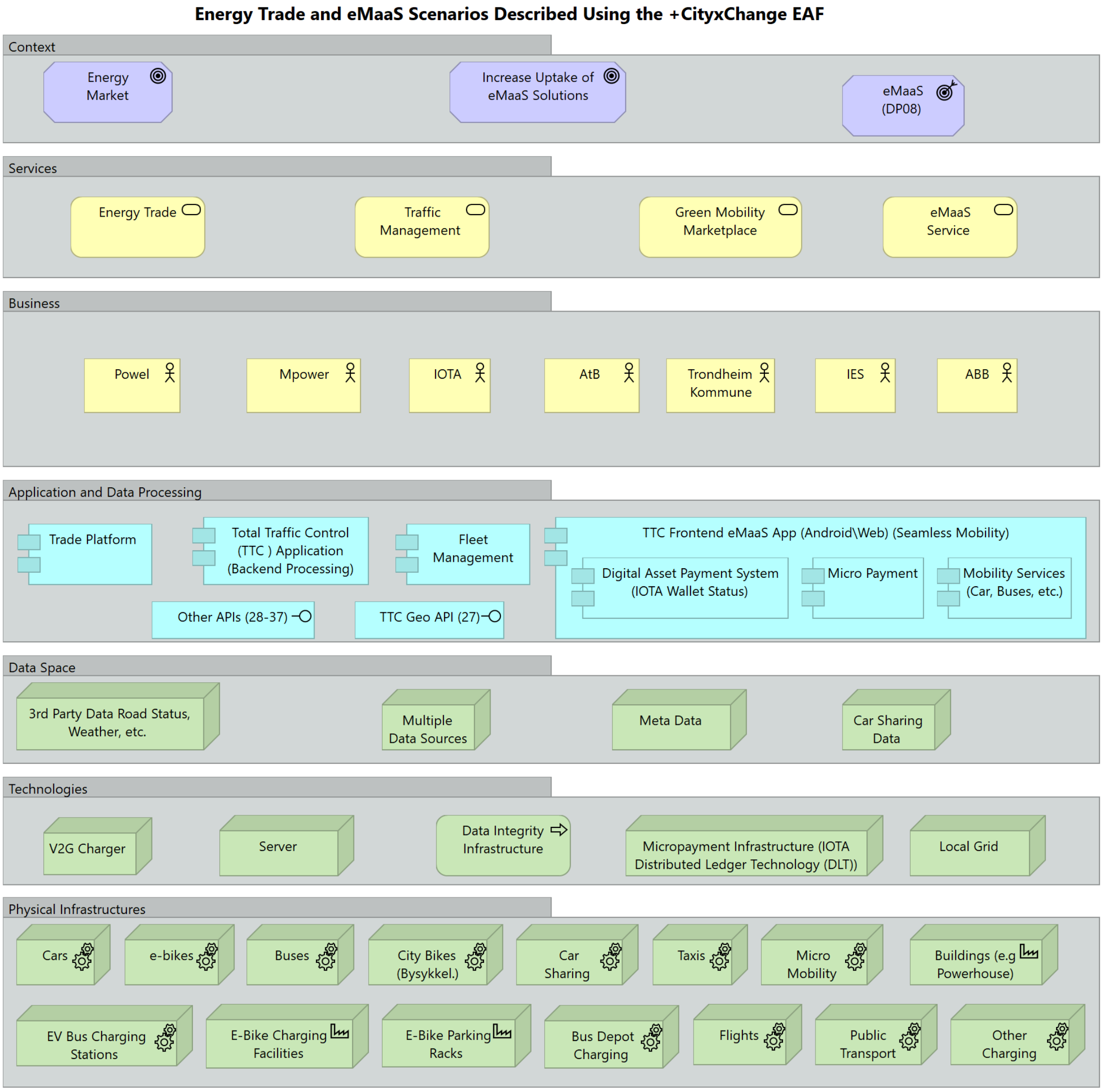

Fig. 4.6: Energy trading and eMaaS scenarios description using the +CityxChange EAF

5 Guidelines for using the +CityxChange EAF

A few simple examples are provided to illustrate how the +CityxChange Enterprise Architecture Framework (+CxC EAF) will be used. To simplify the EAF and to support the adoption of the EAF, the partners have suggested to start by using the horizontal layers (context, services, business, application and data processing, data space, technology, and data source), first and by identifying the different components within the horizontal layers. The information within each horizontal layer can become a complex model of components and relationships. The main challenges in representing such information is structuring the contents in a logical structured manner and visualizing relevant content for the different stakeholders within the relevant context. Therefore, we introduce the concept of views in addition to the layers in the +CityxChange EAF.

- Layers in the +CityxChange EAF show a conceptual structure for the components in a Smart City ICT ecosystem. It provides a means to describe the ICT ecosystem in a structured manner.
- Views can be a means of visualizing selected information represented using the +CityxChange EAF. Views are adapted to the needs of the specific stakeholders, for the specific need or context. For example, a municipality and a technology developer are likely to be interested in different views of the same ICT ecosystem.

Fig. 5.1: Main steps for applying the +CityxChange EAF

The main steps for applying the +CityxChange as shown in Figure 5.1 can be summarized as follows:

1. For a specific service, identify and describe the components in the horizontal layers of the +CityxChange EAF.
    a. If possible, identify additional information for each component; e.g. stakeholders, need for API, etc.
2. Identify and describe the relationships among the components.
3. For each component, identify additional information using the Stakeholder and Data Perspectives (the vertical columns):

   b. Who are the stakeholders for each component? e.g. Who owns the data? Who has access to the data? Who uses the data? Who can I collaborate with to provide a new service?
   c. How can I access the data? e.g. Is there an API? Can I obtain the data model? Does it conform to Open Standards? etc.
4. Iterate the steps and add more detail as relevant for the specific service.
5. Identify the different views to visualize the data.

One important objective of describing services using the +CityxChange EAF would be to document the description of the service so that it can serve as a reference model for other cities to implement the same or a similar service. Therefore, this could serve as a criterion to determine the level of detail of the description.
The next step of the process could be to describe two or more services on the same "canvas" as shown in Figure 4.6. This would support a more complete overview of the city-wide ICT ecosystem and help to see an overview of all the value added services, which data sets are used by several applications, who owns which data and applications, which partners collaborate, etc.
An application of these guidelines in using the EAF is shown in Section 7. The following subsections show examples through these steps based on specific use cases presented in the following section.

5.1 Step 1: Identify Components

The scenarios described in this section show the first step in applying the EAF with technology partners. Two examples are shown in Figure 5.2-5.5, where the components within each horizontal layer of the +CityxChange EAF are shown. It is important to note that these examples of services are preliminary findings from the early stages of development and hence the information provided in this section of the report is not the final version. The final versions of the use case from the EAF can be seen in section 6, 7, and appendix A.

The first example shows the PEB Operations service, described in a workshop conducted 13th June 2019 with Powel for the Trondheim PEB operation; modeled initially in Microsoft Visio as shown in Figure 5.2.
In addition to the "Energy Trade" business operation by Powel and Trønderenergi as the DSO (+CityxChange Demonstration Project DP09 on Local Trading, DP10 on Flexibility Market, supporting DP06 on Positive Energy Blocks), PEBs are enabled by business operations by IOTA (e.g. for micro payment processing) and others. Thus, to enable the PEB Operation service, Powel and IOTA and possibly other partners must collaborate. Trade is

supported by the application "Trade Platform" developed and owned by Powel. The applications "Site EMS" and "System Operation" are developed and owned by Powel. These applications use several data sets, produced and owned by several partners. These data are obtained using several technologies such as Energy Management Systems (EMS) and the IOTA distributed ledgers. The data is obtained from several physical entities such as sensors on buildings or other installations.

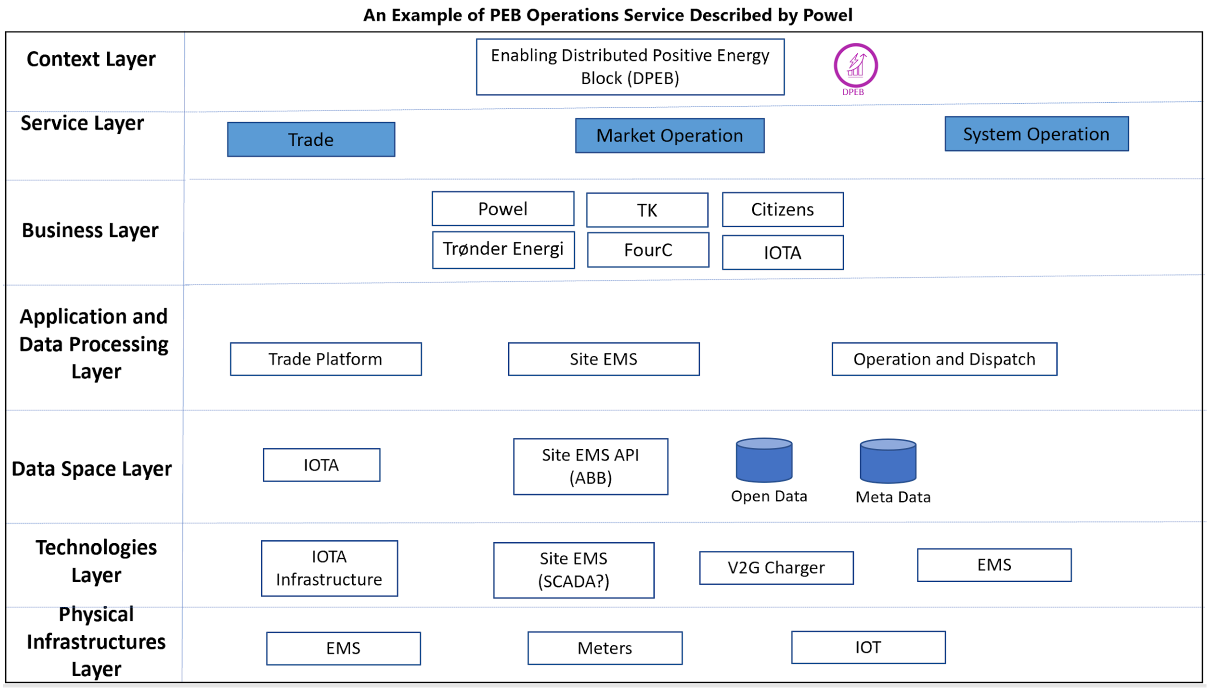

Fig. 5.2: An example of PEB Energy Operations service described by Powel

Within the project proposal, Trondheim Kommune (TK) sketched a first scenario for eMobility and EMaaS (eMobility-as-a-Service). The motivation for this service is the +CityxChange KPI to increase the uptake of eMaaS and is in line with the objectives for D2.5.

The eMaaS service description shown in Figure 5.3 has been developed during a few workshops with FourC (17th June 2019, 17th October 2019, and 2nd December 2019) and TK (12th September 2020, 4th December 2019), conducted to show the eMaaS service using the +CityxChange EAF. Similar to the example of PEB Operations, the components that are relevant for the eMaaS service are described. In this example, wherever possible, additional detail is included for the horizontal layers.

The eMaaS Service is provided through a collaboration among several companies, which are shown in the business layer. It uses several applications such as the eMaaS app and the Total Traffic Control (TTC) application for traffic data. The service requires several types of data; the applications use several data sets to provide the relevant data for the eMaaS service to operate. It also relies on several technological components owned and operated by different partners or third parties. The data sources are varied such as buses, flights, taxis and city bikes.

In this example, the need for APIs to access the data sets have been identified, although it was too early to identify the specifications for all APIs and data models.

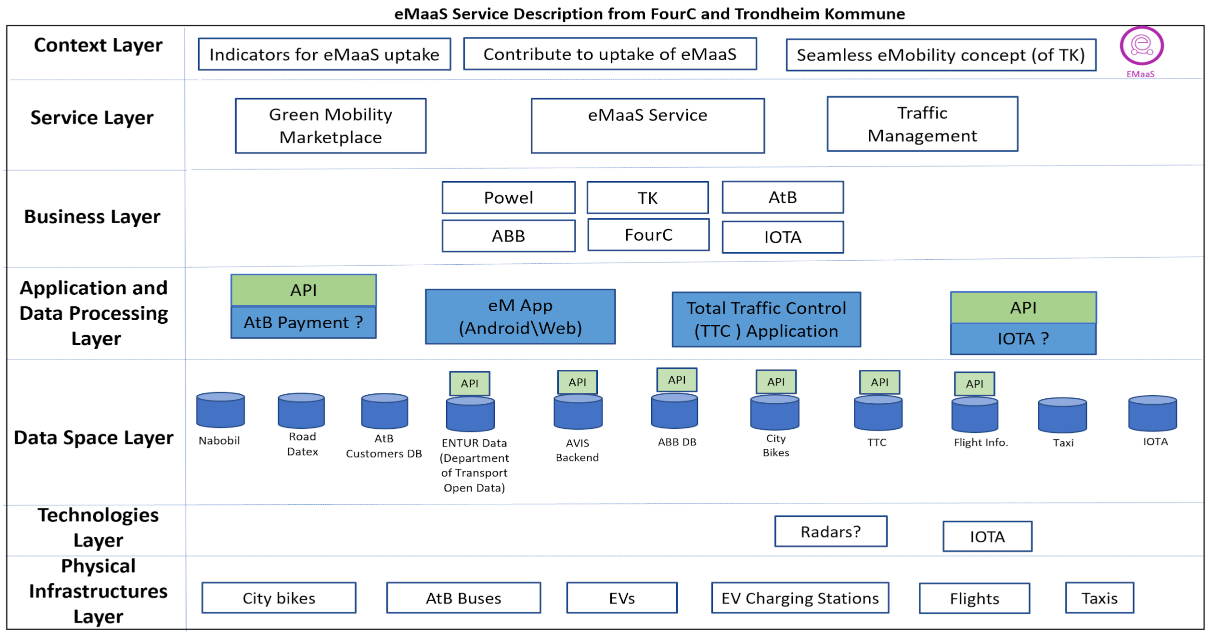

Fig. 5.3: eMaaS service description from FourC and TK

5.2 Step 2: Identify Relationships

The second step is to enhance the description of the service by adding the relationships between the components. Note that to support data-driven services as well as needs or business driven services, it is possible to start from the +CityxChange Data Space layer. An important point is also that data can be created by operating services and running applications. Therefore, it is possible to have data in the Data Space layer that has an arrow pointing to it from an application.

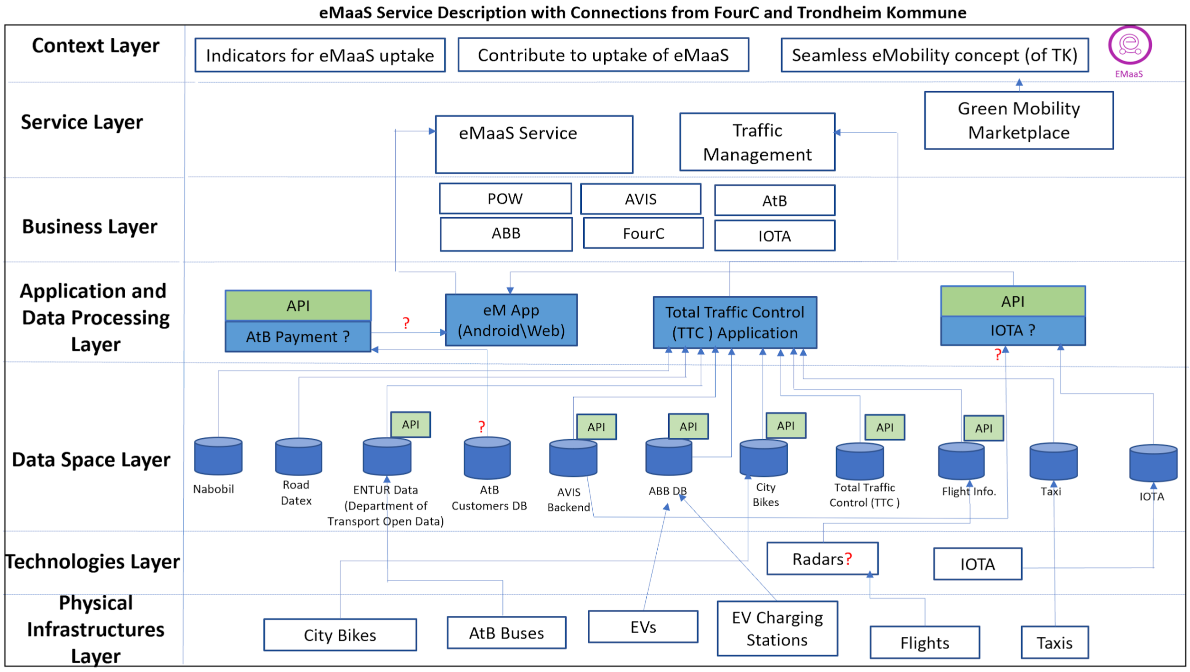

Fig. 5.4: Further detailed of eMaaS examples showing relationships among components

Part of the project objectives is the investigation of the use of IOTA in smart city and energy related scenarios. For example, in order to maintain track of data shared across services, information about data transaction can be included between the Data Sources and the +CityxChange Data Space, using infrastructure technologies such as IOTA. This is expected to leverage IOTA Distributed Ledger ability to provide support and added decentralized trust for both monetary and data transactions as discussed in section A.2 (IOTA eMaaS payments trail and tech specs and requirements use case). The eMaaS example is further detailed by identifying the relationships among the components, as shown in Figure 5.4.

5.3 Step 3: Identify additional information

The third step applies the Stakeholder and Data perspectives from the EAF. Further information can be added such as the APIs, the roles of stakeholders, such as producers, owners, consumers, data models, standards, access rights, etc. Some of this information is included in the eMaaS examples and further work was needed to be done to clarify, as indicated by the question marks in Figure 5.4. The eMaaS examples modelled in Archimate is shown in the next step (see Figure 5.5-5-6). The use cases are modelled using "ArchiMate Object and Descriptions"[4]. ArchiMate 3.0 notation business layer elements can be assessed from Open Group [4].

5.4 Step 4: Iterate and detail

Iterate steps 1-3 and add more detail. The eMaaS example developed in dialogue with FourC and TK is shown in Figure 5.5 which shows more detail and modelled using an enterprise modeling tool. The traffic management service and eMaaS service provide information to citizens via the eMaaS app. The example identifies where APIs are relevant and possible APIs have been identified. It also identifies the different data sources that are used by the TTC applications to provide eMaaS. Note that this scenario illustrative from the preliminary findings from TK and FourC. The final eMaaS use case is shown in section A.1.

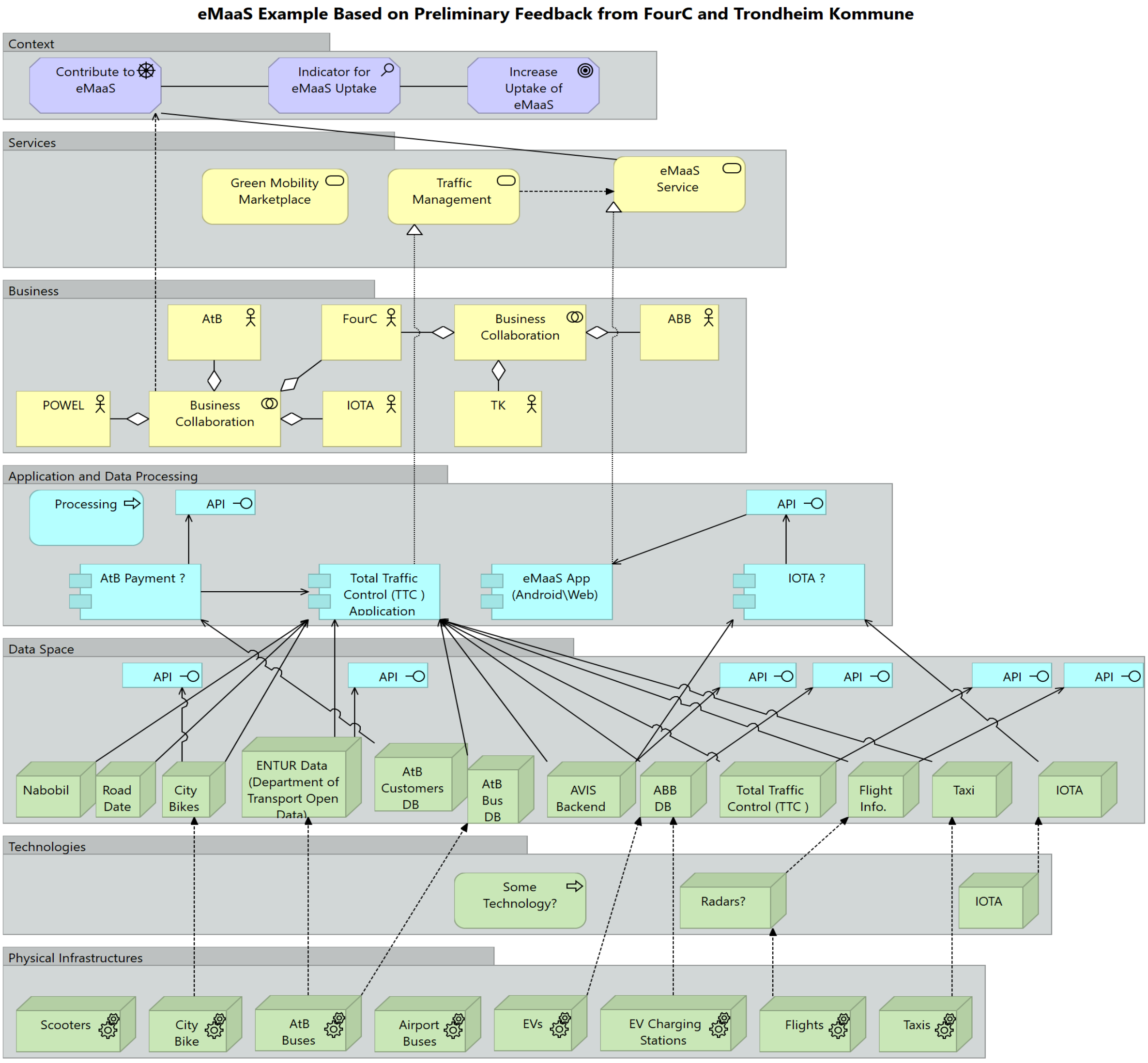

Fig. 5.5: eMaaS example modelled in Archimate based on preliminary feedback

5.5 Step 5: Identify Views

The detailed descriptions of services can become very complicated and a challenge for all stakeholders to understand. Hence, means of different views would be an advantage so that only relevant information can be filtered for viewing at any time. An eMaaS example of a possible view for all layers of the +CityxChange EAF from the preliminary information gathering from FourC and TK is shown in Figure 5.6.

As seen in Figure 5.6, the example of eMaaS view of all the EAF layers comprises the physical infrastructures which captures the mobilities available in the city as well as the energy assets used by the eMobility used by citizens to transport services. These energy assets may also provide energy via V2G chargers. Next is the technologies layer which processes data produced from the physical infrastructures layer. This layer also captures energy related technologies such as V2G chargers, micro payment infrastructure, etc.

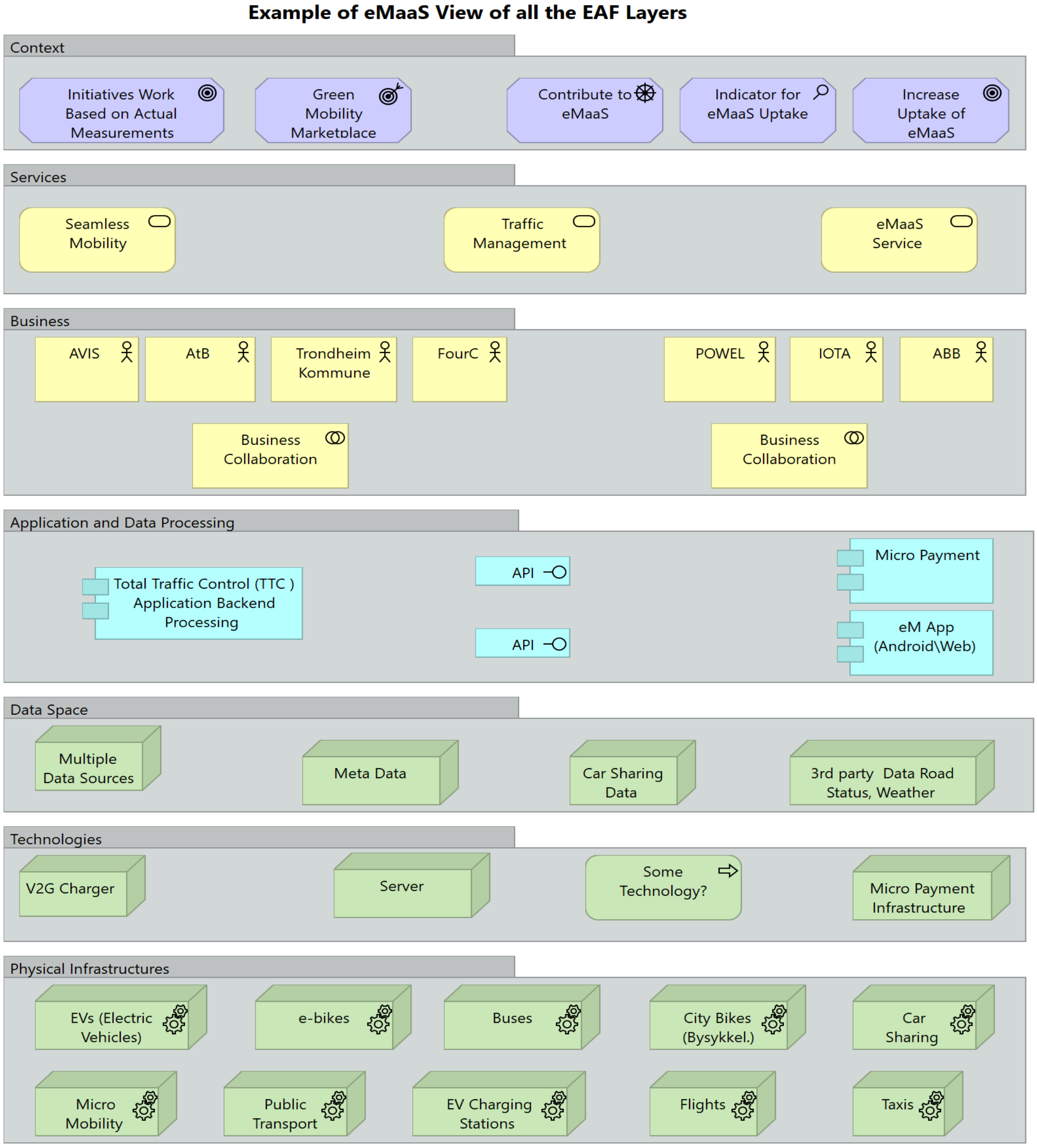

Fig. 5.6: Example of eMaaS view of all the EAF layers

Then, the data space layer comprises all data sources used to support provision of eMaaS by partners involved. The application and data processing comprise of all software applications used by citizens and partners to provide eMaaS such as eMaaS application, Total Traffic Control (TTC) application, etc. The business layer comprises all partners or virtual enterprises that collaborates to provide eMaaS, then services layer captures all services provided to citizens and stakeholders in the city such as traffic management, seamless mobility, etc. Lastly, context layer captures the main goals and requirements from the project and the cities as regards to eMaaS.

Additional examples of other use cases from +CityxChange project partners are discussed in section 6, 7, and appendix A.

6 Overall ICT Eco-system

This section illustrates the overall ICT Eco-system for the +CityxChange project. The ICT Eco-system based on the developed EAF (see Section 4.2, Figure 4.1) provides an architecture and service-based ecosystem which aims to ensure that services are developed through integrated and interconnected approaches and that data can be transferred in an open, accessible, interoperable, and secure manner. The ICT Eco-system for the +CityxChange project is shown in Figure 6.1.

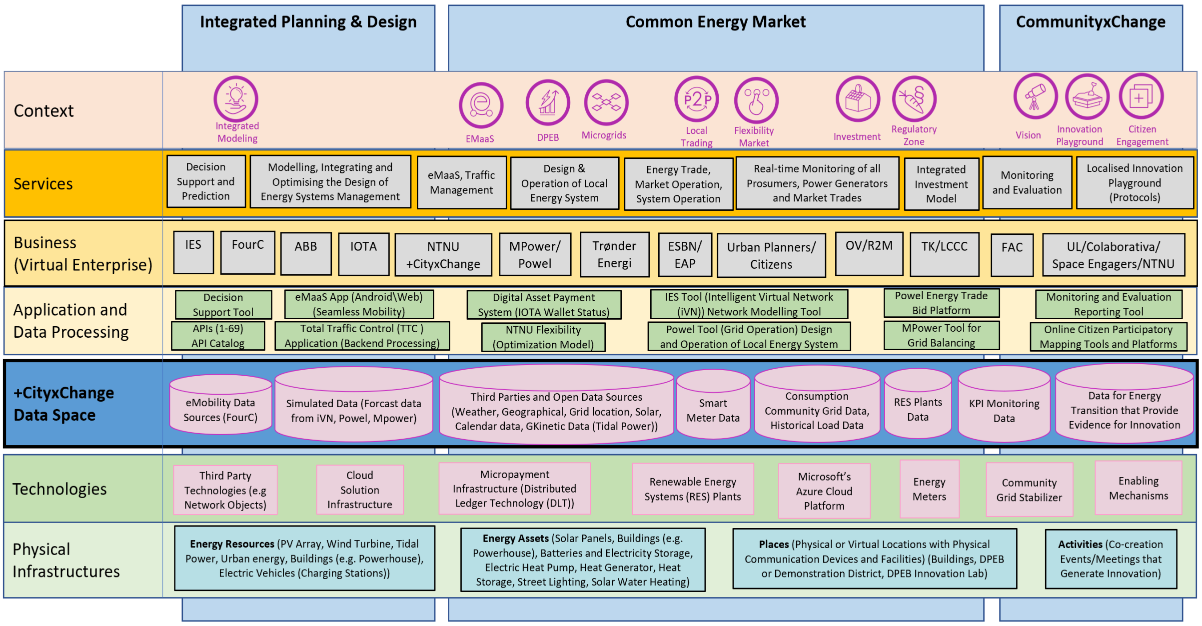

Fig. 6.1: Overall ICT Eco-system for the +CityxChange project

Figure 6.1 shows the overall ICT Eco-system for the +CityxChange project by highlighting the three main goals of the project: Integrated Planning and Design, Common Energy Market, and CommunityxChange aligned within the horizontal layers (context, service, business, application and data processing, data space, technologies, and physical infrastructures) of the developed EAF (as seen in Figure 3.1).
The context layer comprises all the DPs (DP1-DP11) to be achieved in the +CityxChange project which are carried out in the Lighthouse Cities/Trondheim and Limerick) and replicated in the Follower Cities. Service layer presents a summary of services provided by all partners in the +CityxChange project such as Decision Support and Prediction, etc. Next, the business layer highlights all partners involved in the project that collaborates to provide different services aimed at supporting the actualization of a DPEB.
Application and data processing layer involve all systems developed by partners in providing services such as decision support tool, eMaaS App, etc.

Data space layer comprises different data sources used by different systems deployed in the +CityxChange project to achieve a PEB. This layer aids DataxChange among project partners in providing services.
The technologies layer mainly captures the software and hardware employed to support applications and data processing layer, such technologies involve Micropayment Infrastructure (DLT) used by IOTA, Microsoft's Azure Cloud Platform used by Powel, etc.
Lastly, the physical infrastructures layer shows all physical and digital infrastructures involved to support a PEB. Within the PEB this layer comprises energy resources, energy assets, places, and activities.

Additionally, this section presents a generic use cases for Integrated Planning and Design, Common Energy Market, and CommunityxChange for the follower cities to support replication.

6.1 Integrated Planning and Design Use case

Use case Summary/Overview

This use case aims to model the Integrated Planning and Design linked to Modeling and ICT (WP1). The use case models how the +CityxChange project is able to prototype the future, through an innovative ICT enabled Decision Support Tool (DST).

Case Description

This case encompasses the developed ICT ecosystem (EAF), which will act as an enabler for all +CityxChange demonstration projects (see Figure 6.1), including the DST, allowing cross collaboration and connection.

The Integrated Planning and Design is linked to Modeling and ICT (WP1). Thus, a generic use case for Integrated Planning and Design of PEB as related to the +CityxChange project to Prototype the Future is presented in Figure 6.2 and a description of the use case is shown in Table 6.1.

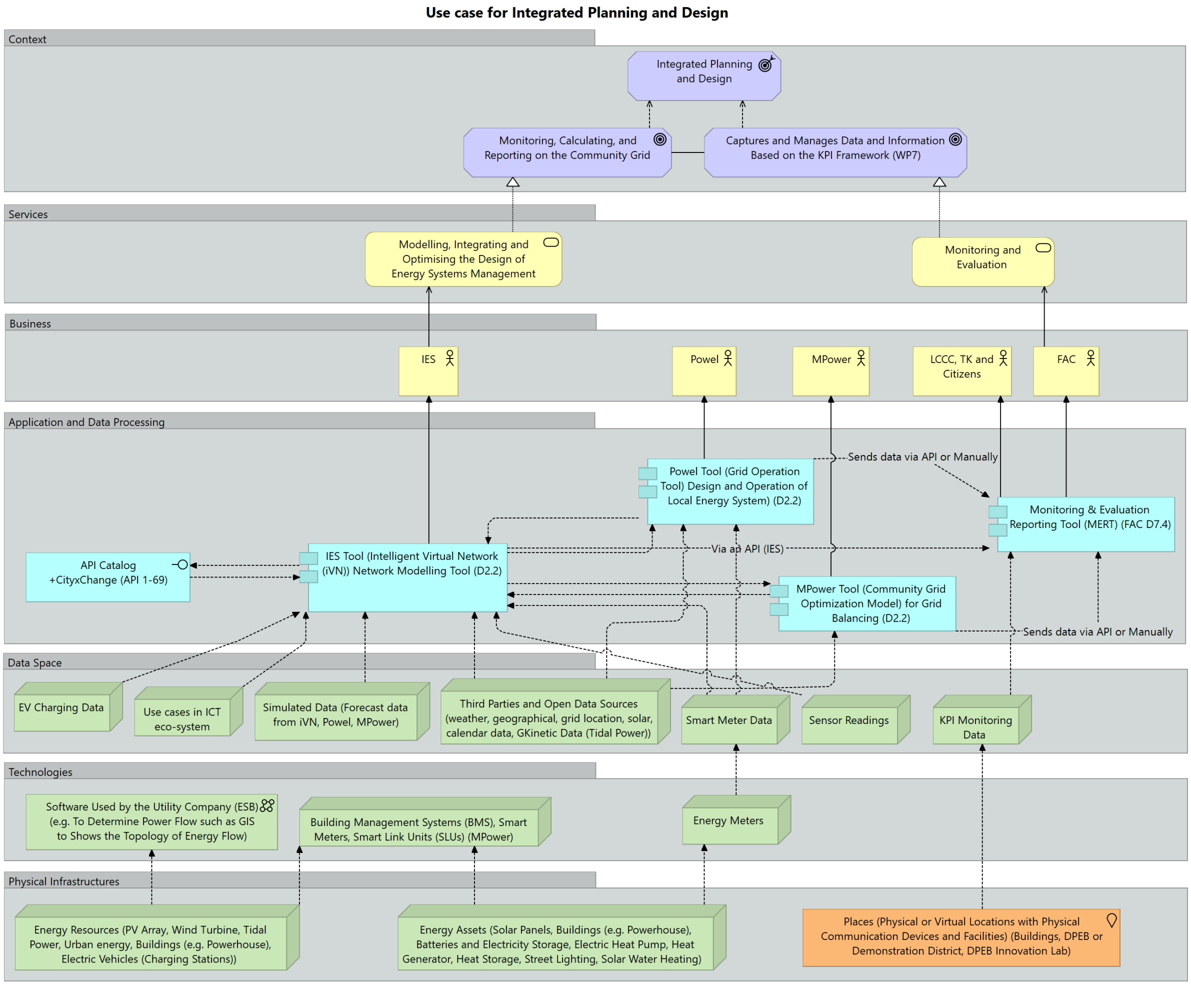

Fig. 6.2: Use case for integrated planning and design of PEB

No	EA Layer	Components	Description
1	Context	• Monitoring, calculating, and reporting on the community grid. • Captures and manages data and information based on the KPI framework (WP7). • Integrated planning and design.	• This is the main target which comprises integrated planning and design.

2	Services	• Modelling, integrating, and optimizing the design of energy systems management. • Monitoring and evaluation	• Entails the integrated planning and design services.
3	Business	• IES • Powel • MPower • LCCC, TK and Citizens • FAC	• Comprises the partners that collaborates to achieve Integrated Planning and Design in PEB.
4	Application and data processing	• APIs • IES Tool • Powel Tool • MPower Tool • Monitoring & Evaluation Reporting Tool (MERT)	The applications used for Integrated Planning and Design comprise of • API catalog of the +CityxChange comprises (API 1-69) as discussed in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39]. • IES Tool is used as the Limerick DST (D2.2) as discussed (see section A.3). • Powel Tool (Grid Operation Tool) Design and Operation of Local Energy System) (D2.2) (see section A.7). • MPower Tool (Community Grid Optimization Model) for Grid Balancing (D2.2) (see section A.6). • Monitoring & Evaluation Reporting Tool (MERT) (FAC D7.4) (see section 7.1).
5	Data space	• Several data sources used for integrated planning and design	The data sources used for integrated planning and design comprises EV • Charging data. • Use cases in ICT Eco-system. • Simulated Data (forecast data from iVN, Powel, MPower). • Third parties and open data sources (weather, geographical, grid location,

			solar, calendar data, GKinetic Data (Tidal Power)). ● Smart meter data. ● Sensor readings. ● KPI monitoring data.
6	Technologies	● Software used by the utility company ● Energy systems ● Energy meters	● Software used by the utility company (ESB) (e.g. to determine power flow such as GIS to show the topology of energy flow). ● Also, comprises building management systems, smart meters, Smart Link Units (SLUs) (MPower). ● Energy meters installed in buildings in the PEB.
7	Physical infrastructures	● Energy Resources ● Energy Assets ● Places	● The energy resources comprise of PV Array, Wind Turbine, Tidal Power, Urban energy, Buildings e.g. Powerhouse, Electric Vehicles (charging stations)). ● The energy assets (solar panels, buildings (e.g. powerhouse), batteries and electricity storage, electric heat pump, heat generator, heat storage, street lighting, solar water heating). ● Places comprises physical or virtual locations with physical communication devices and facilities) (buildings, DPEB or demonstration district, and DPEB innovation lab).

Table 6.1: Description of integrated planning and design in PEB use case

6.2 Common Energy Market Use case

Use case Summary/Overview

This use case for the Common Energy Market models how the +CityxChange project is able to innovate technology and regulatory options to enable positive energy blocks and districts through common local energy markets. It encompasses the delivery that focuses on how the common market will initiate incentives and possibilities for

bankability and new business models. The common energy market is basic for that customers and inhabitants will get involved in PEB related issues.

Case Description

This case is an outcome of WP2, and it described and discussed the general process towards achieving a PEB. Also, this case present how the Follower Cities in the +CityxChange project design and operate the PEB in a local flexibility market surrounding with all local energy resources included as market participants. It involves ICT tools needed to define, create and operate PEB markets. The common energy market serves as a basis for customers and inhabitants to get involved in PEB related issues.

In regard to WP2 a generic use case for Common Energy Market in PEB as related to the +CityxChange project to Enable the Future is presented in Figure 6.3 and a description of the use case is shown in Table 6.2.

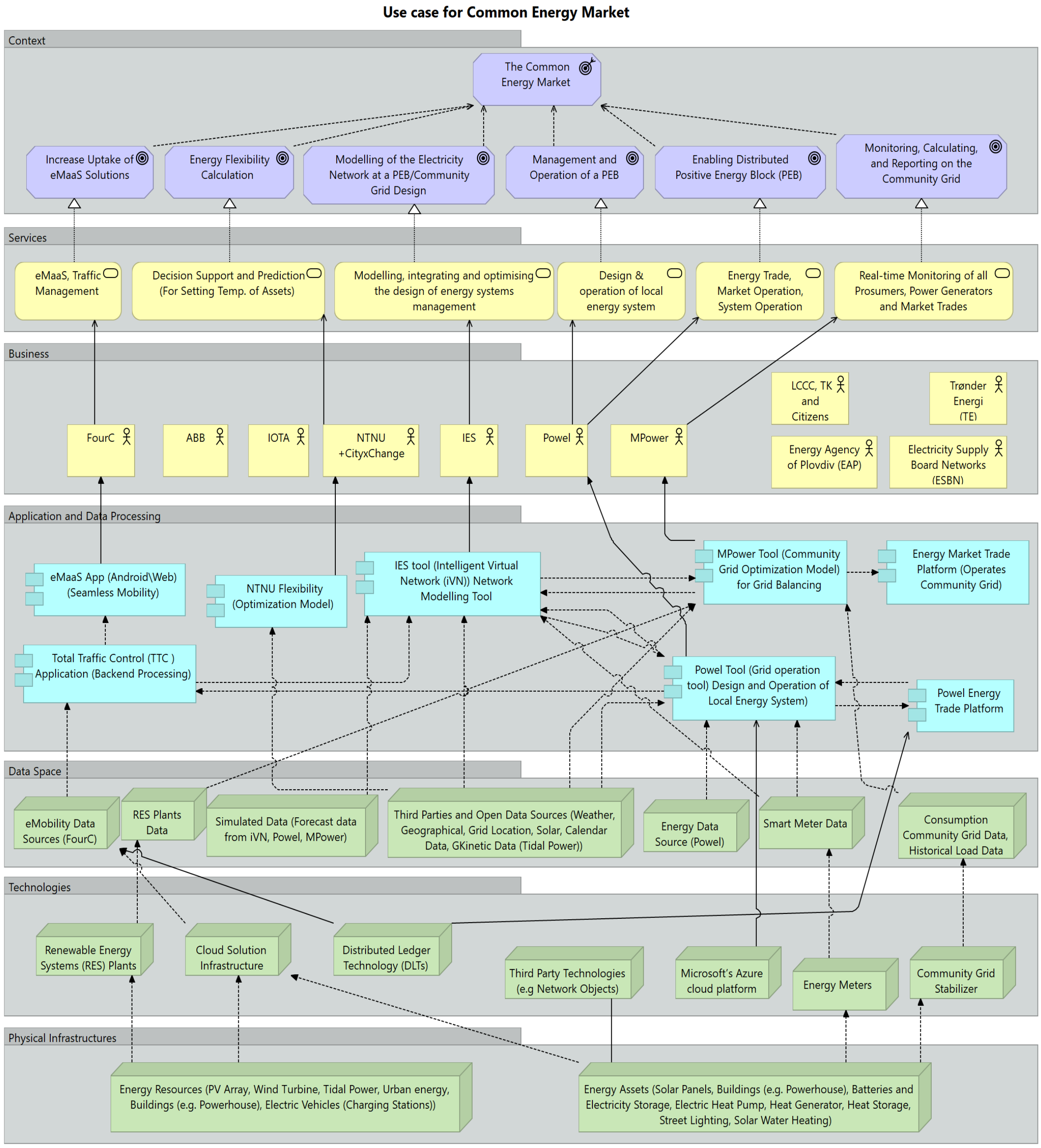

Fig. 6.3: Use case for common energy market of PEB

No	EA Layer	Components	Description

1	Context	• Increase uptake of eMaaS solutions • Energy flexibility calculation • Modelling of the electricity network at a PEB/community grid design • Management and operation of a PEB • Enabling Distributed PEB. • Monitoring, calculating, and reporting on the community grid • The common energy market	• The context layer captures the goals and requirements required to achieve the common energy market.
2	Services	• eMaaS, Traffic Management • Decision support and prediction • Modelling, integrating and optimizing the design of energy systems management • Design & operation of local energy system • Energy trade, market operation, system operation • Real-time monitoring of all prosumers, power generators and market trades	• Comprises services from partners involved in WP2. These services contribute in achieving the common energy market in PEB.

3	Business	• FourC, ABB, IOTA, NTNU +CityxChange, IES, Powel, MPower, LCCC, TK and Citizens, EAP, TE, and ESBN	• These are the partners involved in achieving the common energy market in PEB.
4	Application and data processing	• eMaaS App • Total traffic control Application • NTNU flexibility • IES tool • MPower tool • Powel tool • Energy market trade platform • Powel energy trade platform	• These are the applications used by partners to support the common energy market in PEB. The applications include; • eMaaS App (Android\Web) (seamless mobility) (see section A.1). • TTC application (backend processing) (see section A.1). • NTNU flexibility (optimization model) as discussed in section A.13. • IES Tool also same as the Limerick DST (D2.2) as discussed (see section A.3). • MPower tool (community grid optimization model) for grid balancing (see section A.6). • Powel tool (grid operation tool) design and operation of local energy system) (see section A.7). • Energy market trade platform (operates community grid) as discussed in section A.10. • Powel energy trade platform (see section A.11).
5	Data space	• eMobility data sources • RES plants data • Simulated data • Third party data • Energy data source • Smart meter data • Consumption data	• The system comprises different data sources uses by different system deployed for common energy market. Data from eMobility data sources provided by FourC. • Other data sources used comprises RES plants data, simulated data and forecast data from iVN, Powel, MPower. • It also includes third parties and open data sources (weather, geographical, grid location, solar, calendar data,

			GKinetic data (tidal power)), energy data source (Powel), smart meter data. • Lastly other data are consumption data comprises community grid data, historical load data.
6	Technologies	• RES plants • Cloud solution infrastructure • DLTs • Third party technologies • Microsoft's Azure cloud platform • Energy meters • Community grid stabilizer	• The technologies deployed in achieving a Common Energy Market comprises RES plants, cloud solution infrastructure used by the energy tools. Other technologies comprise DLTs, third party technologies (e.g Network Objects), Microsoft's Azure cloud platform, energy meters and community grid stabilizer.
7	Physical infrastructures	• Energy Assets • Energy Resources	• Energy assets comprises solar panels, buildings (e.g. powerhouse), batteries and electricity storage, electric heat pump, heat generator, heat storage, street lighting, solar water heating. • Energy resources involves PV array, wind turbine, tidal power, urban energy, buildings (e.g. powerhouse), electric vehicles (charging stations)).

Table 6.2: Description of common energy market in PEB use case

6.3 CommunityxChange Use case

Use case Summary/Overview

This use case for CommunityxChange is linked to Citizen Engagement (WP3) which aims to create a framework for participatory design and co-creation to enable citizens, businesses and other stakeholders in the demonstration districts, develop the sense of ownership needed to manage the change towards living and doing business in a positive energy city.

Case Description

This case is an outcome of Citizen Engagement (WP3) framework which is used in the lighthouse cities and follower cities. The CommunityxChange is organized around six tasks, each of which develops an element of the framework.

The CommunityxChange is linked to Citizen Engagement (WP3). Thus, a generic use case for CommunityxChange in PEB as related to the +CityxChange project to Accelerate the Future is presented in Figure 6.4 and a description of the use case is shown in Table 6.3.

Use case for CommunityxChange

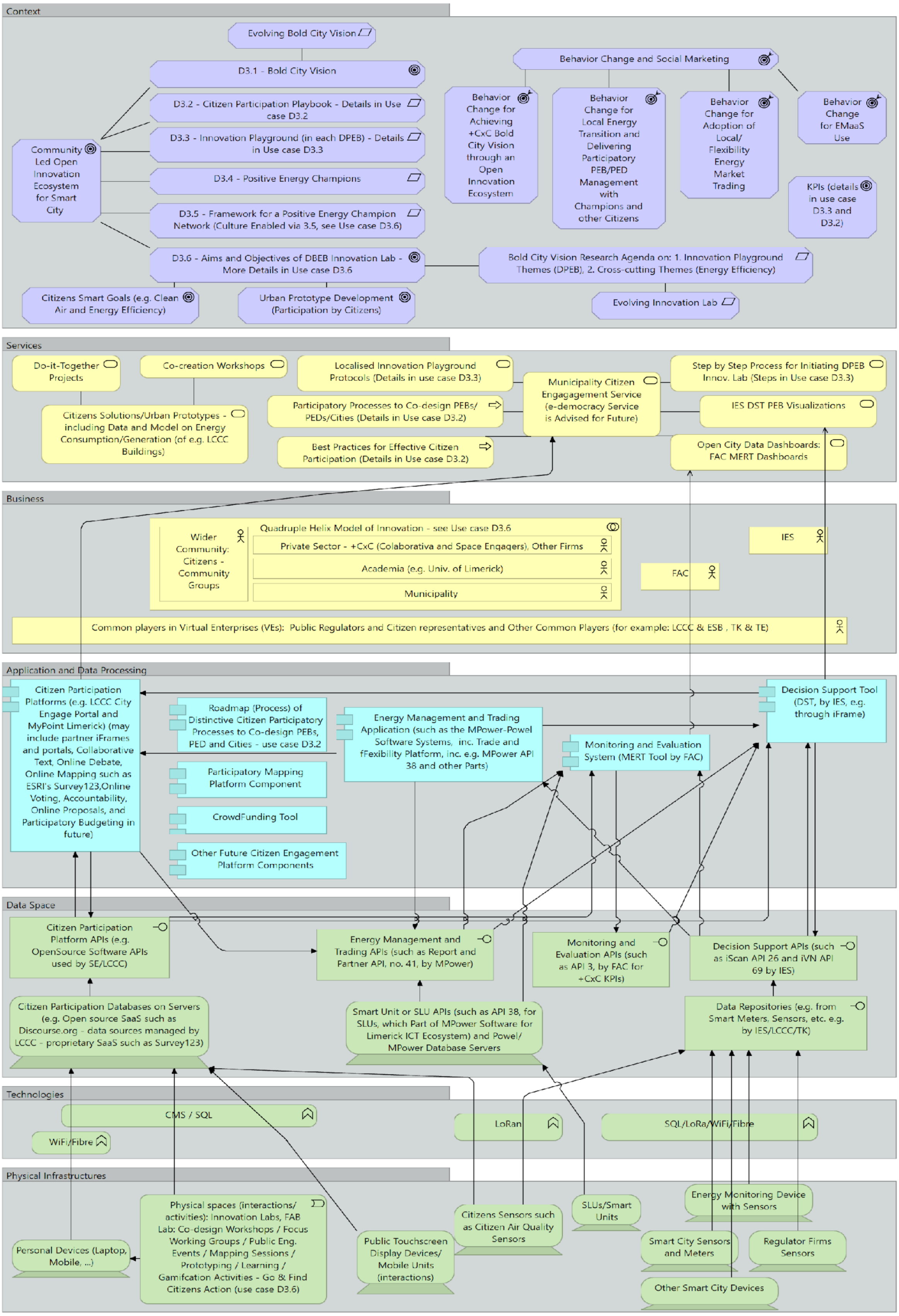

Fig. 6.4: Use case for CommunityxChange

No	EA Layer	Components	Description
1	Context	● Community led open innovation ecosystem for smart city ● Behavior change and social marketing ● Bold city vision research agenda ● KPIs	The main initiatives for CommunityxChange in PEB comprise of; ● Community led open innovation ecosystem for smart city which entails D3.1 to D3.6 (citizens smart goals (e.g. clean air and energy efficiency) and urban prototype development (participation by citizens). ● Behavior change and social marketing is linked to different initiatives to contribute to actualization of PEB as seen in Figure 6.4. ● Bold City Vision Research Agenda which involves innovation playground themes (DPEB), and cross-cutting themes (energy efficiency) connected to evolving innovation lab. ● The KPIs related to community engagement are discussed in use case for D3.3 and D3.2 as seen in section A.4 and A.5.
2	Services	● Citizens solutions/urban prototypes - including data and model on energy consumption/generation (of e.g. LCCC buildings) ● Municipality citizen engagement service (e-democracy service is advised for future)	The services for the CommunityxChange in PEB comprise of; Citizens solutions/urban prototypes ● Do-it-Together Projects. ● Co-creation Workshops. Municipality citizen engagement service ● Localised Innovation Playground Protocols (Details in use case for D3.3). ● Participatory processes to co-design PEBs/PEDs/Cities (details in use case for D3.2). ● Best practices for effective citizen participation (details in use case for D3.2). ● Step by step process for initiating DPEB innovation lab (steps in use case for D3.3).

			● IES DST PEB Visualizations. ● Open city data dashboards such as FAC MERT dashboards.
3	Business	● Quadruple helix model of innovation as described in the use case for D3.6.	● Involves the stakeholders from the quadruple helix model and other common players in Virtual Enterprises (VEs): public regulators and citizen representatives and other common players (for example: LCCC & ESB, TK & TE), IES, FAC.
4	Application and data processing	● Citizen participation platforms ● Energy management and trading application ● MERT ● DST	● The applications adopted for CommunityxChange comprises citizen participation platforms as described in Figure 6.4, energy management and trading application (e.g MPower/Powel tools, etc.), MERT by FAC, and DST by IES.
5	Data space	● Citizen Participation Platform APIs ● Citizen Participation Databases on Servers ● Energy Management and Trading APIs ● Smart Unit or SLU APIs ● Monitoring and Evaluation APIs (such as API 3, by FAC for +CityxChange KPIs) ● Decision Support APIs ● Data Repositories	The data sources utilized for CommunityxChange in the FCs comprises ● Citizen participation platform data source APIs (e.g. OpenSource Software APIs used by SE/LCCC). ● Citizen participation databases (e.g. open source SaaS such as Discourse.org, data sources managed by LCCC proprietary SaaS such as Survey123). ● Energy management and trading data sources (such as report and partner API, no. 41, by MPower). ● Smart unit or SLU sources (such as API 38, for SLUs and Powel/MPower database servers. ● Monitoring and evaluation data sources (such as API 3, by FAC for +CityxChange KPIs). ● Decision support sources (such as iScan API 26 and iVN API 69 by IES).

			• Data repositories (e.g. from smart meters, sensors, etc. e.g. by IES/LCCC/TK).
6	Technologies	• CMS/SQL (used in Community-led Open Innovation in Limerick), WiFi/Fibre, LoRan	• These technologies are deployed in the DPEB in FCs where CommunityxChange occurs.
7	Physical infrastructures	• Personal devices • Physical spaces • Public touchscreen • Citizens Sensors • SLUs/Smart Units • Energy Monitoring device with sensors • Smart city sensors and meters • Regulators firms' sensors • Other smart city devices	The physical infrastructures deployed in CommunityxChange includes; • Personal devices such as laptop, mobile, etc. • Physical spaces interactions/activities which comprises innovation labs, FAB Lab as discussed in use case D3.6 (section A.9). • Public touchscreen display devices/mobile units' interactions. • Citizens sensors such as citizen air quality sensors. • SLUs/smart units. • Energy monitoring device with sensors. • Smart city sensors and meters. • Regulators firms' sensors. • Other smart city devices.

Table 6.3: Description of CommunityxChange in PEB use case

6.4 Overview of +CityxChange Use case for Trondheim

Use case Summary/Overview

This use case depicts a generic use case for Trondheim. It models a summary of all systems, data sources, and services provided by +CityxChange project partners involved in Trondheim.
It thus provides a high-level view of the individual innovation cases presented in Section 7 and appendix A and the three topical cases presented in this section in their application to the ongoing Lighthouse City Trondheim deployments.

Case Description

This case represents a generic use case for LHC Trondheim. The case is a summary of Integrated Planning and Design, Common Energy Market, and CommunityxChange in Trondheim.

The generic use case for Trondheim is presented in Figure 6.5 and a description of the use case is shown in Table 6.4.

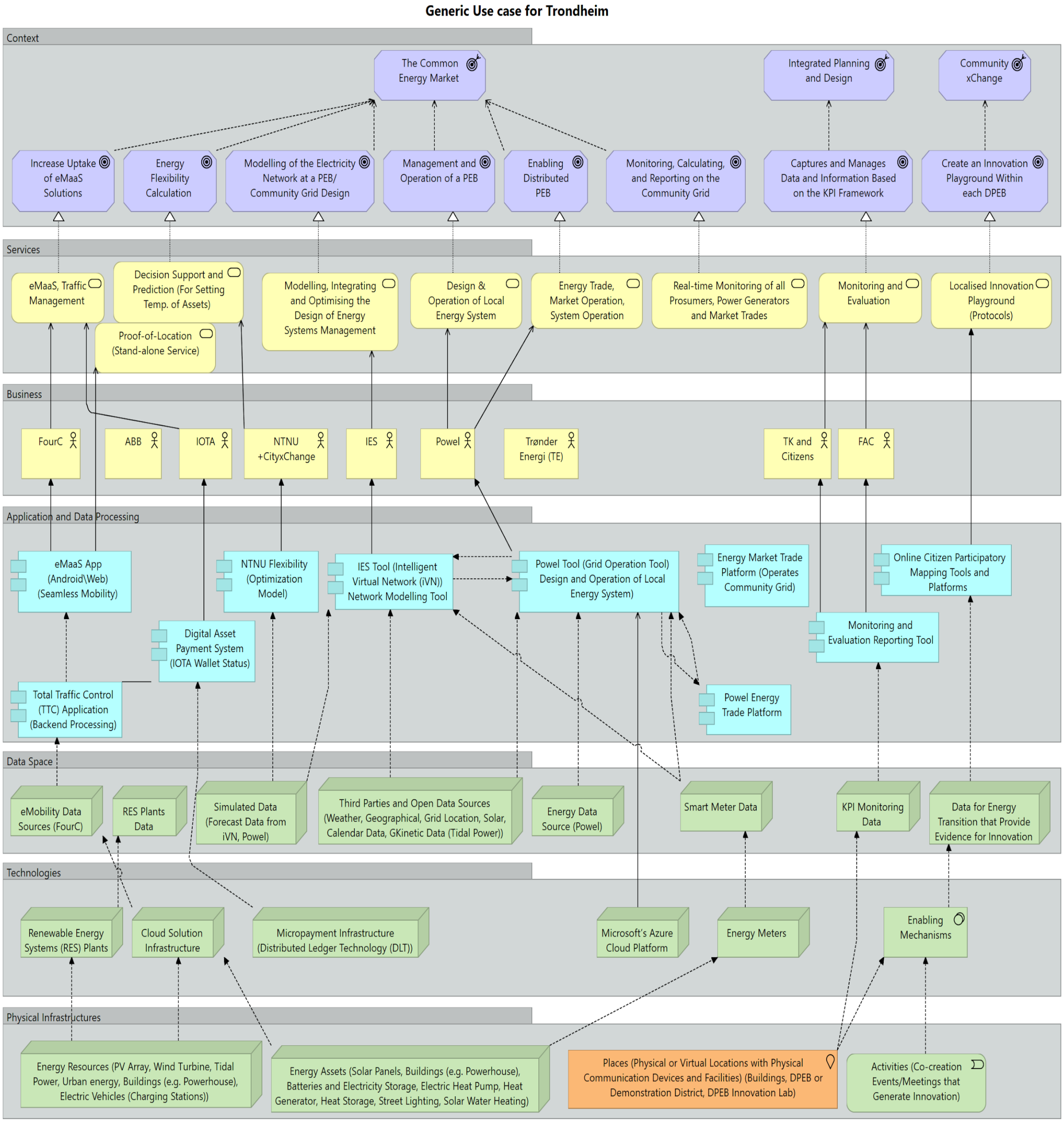

Fig. 6.5: Generic use case for Trondheim

No	EA Layer	Components	Description
1	Context	● The common energy market ● Integrated planning and design ● CommunityxChange	The main target for the +CityxChange comprises; ● The Common Energy Market ○ Increase uptake of eMaaS solutions. ○ Energy flexibility calculation. ○ Modelling of the electricity network at a PEB/community grid design. ○ Management and operation of a PEB. ○ Enabling distributed PEB. ○ Monitoring, calculating, and reporting on the community grid. ● Integrated Planning and Design ○ Captures and manages data and information based on the KPI framework. ● CommunityxChange ○ Create an Innovation Playground Within each DPEB.
2	Services	● eMaaS, traffic management ● Proof-of-Location ● Decision support and prediction ● Modelling, integrating and optimizing the design of energy systems management ● Design & operation of local energy system ● Energy trade, market operation, system operation ● Real-time monitoring of all prosumers, power	● The Common Energy Market services ranges from: ○ eMaaS such as eMaaS, traffic management, and proof-of-location (stand-alone service). ○ The decision support and prediction comprise of setting temperature of assets, modelling, integrating and optimizing the design of energy systems management. ○ Design & operation of local energy system, energy trade, market operation, system operation, real-time monitoring of all prosumers, power generators and market trades. ● The Integrated planning and design services aims to support monitoring and evaluation.

		generators and market trades ● Monitoring and evaluation ● Localised innovation playground	● CommunityxChange services is categorized as Localised innovation playground (protocols).
3	Business	● FourC, ABB, IOTA, NTNU +CityxChange, IES, Powel, Trønder Energi (TE), TK and Citizens, and FAC	● The partners involved in LHC Trondheim as regards to cases for Integrated Planning and Design, Common Energy Market, and CommunityxChange are captured.
4	Application and data processing	● eMaaS app ● TTC application ● Digital asset payment system ● NTNU flexibility ● IES tool ● Powel tool ● Energy market trade platform ● Powel energy trade platform ● Energy market trade platform ● MERT ● Online citizen participatory mapping tools and platforms	The list of main applications deployed in Trondheim for Integrated Planning and Design, Common Energy Market, and CommunityxChange comprises; ● The eMaaS App (Android\Web) (Seamless Mobility) as discussed in section A.1. ● Total Traffic Control (TTC) application backend processing as discussed in section A.1. ● Digital asset payment system used IOTA wallet status as discussed in section A.10. ● NTNU flexibility optimization model as shown in section A.13. ● IES Tool also same as the Limerick DST (D2.2) as discussed (see section A.3). ● Powel tool (grid operation tool) design and operation of local energy system) as discussed in section A.7. ● Powel energy trade platform as discussed in section A.11. ● Energy market trade platform which operates community grid as shown in section A.10. ● MERT as discussed in section 7.1. ● Online citizen participatory mapping tools and platforms as discussed in section A.4, A.5, and A.9.

5	Data space	• eMobility data sources (FourC) • RES plants data • Simulated data (forecast data from iVN, Powel) • Third Parties and Open Data Sources • Energy Data Source • Smart Meter Data • KPI Monitoring Data • Data for Energy Transition	The list of data sources used in Trondheim for Integrated Planning and Design, Common Energy Market, and CommunityxChange comprises; • eMobility data sources utilized by FourC • RES plants data used to provide data on RES sources such as from wind, solar, etc. • Simulated data which includes forecast data from iVN, Powel. • Third parties and open data sources from weather, geographical, grid location, solar, calendar data, GKinetic data (tidal power)) used by Powel tool and DST tool (IES). • Energy data source from Powel. • Smart meter data from energy data from buildings used by Powel tool and DST tool (IES). • KPI monitoring data used by MERT. • Data for energy transition that provide evidence for innovation for community engagement.
6	Technologies	• RES plants • Cloud solution infrastructure • Micropayment infrastructure • Microsoft's Azure cloud platform • Energy meters • Enabling mechanisms	• The technologies comprise of RES plants, cloud solution infrastructure, micro payment infrastructure (DLT) by IOTA, Microsoft's Azure cloud platform used by Powel, energy meters in building, and enabling mechanisms required to support innovation in DPEB.
7	Physical infrastructures	• Energy Resources • Energy Assets • Places • Activities	• These comprises energy resources (PV array, wind turbine, tidal power, urban energy, buildings (e.g. powerhouse), EVs (charging stations)). • Energy assets (solar panels, buildings (e.g. powerhouse), batteries and electricity storage, electric heat pump,

			heat generator, heat storage, street lighting, solar water heating). ● Places (physical or virtual locations with physical communication devices and facilities) (buildings, DPEB or demonstration district, DPEB innovation lab). ● Activities (co-creation events/meetings that generate innovation).

Table 6.4: Description of generic use case for Trondheim

6.5 Overview of +CityxChange Use case for Limerick

Use case Summary/Overview

This use case depicts a generic use case for Limerick. It models a summary of all systems, data sources and services provided by +CityxChange project partners involved in the LHC Limerick. It thus provides a high-level view of the individual innovation cases presented in appendix A and the three topical cases presented in this section in their application to the ongoing Lighthouse City Limerick deployments.

Case Description

This case represents a generic use case for LHC Limerick. The case is a summary of Integrated Planning and Design, Common Energy Market, and CommunityxChange in Limerick.

The generic use case for Limerick is presented in Figure 6.6 and a description of the use case is shown in Table 6.5.

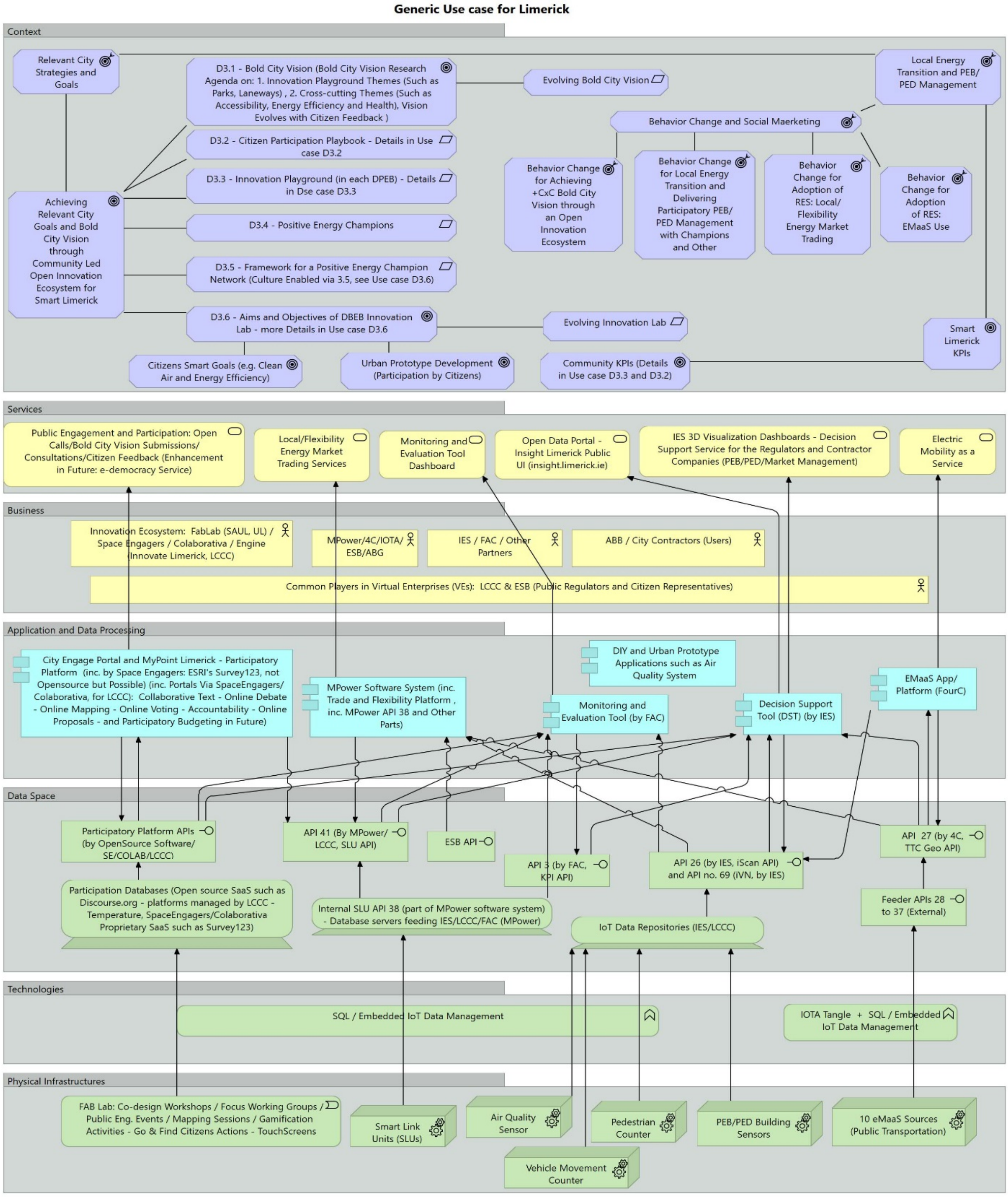

Fig. 6.6: Generic use case for Limerick

No	EA Layer	Components	Description
1	Context	• Evolving Bold City vision	• Aimed to achieve relevant city goals and bold city vision through community led open innovation

		● Citizens smart goals (e.g. clean air and energy efficiency) ● Urban prototype development (participation by citizens) ● Community KPIs (details in use case D3.2, D3.3 and D3.6) ● Evolving Innovation Lab in consideration to D3.1-D3.6.	ecosystem for smart Limerick. This is done by employing relevant city strategies and goals aligned to local energy transition and PEB/PED management for accomplishing Smart Limerick KPIs.
2	Services	● Public Engagement and Participation ● Local/Flexibility Energy Market Trading Services ● Monitoring and Evaluation ● Open Data Portal ● IES 3D Visualization Dashboards ● Electric Mobility as a Service	The services in Limerick for the +CityxChange project comprises ● Public engagement and participation which involves open calls/bold city vision submissions/consultations/citizen feedback (enhancement in future: e-democracy service). ● Local/flexibility energy market trading services within the PED. ● MERT KPI dashboards for representing city level data. ● Open data portal such as insight limerick public User Interface (UI) accessed via insight.limerick.ie. ● IES 3D Visualization Dashboards and decision support service for regulators and contractor companies (PEB/PED/market management). ● eMaaS within some part of Limerick.
3	Business	● Innovation Ecosystem: FabLab (SAUL, UL) / Space Engagers / Colaborativa / Engine (Innovate Limerick, LCCC)	● The partners and other virtual enterprises involved directly or indirectly in the +CityxChange project are presented as seen in Figure 6.6.

		• Powel/MPower/ FourC /IOTA/ESB • IES / FAC / other partners • ABB / City Contractors (users) • Common players in VEs LCCC & ESB (public regulators and citizen representatives)	
4	Application and data processing	• City Engage Portal and MyPoint Limerick participatory platforms • MPower software system • MERT • DIY and urban prototype • DST • EMaaS App	The applications employed in the +CityxChange project in Limerick comprises; • City engage portal and MyPoint Limerick participatory platforms employed for community engagement. • MPower software system including trade and flexibility platform, MPower API 38 (as discussed in D1.3 [39]. • MERT KPI Dashboard provided by FAC. • DIY and urban prototype applications such as air quality system. • DST provided by IES. • EMaaS App/Platform developed by FourC.
5	Data space	• Participatory Platform APIs • Participation Databases • API 41 • Internal SLU API 38 • ESB API • API 3 • API 26 • IoT Data Repositories (IES/LCCC) • API 27 • Feeder APIs 28 to 37	The data sources employed in the +CityxChange project in Limerick comprises; • Data from participatory platform APIs which includes OpenSource Software/SE/COLAB/LCCC. • Participation databases open source SaaS such as Discourse.org - platforms managed by LCCC - Temperature: SpaceEngagers/Colaborativa - proprietary SaaS such as Survey123) API 41 (By MPower/LCCC, SLU API). • Internal SLU API 38 which are part of MPower software system and

			database servers feeding IES/LCCC/FAC (MPower). ● ESB API, API 3 (provided by FAC, KPI API). ● API 26 (by IES, iScan API) and API no. 69 (iVN, by IES). ● IoT Data repositories provided by IES/LCCC. ● API 27 (TTC Geo API) provided by FourC. ● Feeder APIs 28 to 37 from external sources.
6	Technologies	● SQL/embedded IoT data management ● IOTA Tangle + SQL/ embedded IoT data management	● The technologies deployed in Limerick comprises SQL, embedded IoT data management, and IOTA Tangle.
7	Physical infrastructures	● FAB Lab ● SLUs ● Air quality sensor ● Vehicle movement counter ● Pedestrian counter ● PEB/PED building sensors ● 10 eMaaS sources	The physical infrastructures deployed in Limerick comprise of; ● FAB Lab comprises co-design workshops/focus working groups / public Eng. events/mapping sessions/ gamification activities - go & find citizens actions touchscreens. ● SLUs deployed in buildings. ● Air quality sensor deployed in streets. ● Vehicle movement counter deployed in streets. ● Pedestrian counter deployed in streets. ● PEB/PED building sensors ● 10 eMaaS sources that provides data for public transportation.

Table 7.5: Description of generic use case for Limerick

7 Description of Use cases (High Level User Stories of the Demonstration Projects)

The section provides a description of services, use cases with the cities and other partners. Therefore, the details of the use cases are developed in cooperation with existing and some future deliverables and tasks which relate to the demo projects (DPs) within the +CityxChange project as summarized in Table 7.1. The project partners have provided brief information on APIs, which are explored in more detail in D1.3: Report and Catalogue on the ICT Data Integration and Interoperability, where also more detailed API structures are presented. The description of the services can be utilized as reference models for replication of services by followers' cities. In addition, specific and generalized scenarios are presented for each use case to identify recommendations and guidelines for replication of services. A brief description of the use cases stories modelled in the developed EAF are shown in Table 7.1.

No	Name	Task/ Deliverable	Partners Involved	Demonstration Project
1	Monitoring and Evaluation Dashboard	T7.4, D7.4- Monitoring and evaluation dashboard	FAC, ISOCARP	**Model (DP01)** Record data and provide integrated decision support to cities
2	Seamless eMobility system including user interface	T2.4, T5.8, T4.8, D2.5-Seamless eMobility system including user interface	FourC, TK, IOTA, Powel, MPower	**eMaaS (DP08)** Integrate seamless e-mobility within the PEB.
3	IOTA eMaaS payments trail and Tech specs and requirements	T2.4, D2.5-Seamless eMobility system including user interface	IOTA, FourC	**eMaaS (DP08)** Integrate seamless e-mobility within the PEB.
4	Limerick DST (Integrated Modelling and Decision Support Tool)	T4.1, D4.1. Limerick DST (Integrated Modelling and Decision Support	IES, LCCC, FAC, ESB, ESBN, MPower	**Model (DP01)** Record data and provide integrated decision support to cities

		Tool) including training manuals/videos		
5	Delivery of the citizen participation playbook	T3.2, D3.2- Delivery of the citizen participation playbook	Colaborativa, LCCC, TK, NTNU	**Vision (DP02)** Co-create a bold city vision, to plan, implement, replicate & scale-up to PED & cities. **Engage (DP03)** Co-create PED. **Playground (DP05)** Accelerate change and disruptive solutions through innovation playgrounds.
6	Framework for an Innovation Playground	T3.6, D3.3- Framework for innovation playgrounds	Space Engagers, NTNU, Officinae Verdi Group	**Playground (DP05)** Accelerate change and disruptive solutions through innovation playgrounds.
7	Mpower Tool (Mpower enerXchange platform)	T 2.2, T 2.3, D2.2- Toolbox for design of DPEB including eMobility and distributed energy resources	Mpower, IES	**PEBs (DP6)** Create distributed PEBs through improved energy performance and integration with the energy system. **Local Trading (DP09)** Enable Peer-to-Peer trading within the PEB. **Flexibility Market (DP10)** Enable a fair deal to all consumers through a flexibility market.
8	Powel tool – (Grid operation tool) design and	T 2.2, T 2.4, D2.2- Toolbox for design of DPEB including	Powel, IES	**PEBs (DP6)** Create distributed PEBs through improved energy performance

	operation of local energy system	eMobility and distributed energy resources		and integration with the energy system. **Local Trading (DP09)** Enable Peer-to-Peer trading within the PEB. **Flexibility Market (DP10)** Enable a fair deal to all consumers through a flexibility market.
9	The Common Energy Market	T 2.2, D2.2- Toolbox for design of DPEB including eMobility and distributed energy resources	Mpower, Powel, IES	**Local Trading (DP09)** Enable Peer-to-Peer trading within the PEB.
10	Community-led open innovation/Framework for DPEB Innovation Labs	T3.5, T3.6, D3.6- Framework for DPEB innovation labs	UL, LCCC, IES, FAC, ESB, Colaborativa, Space Engagers, TK	**Playground (DP05)** Accelerate change and disruptive solutions through innovation playgrounds.
11	The IOTA module for traded flexibility energy marketplace	T2.5, T5.9 D2.7- Local DPEB trading market demonstration tool	IOTA, Powel, ABB	**Local Trading (DP09)** Enable Peer-to-Peer trading within the PEB.
12	Local DPEB trading market demonstration tool	T2.5, D2.7- Local DPEB trading market demonstration tool	Powel, IOTA, TE, TK, FourC	**Local Trading (DP09)** Enable Peer-to-Peer trading within the PEB. **Flexibility Market (DP10)** Enable a fair deal to all consumers through a flexibility market.
13	Continuous intraday trading: integration	Part of T5.9, T2.5, D5.5, D2.7- Local DPEB trading market	ABB, Powel, TK, IOTA, TE	**Local Trading (DP09)** Enable Peer-to-Peer trading within the PEB.

	between project partners	demonstration tool		**Flexibility Market (DP10)** Enable a fair deal to all consumers through a flexibility market.
14	Optimization model (microgrid balancing and optimization)	T5.7, D5.3- Campus microgrid model prototype	NTNU, ABB, TK, Powel, TE, Statkraft Varme AS (SV)	**Microgrids (DP07)** Balance and optimize energy in the PEB through microgrids.
15	(Integrated) Booking System for Space	T5.3, T5.5, D5.8- +Trondheim Citizen Observatory	TK, NTNU	**Engage (DP03)** Co-create PED. **Playground (DP05)** Accelerate change and disruptive solutions through innovation playgrounds.
16	Citizen Power Platform (DECIDIM (Playable Trondheim)	T5.3, T5.5, D5.8- +Trondheim Citizen Observatory	TK, NTNU	**Engage (DP03)** Co-create PED. **Playground (DP05)** Accelerate change and disruptive solutions through innovation playgrounds.
17	Integrated Investment Model	T2.7, D2.4 Optimize the bankability of the demonstrated innovations	Officinae Verdi Group Spa (OV), Research to Market Solutions (R2M)	**Invest (DP11)** Enable Consumers to Invest in their Buildings, which is Critical to the Creation of a PEB.

Table 7.1: List of use cases stories

Thus, Table 7.1 shows the use case name, task/deliverable of the use case, partners involved in the use case, and DP the use case contributes to. Each use case is described using text and models using the +CityxChange EAF. Some of the use cases have more than one model (a specific model and a generic model). The specific use case model shows the specific implementation of the use case in one of the Lighthouse cities. It is unlikely that the follower cities will adopt exactly the same implementation as the Lighthouse cities. Hence, the specific use case that is implemented in a Lighthouse city is generalised in a generic model, to describe the relevant stakeholders, partners, applications and data sources, etc.

However, most use cases do not have both generic and specific use cases as the work is still in progress in WP 4 and 5. So that the follower cities and other cities may find it easier to adopt solutions from the +CityxChange project. The main components of the use case descriptions are shown in Table 7.2.

Sub-headings	Descriptions and Rationale
Use case summary/ overview	A brief textual description of the use case with references to the corresponding deliverable and the relevant partners.
Case Description	A brief textual overview of the context for the use case and the motivations of the use case. The relation to the overall +CityxChange objective and the DPOs are briefly discussed here.
Generic Use case	A detailed, generalised model of the use case, containing all the entities that are relevant and necessary to implement a specific use case or service. It is unlikely that the Follower Cities will adopt exactly the same implementation as the Lighthouse cities. Hence, the specific use case that is implemented in a Lighthouse city is generalised to describe the relevant stakeholders, partners, applications and data sources, etc., so that the follower cities and other cities may find it easier to adopt solutions from the +CityxChange project.
Specific Use case	A detailed model of the use case, containing all the entities (e.g. the partners, applications, and data sources) and the relationships, using the +CityxChange EAF. The specific use case shows the specific implementation of the use case in one of the Lighthouse cities.
Description of the use case	The use cases are described in detail by including a list of all the entities in the model (e.g. the partners, applications, and data sources) and the relationships among them. This information is provided in tables (as presented in section 6, 7, and appendix A).

Table 7.2: The main components of the use case descriptions

For 3 of the use cases (D2.7: Local DPEB trading market demonstration tool, D2.5: Seamless eMobility system including user interface, and D7.1: Monitoring and Evaluation Dashboard). We have described how data governance and security have been addressed by the partners (as seen in section 7.1, appendix A.1, and A.10). These serve as examples to

support other use cases. The details about data governance and security are not as relevant in all use cases and are currently in development by partners.
As described in Table 7.1 the monitoring and evaluation dashboard use case is described in section 7.1 and other use cases stories are described in appendix A.

7.1 Monitoring and Evaluation Dashboard Use case

Use case Summary/Overview

This case provides an established methodology for Monitoring and Evaluation (M&E) of +CityxChange project data measured from the implementation of project interventions as described in D7.4. The M&E dashboard aims to ensure consistent and accurate and reliable data analysis over, and beyond, the five-year life cycle of the +CityxChange project [40].
The M&E data to be monitored is generated at the source of the planned intervention implemented in the project area, and can be monitored using sensors, online data collection systems, surveying or other monitoring mechanisms suitable to the project.
The M&E data system promotes wider data dissemination through a project specific dashboard and also reports certain KPI data, to the EU Smart Cities Information System (SCIS) Self-Reporting Tool (SRT) for benchmarking with other projects [40].

Case Description

This case is the monitoring and evaluation dashboard or Monitoring and Evaluation Reporting Tool (MERT) developed by FAC for the +CityXChange project. MERT aims to store, manage, process, display and share project monitoring data. To enable these functions, the MERT was developed as an interactive web-based dashboard to analyze and represent the data [40].The MERT forms part of the ICT Ecosystem of the +CityxChange project and provides a repository for monitoring data captured by KPI and data owners, from where the data is modelled, displayed and made available for further dissemination.
The submission of data can then take place through a manual process (submitting data through the online KPI interface of the MERT or an automated process (sharing data between the partner's data portal and the MERT through API connection) [40].

The monitoring and evaluation dashboard use case modelled in the EAF is shown in Figure 7.1. and a description of the use case is shown in Table 7.3.

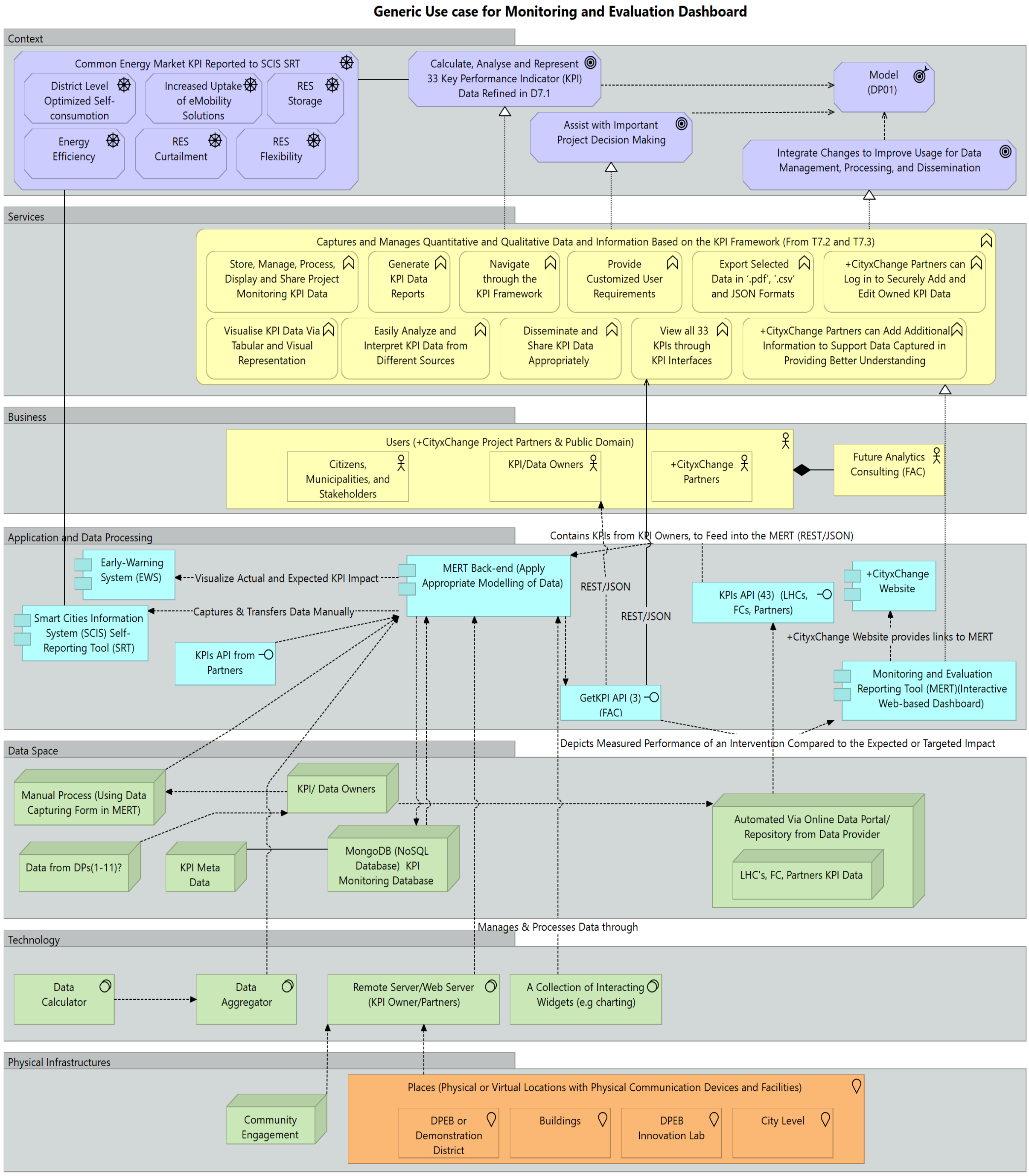

Fig. 7.1: Generic use case for monitoring and evaluation dashboard

No	EA Layer	Components	Description
1	Context	● Common energy market KPI reported to SCIS SRT ● Calculate, Analyze and Represent 33 KPI data refined in D7.1 ● Assist in project decision making ● Integrate changes to improve usage for data management, processing, and dissemination ● Model (DP01)	● The context comprises the common energy market KPI reported to SCIS SRT which are calculated, analyzed, and represented based on the 33 Key KPI data refined in D7.1. This helps with important project decision making in achieving the target "Model (DP01)" which is also influence integrated changes to improve usage for data management, processing, and dissemination.
2	Services	● Captures and manages quantitative and qualitative data and information based on the KPI framework (from T7.2 and T7.3)	● MERT offers several services which includes; ▪ Store, manage, process, display and share project monitoring KPI data. ▪ Generate KPI data reports. ▪ Navigate through the KPI framework. ▪ Provide customized user requirements. ▪ Export selected data in '.pdf', '.csv' and JSON formats. ▪ +CityxChange partners can log in to securely add and edit owned KPI data. ▪ Visualize KPI data via tabular and visual representation. ▪ Easily analyze and interpret KPI data from different sources. ▪ Disseminate and share KPI data appropriately. ▪ View all 33 KPIs through KPI interfaces.

			• Aids +CityxChange partners to add additional information to support data captured in providing better understanding.
3	Business	• Users (+CityxChange project partners & public domain) • Future Analytics Consulting (FAC)	• The users of the MERT comprises citizens, municipalities, and stakeholders, KPI/data owners, and +CityxChange partners. • FAC hosts and manages the MERT.
4	Application and data processing	• Monitoring and Evaluation Reporting Tool (MERT) • MERT back-end • Early-Warning System (EWS) • Smart Cities Information System (SCIS) Self-Reporting Tool (SRT) • +CityxChange website	• The MERT Back-end applies appropriate modelling of data to project partners. • Also, the MERT Back-end uses GetKPI API (3) (FAC) to provide data to the MERT (interactive web-based dashboard), as well as other ICT systems where/if required. MERT Back-end also sends and receives data from the KPI monitoring database. • It supports the actual visualization of expected KPI impact to the Early-Warning System (EWS). Additionally, it captures and manually transfers data to the Smart Cities Information System (SCIS) Self-Reporting Tool (SRT). • The KPI data in the MERT can be connected to the +CityxChange website and partner websites through the use of KPI widgets. The +CityxChange website provides a link to the MERT KPI dashboard. The MERT captures and manages quantitative and qualitative data and information based on the KPI framework (from T7.2 and T7.3). • SCIS provides data on common energy market KPI Reported to SCIS SRT.

5	Data space	● Manual data capturing process ● Data from DPs (1-11) ● KPI Meta ● MongoDB (KPI monitoring database) ● KPI/ data owners ● Automated data	● Data from DPs (1-11) are captured by KPI/ data owners. ● Where, the KPI/ data owners provide data either through an automated process via online data portal/repository managed by data provider or through manual process using data capturing form within the MERT. ● Next, the captured data are send to the MERT Back-end. ● The data space also involves the KPI monitoring database, which is MongoDB (NoSQL database) to store all KPI related data. The KPI monitoring database sends and receives data from MERT Back-end. ● The KPI monitoring database is linked to a KPI Meta data which provides description of the data in MongoDB. ● The automated online data portal/repository from data provider comprises KPI data from LHC's, FC, and partners. KPI data is shared through the use of APIs by partners, (e.g KPIs API 43 used by Trondheim Kommune to provide KPI data).
6	Technologies	● Data calculator ● Data aggregator ● Remote server/web server ● Widgets	● The technology layer comprises data calculator which computes (addition, subtraction, etc.) KPI calculations. The data calculator also send data to the data aggregator. ● It also comprises data aggregator which aggregated KPI related data sent to the MERT backend (where applicable to the KPI calculation). ● Next is the remote server/web server used by KPI owner/partners when they send in KPI data into the MERT. ● The last component in technology layer comprises a collection of

			interacting widgets such as charting widget with filters used for data interpretation and visualization.
7	Physical infrastructures	• Community engagement • Places	• The physical Infrastructure captures the places which comprises physical or virtual locations with physical communication devices and facilities. The physical places include; ▪ DPEB or demonstration district ▪ Buildings ▪ DPEB innovation lab ▪ City level This layer also includes community engagement where real-time data is generated.

Table 7.3: Description of monitoring and evaluation dashboard use case

The monitoring and evaluation dashboard use different APIs (3, 43, etc.) which are discussed in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39]. Furthermore, As discussed in section 4.7.2 and 4.7.3 data governance and security was achieved in the MERT by FAC where data was secured using data security standards, Secure Sockets Layer (SSL), and user authentication. Also, Findable, Accessible, Interoperable and Re-usable was adhere to (FAIR) according to the European Commission's guidelines to support interoperable, findable, and reusable metadata and data towards achieving open data policy within the +CityxChange project [41].

As previously stated, other use cases stories are described in appendix A.

8 Reflections and Lessons Learned

The work presented in this deliverable highlights the complexity of understanding and describing the ICT ecosystems that are a part of the demonstration projects in +CityxChange. EA is a field of research and practice that emerged to bridge the business and IT strategies and that in itself sets the scene for multi-disciplinary research and activities. As such, creating the use case models described in this deliverable necessitated the collaboration and dialogue with the complete spectrum of partners and research domains that form the +CityxChange consortium. Thus, it is not surprising that the feedback that we received were from different perspectives.

It is also worth reiterating that creating the use case models involved several steps. The first step was the development of an appropriate EAF that would support the modelling of the use cases. That activity was conducted while the lighthouse cities and several partners were designing and developing the demonstration projects. Hence, some of the challenges were not only related to the +CityxChange EAF itself, but also in designing and developing the services. In this respect, these two parallel activities had mutual benefits and provided insights, input and feedback to one another. The challenges we faced and the feedback from the partners during the description and modelling of the use cases could be categorised as follows:

- Feedback related to the design of the demonstration projects and services.
- Feedback related to the +CityxChange EAF.
- Feedback related to the use case descriptions and models.

The summary of the challenges and feedback related to each category are provided in the following sub-sections.

8.1 Lessons from Service Design

One of the challenges for the lighthouse cities within the project was to identify value added services for the citizens, which served as parts of the demonstration projects. The technology partners appeared to have a clearer idea of the services; however, as the project evolved the partners were constantly defining and describing the details of the services in collaboration with other project partners. Thus, in the early stages of that work, not all information regarding data sources deployed for all services provided by the partners were documented. However, as the ideas and concepts around the services matured, it was easier to identify and describe the elements of the use cases. The final versions are the ones that are provided in this deliverable.

Almost all use cases were a collaboration among several partners, where each partner had a particular role and contributed with different technological components. In some cases, particularly, in the early stages of the design of the use case, the EAF served as a medium to create a common understanding among the different partners (e.g. the use case on the energy exchange section A.8). The structured approach that EA supported served to "dissect" the case and expose all the components and how they related to each other, which seemed to help the sharing of the ideas. Although at first the EAF appeared as an unfamiliar approach to most partners, it became accepted as the partners started seeing their use cases visualised through the models.

8.2 Related to the +CityxChange EAF

One of the main challenges related to the +CityxChange EAF was in communicating the EA approach and the +CityxChange EAF itself. As most of the partners were not acquainted with EA approaches, the first feedback that was received was the importance of communicating the relevance of this approach and the benefits of it to the different partners, stakeholders and the work in the +CityxChange project. Most of the partners acknowledged that it was not their field of work; yet approached the work with an open mind which led to many interesting dialogues of mutual benefit.
There were several partners who had a broad experience in applying EA methods in their work. Most of them were familiar with several EA methods that are practiced today, of which The Open Group's TOGAF is the defacto standard. Here, the main challenge was shifting the mindset from the current version of TOGAF to an enhanced version, which served the needs of cities and Smart City projects (rather than a single organisation). Thus, the main feedback related to the terminology adopted by the +CityxChange EAF; in particular where it differed from that used in TOGAF. At times, this was beyond terminology and hinged on the semantics and the concepts the EAF was trying to address. Examples of such feedback are provided below:

- The concept of a virtual enterprise, as a collaboration among several partners as a business collaboration, was difficult for many to understand. This caused some confusion in the Business layer.
- Citizens cannot be a part of business. Thus, citizens should not be part of a business or client. This is because citizens are not clients.
- Citizens should not be included in the Business layer as business layer implies profit making.
- Citizens can also not be considered as stakeholders. In +CityxChange, we always include citizens in the stakeholder definition and often make it explicit, but this may not be clear enough in terminology and structure.

- There should be a separate horizontal layer that describes the APIs and the data standards and formats.
- It is hard to distinguish between the data space/DataxChange layer, application and other technology layers.
- It was difficult to distinguish between the data layer and the layer for the physical infrastructure, which is included to model the sources of the data.
- The vertical pillars, which were added to cover aspects of the enterprise that related to all the horizontal layers, were confusing for several partners and this raised questions.

8.3 Related to the Use Case Models

One of the questions that was asked by several partners was in creating the models was: how much should be included in one use case? Since there were overlaps among use cases, how do you determine what is modelled in each use case, e.g. community grid in the IES case?

Some of the use cases were very complex and they could in fact have been several simpler cases, that focused on one aspect or around one of the cities or partners. An example of this is the IES use case. As such, another question that was asked by partners was if some cases should be modelled as several simpler cases.

One of the main challenges in creating the use case models was in identifying an appropriate modelling tool, which was not available. However, the Open Source Archi modelling tool seemed adequate to capture the relevant parts of the use cases. Another challenge in creating the use case models was the gathering of relevant information from all the partners. Similarly, it was also challenging to find an effective way of receiving feedback on the models. Dialogues proved the best way to conduct the iterative modelling activities.
The restrictions in face-to-face meetings, imposed as a consequence of the COVID-19 pandemic, posed additional challenges in obtaining the contents for the use case models. Hence, the deliverables and working documents from partners available in the +CityxChange Google drive was used as information sources to model the first versions of the use cases. These were then shared with the relevant partners to obtain their feedback. The feedback was used to further improve the use case models.

8.4 Feedback through an Online Questionnaire

Several partners in the project have seen the +CityxChange EAF in various presentations and several have been directly exposed through the use case modelling activities. In order to obtain more systematic feedback from the partners, an online questionnaire has been created. A copy of the complete questionnaire is provided in appendix F.

8.4.1 Questionnaire Design

The +CityxChange EAF has been used mainly by the partners leading the tasks T1.1 and T1.2. The other participants of these tasks and those involved in developing ICT-based solutions for the Demonstration Projects have been exposed to the framework and the use case models. However, the framework is still relatively new, and it is too early to assess its use in the future. Hence, the Technology Acceptance Model (TAM) [42], has been used to design the questionnaire. TAM is a model used in Information Systems research, to understand how users will likely accept and use a technology in the future. TAM suggests that a number of factors influence their behavioural intention and the decision about how and when they will use information system:

- Perceived usefulness – which indicates the degree to which a person believes that using a technology (in this case the +CityxChange EAF and the use case models), would enhance their work; if someone perceives +CityxChange EAF or the use case models to be useful for them.
- Perceived ease-of-use – which is the degree to which a person believes that using a technology would be easy; i.e. if the technology is easy to use, then the likelihood of it being used is greater.

The questionnaire contained five sub-sections:

- Consent form, in compliance with GDPR and NTNU guidelines.
- Demography, to understand participants' interests and experience with EA and the +CityxChange EAF.
- TAM for +CityxChange EAF.
- TAM for the use case models based on +CityxChange EAF.
- Supporting knowledge transfer across cities using the +CityxChange EAF and the use case models.

The questionnaire is designed as a set of statements, where the respondents need to indicate their level of agreement with the statements based on a Likert Scale: "Strongly Agree", "Agree", Neither Agree or Disagree", "Disagree" and "Strongly Disagree". Where relevant, "Not applicable" was included. In addition, a set of open questions were added at the end, focused on knowledge transfer and learning across cities (as a part of a master's thesis at NTNU).

As part of the work in Task T1.1, more than forty participants had been exposed to the +CityxChange EAF and the use case scenarios. Hence, the invitation to respond to the questionnaire were sent to these individuals. At the time of writing, 10 responses were available, and the following sub-section analyses the results so far.

8.4.2 Responses and Analyses

Of the 10 respondents, 9 were male and 1 was female. 30% of them had 1-3 years of experience with EA, 40% had less than a year's experience and 30% did not have any experience with EA. 30% had seen presentations of the +CityxChange EAF, 30 had provided feedback to the framework, 30% had provided feedback and/or input to the use case models, while only 10% said that they were not familiar with the framework. 40% of the respondents strongly agreed that EA is relevant for the +CityxChange project; 40% agreed and no one disagreed that EA was relevant for +CityxChange; see Fig. 8.1: .

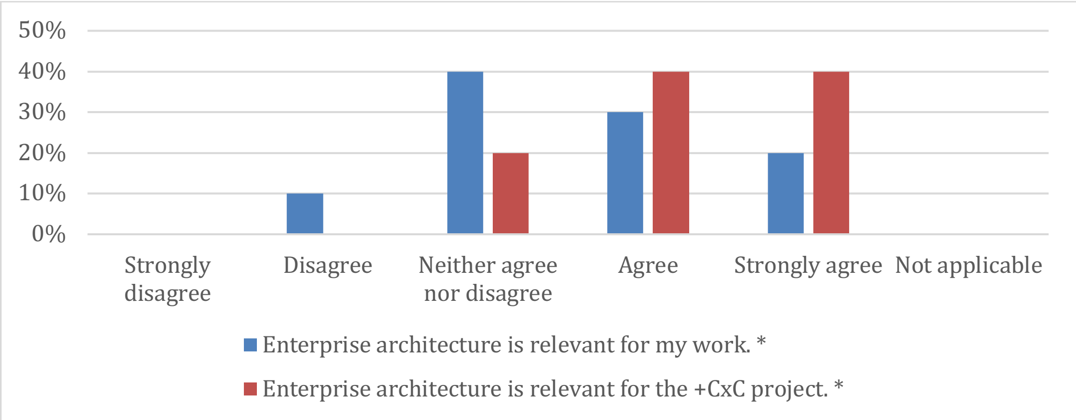

Fig. 8.1: Relevance of EA for +CityXChange

The responses to the TAM based statements for the +CityxChange EAF are shown in Error! Reference source not found.. A high percent of the responses indicates neither agreement or disagreement to the statements, which may be due to their lack of hands-on experience with the framework. However, there is agreement to the statements; 60% agree that the framework is useful for the +CityxChange project and 50% agree that they will recommend the framework to colleagues in their organisations.

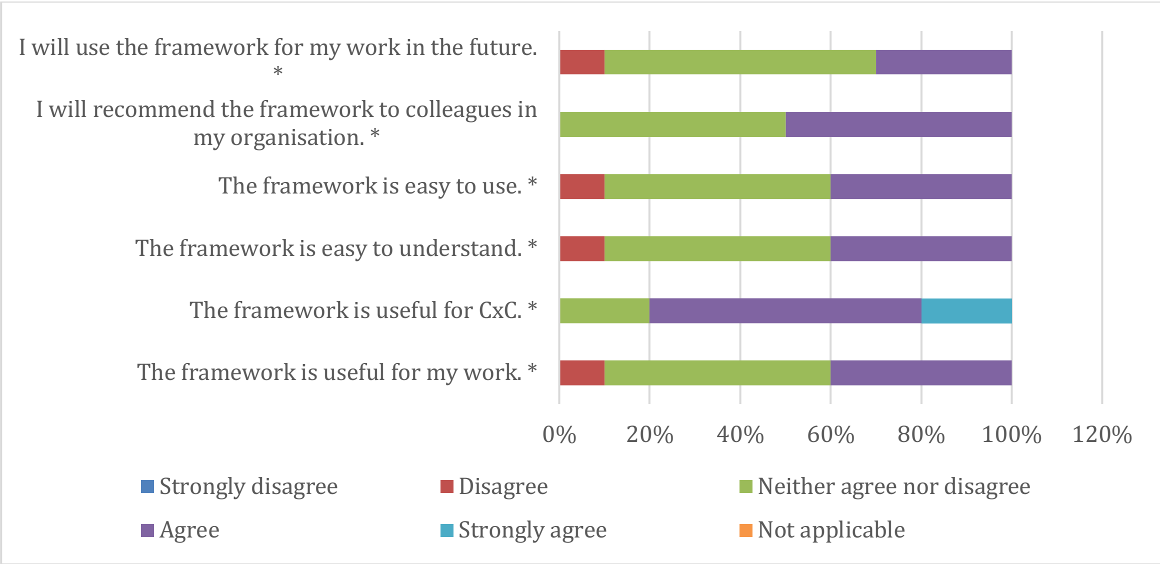

Fig. 8.2: Acceptance of +CityxChange EAF

The responses to the TAM based statements for the use case models using the +CityxChange EAF are shown in **Error! Reference source not found.**. There is general agreement that the use case models are useful and easy to use; 70% of the respondents strongly agree that the use case models are useful for the +CityxChange project, while no one disagreed. 40% of the respondents strongly agree and 40% agree that the use case models are useful for their work. 50% strongly agree and 40% agree that the use case models are easy to understand, while no one disagreed. 50% strongly agree and 40% agree that the models helped them clarify details about their use cases (i.e. their demonstration projects). 40% strongly agree and 50% agree that they will use the use case models for their work in the future. 60% strongly agree and 40% agree that they will recommend the use case models to colleagues in their organisations.

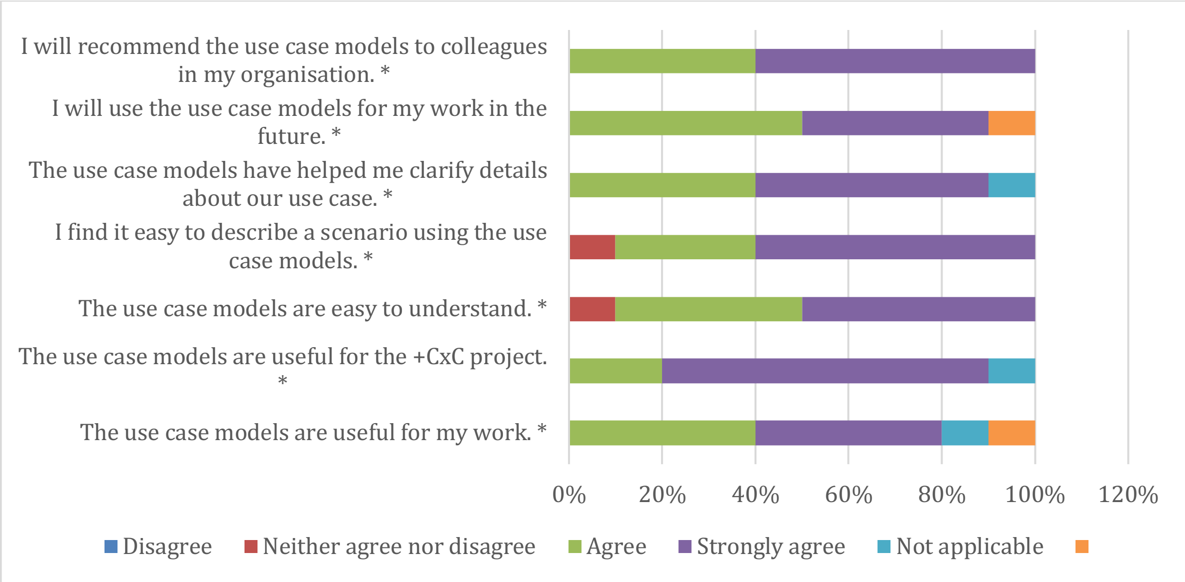

Fig. 8.3: Acceptance of Use Case Scenario Models using +CityxChange EAF

One of the main reasons for creating the +CityxChange EAF and the use case models are to support knowledge transfer across cities. The statements are designed based on the literature on learning across cities, where sharing, discussions and collaboration were identified as important elements in learning and knowledge transfer across cities. Thus, some statements were formulated to obtain feedback from the partners. The responses to these are shown in **Error! Reference source not found.**. The results so far indicate agreement among a high percentage of the respondents that the +CityxChange EAF can support capture, sharing and reuse of knowledge, and discussions and collaborations among colleagues and partners in the project. 10-20% of the respondents strongly agree, while no one disagrees.

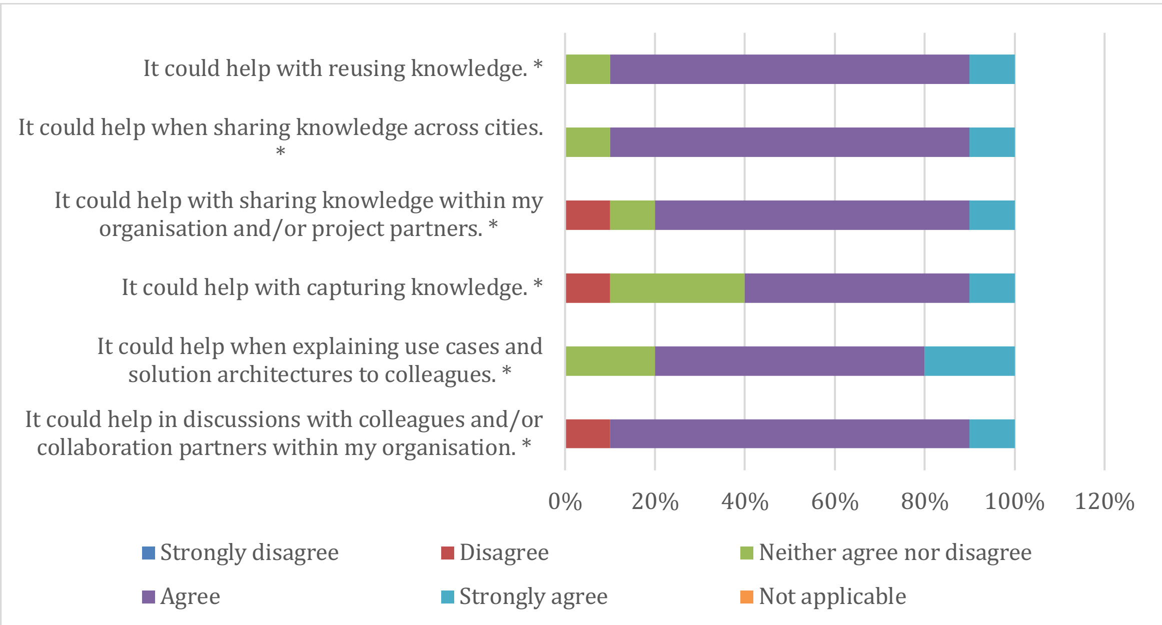

Fig. 8.4: +CityxChange EAF as a means of knowledge transfer across cities

In the responses to the open-ended questions, one of the respondents indicated that the learning curve for using the +CityxChange EAF is steep and it should be presented in a way that it's easier for people with no experience in EA. The types of problems that the respondents suggested that EA could solve include defining blueprints of architecture, aligning goals across different organisations, duplication of ICT systems and data. Most importantly, EA could introduce frameworks and tools for determining and implementing application and technology architecture, data governance, data interoperability, data security and risk management, relevant regulatory compliance, knowledge retention and all in all digital transformation.

9 Guidelines and Roadmap for Follower Cities

As stated at the beginning of this deliverable, the main objective of this deliverable is to orchestrate the development and evolution of the ICT ecosystem for the +CityxChange project and to help partners by providing an ICT-based project overview for integration, interconnection, and gap analyses of Demo Projects. Thus, this deliverable describes the ICT-based services and ICT ecosystems that have been developed in the lighthouse projects as a set of use case models. One of the main objectives of these use case models describing the ICT ecosystem is to support the follower cities to provide similar services to their citizens and adopt similar ICT ecosystems in their cities. While each city is different and have different needs and solution opportunities, these descriptions are aimed at helping them gain inspiration as well as identify the new opportunities for their cities. These use case descriptions also provide an overview of the ICT-based applications data sources that are available within the +CityxChange project. Furthermore, they identify the possibilities of accessing the data sources, in terms of the APIs and data standards, which are further described in detail in the deliverable D1.2 (as seen in most of the modelled use cases in appendix A).

This section aims to outline a roadmap and guidelines to support the follower cities to create services, use the EA approach and the +CityxChange EAF and adapt some of the use case models and descriptions to develop new services in their cities. These guidelines are based on the experiences from dialogues with the lighthouse cities and other partners and from describing the use cases included in this deliverable.
It is also worth reiterating that creating the use case models may involve several steps such as designing and creating a new service and/or adapting a demonstration project or a use case from a Lighthouse city. A new service or a demonstration project may be developed to meet the needs of citizens. Similarly, updating or evolving a service, by incorporating a part of the ICT ecosystem from a Lighthouse city. Based on the experiences in creating this deliverable, the following sub-sections provide guidance for the Follower Cities:

- Design and development of services or demonstration projects.
- Create a use case model of the ICT ecosystem that supports the service.
- Adapt an existing demonstration project from the Lighthouse Cities.

9.1 Design of New Services

This sub-section describes an approach to support Follower Cities to define new services and enhance existing services, to meet the needs of their citizens. The identification and definition of services is an iterative process and is shown in Fig. 9.*1: Service design in cities* . It starts by identifying stakeholders' values and concerns followed by describing the stakeholders' or citizens' perspectives as a customer journey. Here, the focus is on describing how the service would be experienced by the citizens and how the interaction between the service and the citizens would be. This is followed by an evaluation of the value of the service and its quality, usability, and usefulness to the citizens. This is then followed by the description of the backend of the service, often referred to as the blueprinting of the service, which includes the identification of the data that is relevant for implementing the service, identifying the owner of the data and how to access the data, assessment of if and how any existing applications, data, and technologies could be used.

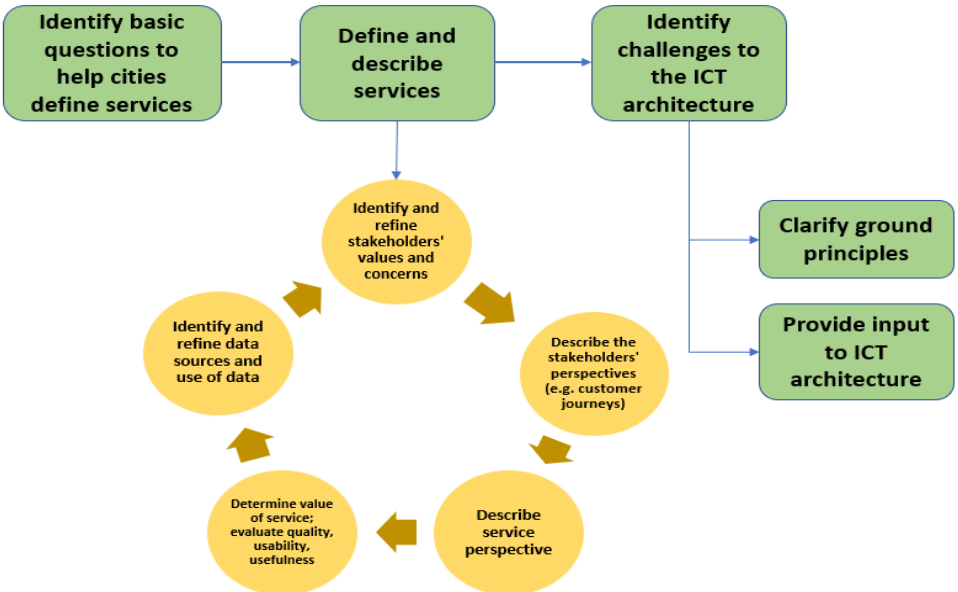

Fig. 9.1: Service design in cities

The service design approach seems relevant to focus on the project, on the citizens and the different stakeholders. Through the discussions with cities and other partners, gathering the relevant information is much easier if it is within a context such as a future scenario or a particular service. Thus, the method to gather information from the cities about their data includes helping them identify and describe relevant scenarios and services that could meet the needs of the citizens. The process for this is also described in Fig. 9.*1: Service design in cities*

. By working with the cities, services could be defined and described, which would help identify the challenges and requirements for the ICT ecosystem and architecture. Figure 9.1 shows the service design that can be adopted by Follower Cities for service specification and description in the developed +CityxChange EAF.

The guidelines for identifying and defining services and the types of questions that could be asked of the cities are as follows:

- What would be the focus area for the demonstrator in the +CityxChange project? (e.g. mobility solutions, integration of electric vehicles; energy optimization).
- Try to identify scenarios/services that would support the KPIs of the cities and the project.
- What is the value of the service and to whom?
- Who is/are the customer(s)?
- Who are the stakeholders?
- What data would the customer like to see?
- What is/are the expected outcome(s) of the service?
- What do you want to improve by digitizing your services?
- What do you need to achieve the new/improved service?
- What data? (i.e. qualitative data (reports, opinions, feedback, interviews) and quantitative data (monitoring data from project interventions, KPI data, etc.)

The services are quite likely to evolve based on a number of factors such as the availability of new data or the change of ownership of an application or technology that is a part of the service. Thus, this is an iterative process where each service may evolve.

9.2 Create Use case Model and ICT Ecosystem

Once the concept for the new service is clear and/or the service description is available (e.g. as a document), the +CityxChange EAF can be used to create the use case model. Detailed guidelines for modelling the use cases using the +CityxChange EAF are provided in Section 5 and consists of the following five steps:

1. Identify the components in the ICT ecosystem.
2. Identify the relationships among the components.
3. Identify any additional information.
4. Iterate and detail (by following the first 3 steps)
5. Identify the different views as relevant, from the different perspectives of the stakeholders.

One of the main activities is the gathering of information (the components, their relationships, data sources, etc.). To support this activity, a use case template has been

developed, which can be used by cities or relevant partners to support information gathering and sharing. This template is provided in appendix B.
Furthermore, to support the description and documentation of specific technical information such as the details of APIs and data models, templates are provided in deliverable D1.3 [39].

9.3 Adapt Demonstrator Project from a Lighthouse City

It is unlikely that Follower Cities will adopt the specific solution that has been developed in the Lighthouse cities. The likely case would be an adaptation of a use case from a Lighthouse City. A few important things to consider in this situation are listed below:

- Determine if and how well the needs of the citizens are aligned in the Follower Cities and the use case from the Lighthouse Cities.
- Study the contexts of the two cities and their alignment to determine if a solution could be adopted or should be adapted. E.g. cultural norms.
- Consider the potential collaboration partners in the provision of the service.
- Determine the capabilities of the collaboration partners in developing the relevant ICT solutions.
- Assess the availability of relevant data sources and ICT applications to replicate the service.
- Assess how much of the ICT ecosystem from the Lighthouse Cities is necessary to meet the desired needs in the Follower Cities.

10 Summary and Future work

The work reported in this deliverable has been conducted within WP1, mainly within T1.1, in collaboration with partners of D1.3 and the participants of WP1. It has further collaborated with the development partners in WP1, WP2, WP3, WP4, WP5, and WP7 and other relevant tasks to develop the ecosystem overview and the individual use cases. This main objective of this deliverable is to orchestrate the development and evolution of the ICT ecosystem for the +CityxChange project. This deliverable describes the +CityxChange approach to support cities to define value added services and a guideline for dialogues for supporting cities in this process.

The main contributions are the +CityxChange EAF and the descriptions of the use cases and demonstration projects, modelled using the +CityxChange EAF. The +CityxChange EAF is a layered approach, centred around the +CityxChange Data Space which supports DataxChange. The main elements that distinguish this EA from others are its focus on value added services leveraging on the data space and the consideration of services through multiple VEs and collaborations among organisations. The +CityxChange EAF includes two perspectives, stakeholder and data, which are related to all the horizontal layers. The principles and guidelines relevant for the EA and to govern the ICT related work in the project are structured using these perspectives and are included in the deliverable.

The main results presented in this deliverable are the use cases, which describe the ICT ecosystems that support the demonstration projects, modelled using the +CityxChange EAF. These use case models provide detailed descriptions of the different components, such as the different partners that collaborate, the data sources and the ICT applications, that come together to form a service. These use case models describe demonstration projects in the Lighthouse Cities and are aimed to support the Follower Cities develop some of their demonstration projects.

In addition to the use case models, an overview of the literature and practices in EA and EAF, Smart City EAFs and relevant EU projects have been presented. Guidelines for the design and development of services and the description of use cases using the +CityxChange EAF are provided in order to support the Follower Cities. An overview of the feedback from the partners and some reflections are also provided.

The +CityxChange EAF fulfils the needs for describing the demonstration projects in +CityxChange, as demonstrated in the seventeen use case models included in this deliverable. A survey, based on the Technology Acceptance Model (TAM), has been developed to obtain systematic feedback from the partners on applying the +CityxChange EAF to describe ICT ecosystems and collaboration networks for cities and services. The survey is presented in appendix F. Several publications describe the work done so far and work is in progress on additional scientific articles.

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Appendix A – Description of Use cases

A.1 Seamless eMobility System Including User Interface Use case

Use case Summary/Overview

The seamless eMobility system including user interface use case is developed as part of Task 2.4, D2.5. It includes a backend system, named FourC Total Traffic Control (FourC TTC) which retrieves, stores, and provides transport data (mainly in Trondheim, Norway). The FourC TTC collects data from various data providers via APIs as discussed in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39]. The FourC TTC API makes data available in a normalized and standardized format via a TTC API.
Moreover, an end-user Android app was also developed. It connects to the TTC backend and shows the mobility options that are available for the user near a chosen position on the map. A digital asset payment system was developed by IOTA, which enable users to book and pay for a multi-modal journey, offered by different transport providers, seamlessly in one step. Finally, for integration with task T2.5, an API is provided by Powel for accessing "temporarily available" EV batteries as flexibilities for use in PEBs as a simulator which provides insights into which data that has to be present in order to exploit EV batteries as temporary energy sources. The simulator is utilized by Powel's trading platform for the PEBs in Trondheim [43].

Case Description

This case aims to achieve a seamless multimodal eMaaS system and an Open Service Platform (OSP) for public transport. The platform will identify the possible transport options for users' mobility needs and allowing them to choose a combination of transport modes for their trip. The eMaaS case integrates V2B/V2G charging approaches by connecting EVs through EV chargers to the local DPEBs. This links to the operation strategies of the DPEB by making the EV batteries a part of the DPEB [43].
This use case captures EV infrastructures and business involved in eMaaS.

- It includes support of new transportation modes of e-bikes, light electric vehicles (LEVs), and EVs.
- The seamless eMaaS will integrate with the trading platform containing a distributed ledger micropayment solution for use of the vehicles.

The seamless eMobility system has a generic use case and a specific use case to support replication for Follower Cities. Figure A.1 depict the generic use case for the eMobility system modelled in the developed EAF that can be replicated in follower cities.

Generic Use case for Seamless eMobility System

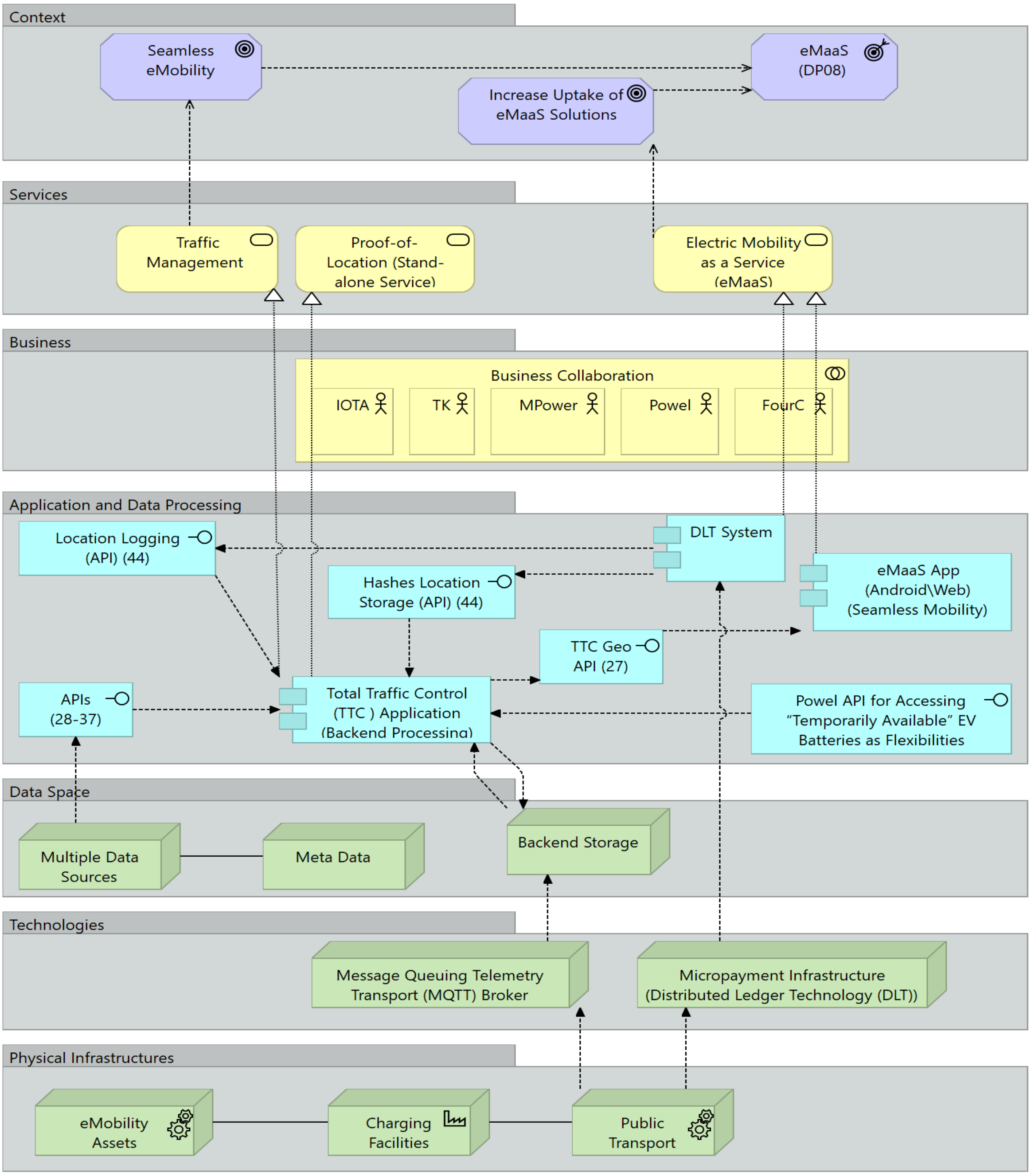

Fig. A.1: Generic use case for seamless eMobility system

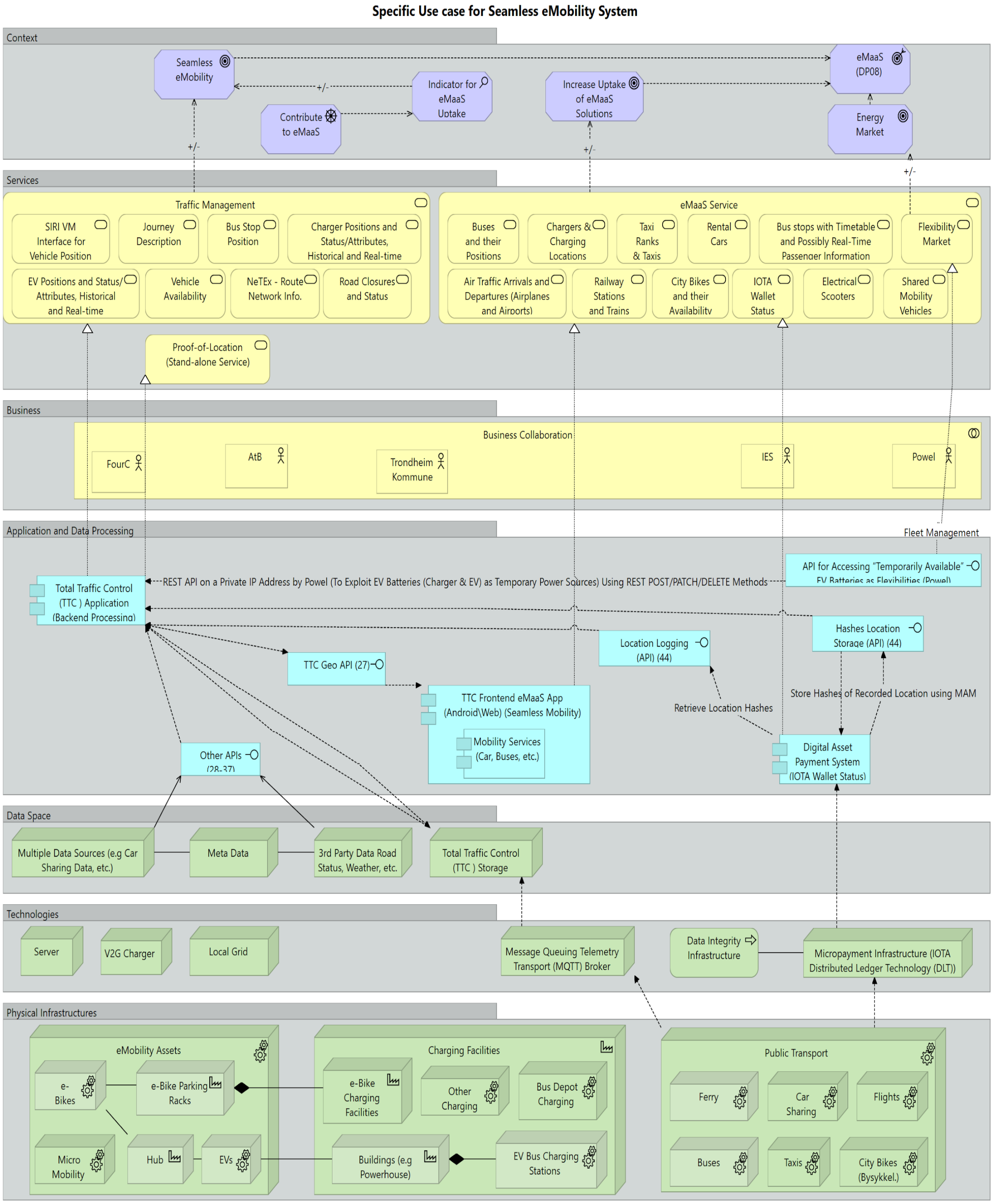

Fig. A.2: Specific use case for seamless eMobility system

Likewise, Figure A.2 depict the specific for seamless eMobility system implemented in Trondheim. A description of the eMaaS is shown in Table A.1.

No	EA Layer	Components	Description
1	Context	• Seamless eMobility • Contribute to eMaaS • Indicator for eMaaS Uptake • Increase Uptake of eMaaS Solutions • Energy Market • eMaaS (DP08)	• The context layer comprises seamless eMobility, increase update of eMaaS solution, and energy market as goals which contributes in achieving the eMaaS (DP08).
2	Services	• Traffic management • eMaaS service • Proof-of-services	• The main services provided in the service layer comprises traffic management, eMaaS service, and proof-of-services (stand-alone service).
3	Business	• FourC, AtB, TK, IOTA, and Powel	• The business layer comprises FourC, AtB, TK, IOTA, and Powel which are virtual enterprises that collaborates to eMobility services.
4	Application and data processing	• TTC application backend • TTC frontend eMaaS app (Android/Web) • Digital asset payment system • An API from Powel	• The application and data processing layer comprise of TTC application backend processing which provides data to TTC frontend eMaaS app (Android/Web) via TTC Geo API (27). • This layer also comprises digital asset payment system used by IOTA to provide digital wallet status to users. • An API is provided from Powel which provides temporal available EV batteries as flexibilities. • Also, the TTC Geo API uses XML or GeoJSON objects (GraphQL), Message Queuing Telemetry

			Transport (MQTT) and websocket (as seen in Figure A.2). ● REST, websockets, and HTTP (GET, POST) are used by APIs to provide data to the TTC application (as seen in Figure A.2).
5	Data space	● Multiple data sources Meta data, ● Third party data ● The backend Total Traffic Control (TTC) storage.	● The data space layer comprises data sources from multiple data sources (e.g car sharing data, etc.). ● It also comprises meta data, third party data road status, weather, etc., and the backend Total Traffic Control (TTC) storage that all provide data to the TTC application.
6	Technologies	● Servers, V2G charger, and local grid. ● Message Queuing Telemetry Transport (MQTT) broker ● Data integrity infrastructure ● Micropayment infrastructure Distributed Ledger Technology (DLT)	● The servers, V2G charger and local grid which are connected to eMobility assets and charging stations in the physical infrastructures layer. ● MQTT is a protocol used by FourC for collecting and processing data from public transport sources, whereas DLT and the data integrity infrastructure is employed by IOTA to ensure trust and record trail of user eMobility experience.
7	Physical infrastructures	● e-Mobility assets ● Charging facilities ● Public transportation	● As seen in Figure A.2 these components are deployed in the cities to provide eMobility services.

Table A1: Description of the eMaaS use case

Additionally, As discussed in section 4.7.2 and 4.7.3 data governance and security was achieved in the seamless eMobility system by FourC where data from TTC application backend was made available in a normalized and standardized format to easily take the data output as a standardized object format based on standard communication protocols [43].

A.2 IOTA eMaaS Payments Trail and Tech Specs and Requirements Use case

Use case Summary/Overview

This use case is for the Innovative Digital Asset Payment System developed as part of T2.4 by IOTA to facilitate payment via IOTA distributed ledger technology with IOTA digital assets [43]. The digital asset payment system integrates into the developed infrastructure of the IOTA Token. This enables customers using the eMaaS app to be able to directly book and pay third party eMaaS solutions, or if being redirected to third party booking platforms, to be able to pay with IOTA's native digital asset, the IOTA token.

Case Description

Based on the final deliverable for Task 2.4, D2.5 (The seamless eMobility system including user interface use case) [43], the use case for a digital asset payment system was modelled in the developed EAF as shown in Figure A.3. The digital asset payment system was developed by IOTA as a proof of concept to enable users to book and pay for a multi-modal journey, offered by different transport providers, seamlessly in one step.

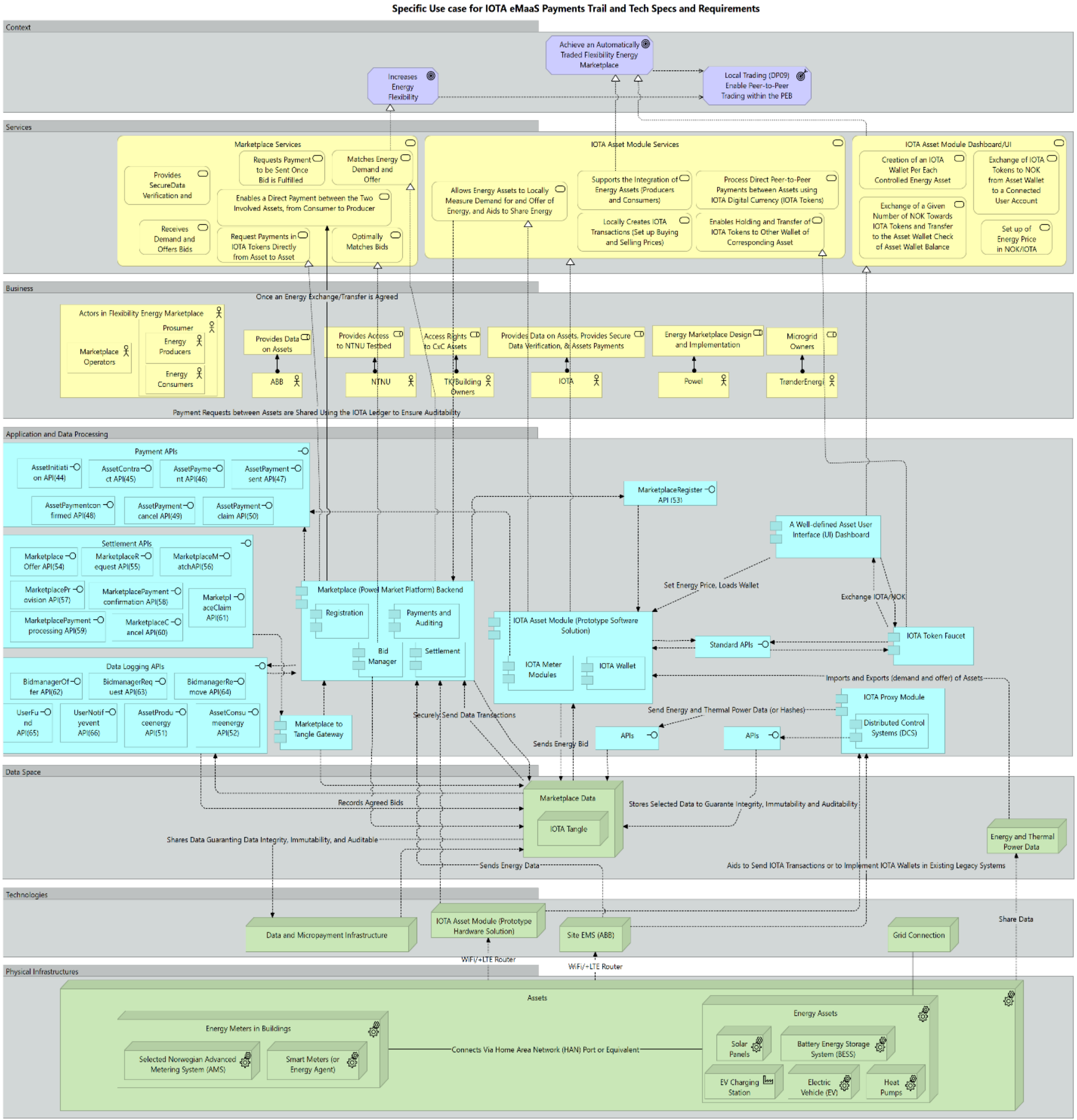

Fig. A.3: Specific use case for IOTA eMaaS payments trail and tech specs and requirements

Figure A.3 depict the specific use case for IOTA eMaaS payments trail and tech specs and requirements in Trondheim. It mainly comprises the digital asset payment system which enables users to pay with IOTA's native digital asset (the IOTA token). A description of the use case is shown in Table A.2.

No	EA Layer	Components	Description

1	Context	• Green transport means • Seamless eMaaS experience • Increase uptake of eMaaS solutions • DP08	• The main requirements as regards to eMobility services which helps to achieve eMaaS DP08 for the project entails achieving a seamless eMaaS experience at the same time increasing update of eMaaS solution as a Green transportation means.
2	Services	• Multi-modal Journey • Billing Service (Send and Receive Payments) • City traveler/Citizen Functionalities • Transport Provider Functionalities	• All services provided by the Digital Asset Payment System to support eMobility services is captured in this layer as seen in Figure 6.3. These services are provided to the city traveler/citizen and Transport Provider (TP).
3	Business	• FourC • City Traveler/Citizen • IOTA • Transport Provider (TP) (e.g AtB, AVIS, Værnes Ekspressen, etc.) • Aggregator Service Providers	• This layer comprises the stakeholders that collaborates to achieve the payment tail for the eMobility services provided. Also, in this case this layer involves the transport provider who are the transport companies that provide mobility services to City Traveler/Citizen. • Lastly, the Aggregator Service Providers ensures that the TPs get payment for the journey performed by the City Traveler/Citizen.
4	Application and data processing	• TTC frontend eMaaS app (Android\Web) (Seamless Mobility) • TTC application (backend processing) • Digital Asset Payment System (IOTA Wallet Status) (IOTA Transport App)	• The TTC frontend is used by the citizen to reserve for eMobility services and is connected to the TTC backend application. • TTC application provides backend processing of data to the TTC frontend. It also connects to IOTA tangle. • Next the Digital Asset Payment System provides the IOTA Wallet Status for IOTA Transport App to support city traveler/citizen payment.

		● Registered dedicated payment system terminal ● IOTA Backend	● The Digital Asset Payment System is also connected to the registered dedicated payment system terminal which processes micro payment. It also provides data for eMobility services via APIs as discussed in as discussed in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability)[39]. ● The registered dedicated payment system provides terminal that processes payment made from the traveler/citizen to the respective TP. ● The IOTA Backend process eMobility services from the IOTA tangle. It is also connected to The Digital Asset Payment System. It processes location logging and hashes location storage of the traveler/citizen via API 44 and 45.
5	Data space	● Total Traffic Control (TTC) storage ● IOTA Tangle ● Cloud Backend Service (Firebase) (Stores MAM Channel Details)	● The TTC storage stores all the eMobility related data that is used by the TTC application as described in Table A.2. ● IOTA tangle captures the location data, encrypts, and publishes data on the citizens journey to be used by IOTA backend. The IOTA tangle also sends and receives data to and from the TTC application. ● The cloud backend service mainly Firebase stores MAM channel details. It also sends stored data to the IOTA tangle.
6	Technologies	● Data integrity infrastructure ● Dedicated cloud service (powered by firebase) ● Micropayment infrastructure (IOTA	● Real time data is transmitted from public transports to IOTA micropayment infrastructure. ● This occurs when users of these public transport scans using QR-code/NFC tag or use start button.

		Distributed Ledger Technology (DLT))	● The data is sent via dedicated Masked Authenticated Messaging (MAM) channel. MAM is a second layer data communication protocol which adds functionality to emit and access an encrypted data stream over IOTA's distributed ledger. ● The data integrity Infrastructure adds integrity and privacy to data streams using MAM. ● The micropayment infrastructure allows to process micropayments for each trip from city traveler/citizen to transport aggregator and Transport Providers (TP) via an API 45. ● Next, the dedicated cloud service sends the collected MAM channel details to be stored. ● Also, the data integrity infrastructure allows booking and record of travel on IOTA Tangle. It provides audit trail to guarantee integrity of payments distributed to TP within the city via an API 44.
7	Physical infrastructures	● Public transport	● As seen in Figure A.3 the public transport comprises Ferry, Car Sharing, Flights, Buses, Taxis, and City Bikes (Bysykkel.) which provides mobility services in Trondheim.

Table A.2: Description of the IOTA eMaaS payments trail use case

As seen in Figure A.3 several APIs are used in providing different services. Each of the deployed APIs specifications are mainly described in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [43].

A.3 Limerick DST (Integrated Modelling and Decision Support Tool) Use case

Use case Summary/Overview

This case applies the Integrated Modelling and Decision Support Tool (DST), developed in WP1, to Limerick and deliver the Limerick DST together with the training and user guides (D4.1). Buildings, energy production and consumption, mobility/transport patterns (including forecasted EV demand), current EV charging stations, current vacancies, current building rates, value of homes, economic activity (number of businesses, employment rate, jobs announcements, etc.) will be forecast to 2050, analysing their impact with respect to the LCCC Bold City Vision and taking future weather scenarios into account [44].

Case Description

The Integrated Modelling and Decision Support Tool (DST) was developed by IESRD one of the +CityxChange partners to inform the development of the Bold City Vision (T4.2) and future development of the Limerick PEB and Positive Energy District.
It allows end users (engineers, urban planners, power system engineers, etc.) to create a model of a city, district, block etc. and carry out different analysis for hard measures such as renovation, or energy efficiency upgrades and understand the impacts on both energy and carbon reduction targets as well as the impact on other socio-economic factors such as health, job growth, improved GDP, etc. It also allows analysis of EV charging stations and local production interacting with the distribution networks and analysis of district heating networks and how the district heating network and electricity networks can work in co-operation with each other to meet the overall PEB requirements.
In the Limerick DST all data can be uploaded to a public cloud based model, which can then be used to engage with the public and other relevant stakeholders [44].The use case for the Limerick DST is part of D4.1.

Figure A.4 depict the specific use case for Limerick DST (Integrated Modelling and Decision Support Tool).

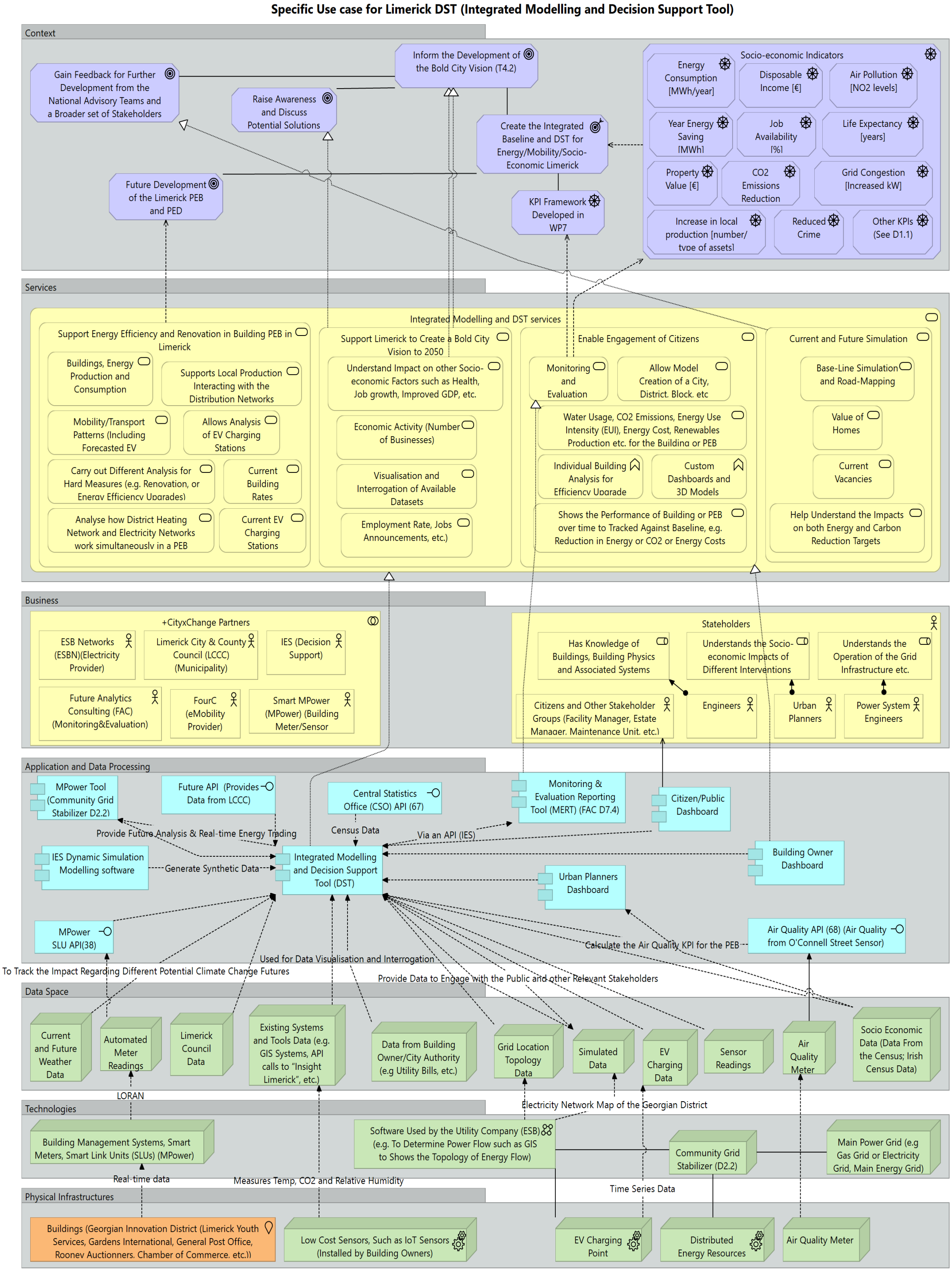

Fig. A.4: Specific use case for Limerick DST (Integrated Modelling and Decision Support Tool)

A description of the Limerick DST (Integrated Modelling and Decision Support Tool) use case is shown in Table A.3.

No	EA Layer	Components	Description
1	Context	• Gain feedback for further development • Raise awareness and discuss potential solutions • KPI framework developed in WP7 • Inform the development of the bold city vision (T4.2) • Create the integrated baseline and DST • Future Development of the Limerick PEB and PED • Socio-economic Indicators	• The context in the Limerick DST aims to create the integrated baseline and DST for Energy/Mobility/Socio-Economic Limerick. Which is based on the socio-economic indicators, KPI framework developed in WP7 and modelled in D1.1, inform the development of the bold city vision (T4.2), and future development of the Limerick PEB and PED. • Also, "to inform the development of the bold city vision (T4.2)" goal as seen in Figure A.4 is based on the raising awareness and discussion of potential solutions and gaining feedback for further development from the national advisory teams and a broader set of stakeholders.
2	Services	• Support energy efficiency and renovation in building PEB in Limerick • Support Limerick to Create a Bold City Vision to 2050 • Enable engagement of citizens • Current and future simulation	• The DST provides a series of functionalities which can be summarized to include integrated modelling and DST services which include among others impact analysis forecast to 2050 For LCCC bold city vision taking future weather scenarios into account, energy efficiency and renovation in building, and analysis of district heating networks. • Also, enabling citizen engagement and simulations current and future conditions are provided within the DST.

3	Business	• +CityxChange partners • Stakeholders	• The +CityxChange partners involved in the Limerick DST comprises ESB Networks (ESBN)(Electricity Provider), Limerick City & County Council (LCCC) (municipality), IES (decision support tool), Future Analytics Consulting (FAC)(monitoring & evaluation), FourC (eMobility provider), and MPower (building meter/sensor provider). • The stakeholder comprises (facility manager, estate manager, maintenance unit, etc.) The Limerick DST also comprises ▪ Engineers (who has knowledge of buildings, building physics and associated systems). ▪ Urban Planners (who understands the socio-economic impacts of different interventions). • Power System Engineers (who understands the operation of the grid infrastructure etc.).
4	Application and data processing	• Integrated modelling and DST • IES dynamic simulation modelling software • Citizen/public dashboard • Urban planners' dashboard • Building owner dashboard • Monitoring and evaluation reporting tool • Mpower tool	• As developed in WP1 the DST aims to achieve an integrated PEB design tools which provides masterplan for PEB/PED, scenario analysis & forecasting, and lastly reporting & decision support. It uses data from different data sources as a software-based integrated modelling and DST services. The DST also gets and provide data to engage with the public and other relevant stakeholders from the simulated data in the dataspace layer. The DST uses the socio economic data to aid decision making as regards to buildings in the Georgian innovation district PEB.

			The DST consumes data from two APIs (Central Statistics Office (CSO) API (67) and Air Quality API (68)) and a future API, yet to be developed (future API (provides data from LCCC)) as shown in Figure A.4. The DST provide future analysis and real-time energy trading to Mpower Tool (Community Grid Stabilizer D2.2). Also, the DST sends data to be reported by Monitoring and Evaluation Reporting Tool (MERT) by FAC (D.7.4) via an API provided by IES. ● The IES dynamic simulation modelling software will be leveraged to generate synthetic data to supplement the DST model where real data is not available. ● The citizen/public dashboard is a cloud based version of the DST that aims to raise awareness with citizens and other stakeholder groups (facility manager, estate manager, maintenance unit, etc.) ● The urban planner’s dashboard mostly compares results from demonstrations with the baseline and visualize using the KPI framework developed in WP7. It sits on top of the DST as the dashboard for stakeholder (e.g Engineers, Urban Planners, Power System Engineers, etc.) to enable stakeholders to take decisions and present these to local councilors and urban planning authorities. ● Next, is the building owner dashboard which provides results from analysis that can be displayed in a format which is suitable to support decision making. The

			building owner dashboard also provide information to enable engagement of citizens. ● The Monitoring & Evaluation Reporting Tool (MERT) (FAC D7.4) provides Monitoring and Evaluation in regard to the KPIs for the +CityxChange project in relation to integrated planning and design, common energy market, and CommunityxChange. It receives data from the DST via an API. ● Then, the MPower tool (community grid stabilizer D2.2) connects to the DST to exchange and provide future analysis & real-time energy trading.
5	Data space	● Current and future weather data ● Automated meter readings ● Limerick council data ● Existing systems and tools data ● Data from building owners/city authority ● Grid location topology data ● Simulated data ● EV charging data ● Sensor readings ● Air quality meter ● Socio economic data	The data sources used by the Limerick DST includes; ● Use of future weather data developed through the FP7-UMBRELLA project, to take into account the effect of climate change on simulation results. Weather data is also taken from the nearest local weather station but where available, weather data can be taken from site located weather stations. ● Real-time data is provided by automated meter readings, BMS, and SLU in the buildings via LORAN communication protocol and is stored in the automated meter readings database. ● Also, LCCC provide data (such as excel, .csv, etc.) which are presently manually imported into the DST. ● Data from existing systems and tools e.g. GIS Systems, API calls to “Insight Limerick”, etc. are feed into the DST. The existing systems and tools data bases also store measured

			temperature, CO_2 and relative humidity data from low cost sensors, such as IoT sensors installed by building owners. ● Also, data from building owners/city authority e.g utility bills, etc. are used for analysis and visualization by DST. ● Next, is the grid location topology database which is used by DST in modelling energy production and consumption in PEB/PED. ● Next, the simulated database which provides data to engage with the public and other relevant stakeholders. The simulated database generates data when there is no available data for buildings. ● Also, the EV charging data stores time series data on EV charger state. ● The sensor data from sensors installed in the PEB also feeds into the DST. ● Next, is the air quality meter database which provide data on the CO_2 level in Georgian innovation district. ● Simulated data regarding the buildings is also generated and stored in IES cloud repository. The IES cloud repository also logs historical data and track progress against impacts. ● Lastly, the socio economic data of the PEB from buildings' owners, sources contained data from the census; Irish census data is used by the Limerick DST to show the socio economic metrics/data for the chosen PEB.
6	Technologies	● Building Management Systems (BMS),	● The BMS, smart meters, and SLUs are installed by MPower to collect data on energy usage and

		Smart meters, and Smart Link Units (SLUs) ● Software used by the utility company ● Community grid stabilizer (D2.2) ● Main power grid	production of buildings in the Georgian Innovation District. ● Next, is the software deployed by the utility company (ESBN) for managing distribution networks. This software also provides Network Model Information (e.g. via Power Flow) which helps to captured buildings connected to the local energy grid. ● The next component is the community grid stabilizer developed by MPower in (D2.2) [45], which helps to control the distribution and production of energy produce and used in the PED to attain energy balance in the Georgian district. ● The community grid stabilizer connects to the main power grid which comprises (e.g gas grid or electricity grid, main energy grid).
7	Physical infrastructures	● Buildings ● Low cost sensors ● EV charging point ● Distributed energy resources ● Air quality meter	● In this layer the Georgian Innovation District (Limerick Youth Services, Gardens International, General Post Office, Rooney Auctionners, Chamber of Commerce, etc.) is deployed as a the PEB which produces real-time data. ● Moreover, this layer captures low cost sensors, such as IoT sensors mainly installed by building owners which provides services such as measuring temperature, CO_2, and relative humidity of PEB or PED. ● EV charging point and position using “Walkability Boundaries” or “Accessibility Assessments” are employed to aid visualization. ● Also, distributed energy resources such as Batteries are deployed in the PEB for analysis on the increase of local production, building demand profiles, and grid information

			analysis. This helps for designing decarbonization strategies. • Lastly, air quality meters are installed which measures the amount of CO_2 in the air.

Table A3: Description of the Limerick DST use case

The Limerick DST (Integrated Modelling and Decision Support Tool) uses different APIs (67,68, 38) as discussed in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [43].

A.4 Delivery of the Citizen Participation Playbook Use case

Use case Summary/Overview

The citizen participation playbook is part of two key sub processes within the Bold City Vision Framework involving new forms of deliberation and localization of the democratic process. The citizen participation playbook supports local authorities in transforming citizen participation into local impact, which increases community engagement and builds citizen trust [46].

Case Description

The Citizen Participation Playbook depicts a detailed roadmap of four distinctive citizen participatory processes to co-design PEBs and PED including phases, steps, stakeholders, outcomes and a catalog of physical tools and a set of online tools. The use case for the Citizen Participation Playbook is based on D3.2. The Citizen Participation Playbook is supported by six best practices for effective citizen participation distilled after an analysis of other smart city projects, European Commission Initiatives and other organizations [46]. The playbook is not a mere catalog of physical and online participatory tools, but a detailed roadmap of four distinctive citizen participatory processes to co-design PEBs and PED including phases, steps, stakeholders, outcomes, and a catalog of physical tools and a set of online tools.

The citizen participation playbook use case modelled in the EAF is shown in Figure A.5.

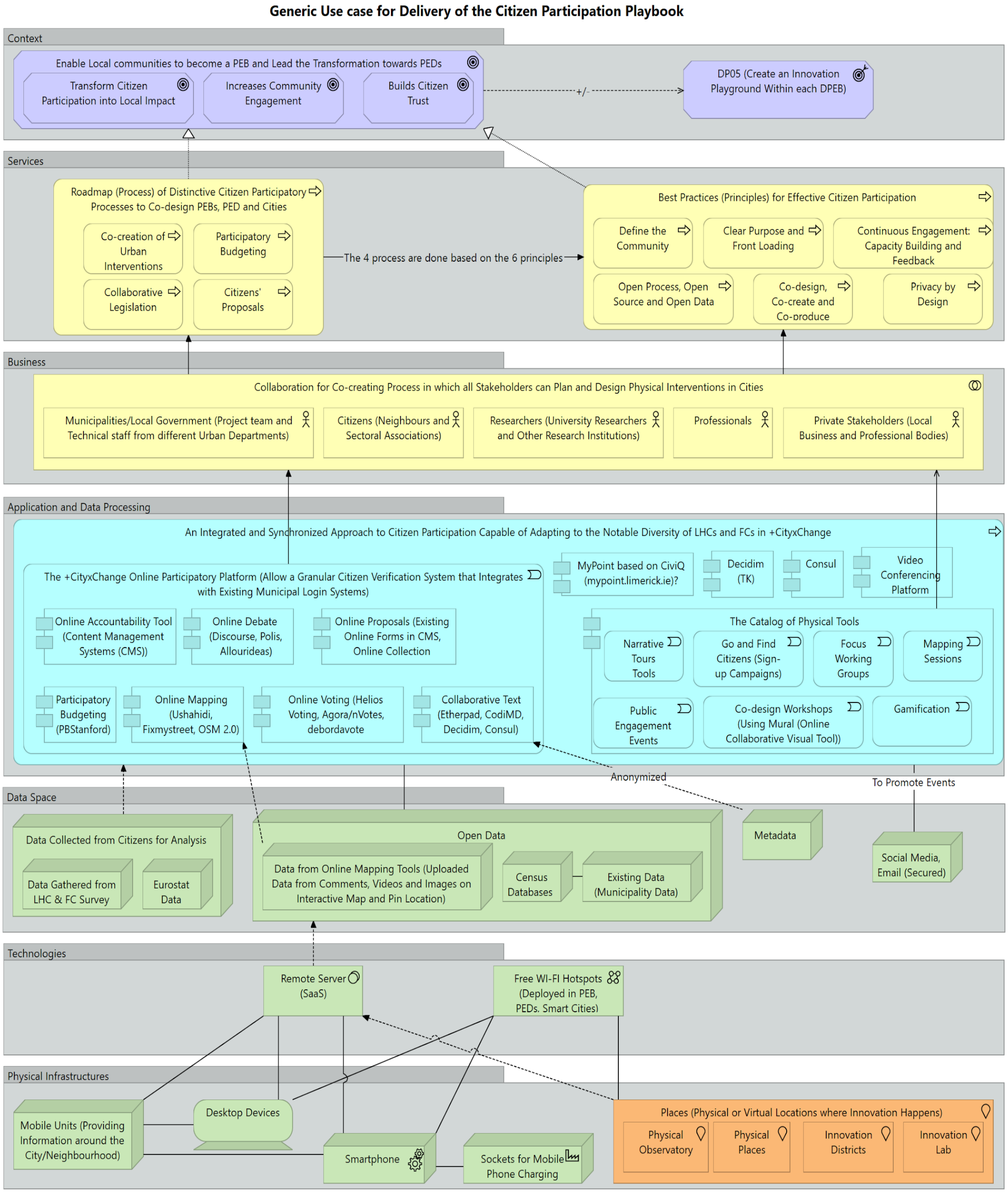

Fig. A.5: Generic use case for delivery of the citizen participation playbook

A description of the use case for delivery of the citizen participation playbook is shown in Table A.4.

No	EA Layer	Components	Description
1	Context	• Enable local communities to become a PEB and lead the transformation towards PEDs • DP05	• The context layer in this use case aims to enable local communities to become a PEB and lead the transformation towards PEDs in achieving DP05 (creation an innovation playground within each DPEB) by: ▪ Transform citizen participation into local impact. ▪ Increases community engagement. • Builds citizen trust.
2	Services	• Roadmap (process) of distinctive citizen participatory processes to co-design PEBs, PED and cities • Best practices (principles) for effective citizen participation	• The services comprise of roadmap (process) of distinctive citizen participatory processes to co-design PEBs, PED and cities. This includes: ▪ Co-creation of urban interventions. ▪ Participatory budgeting. ▪ Collaborative legislation. ▪ Citizens' proposals. • Besides, this layer entails best practices (principles) for effective citizen participation. The best practice includes: ▪ Define the community, ▪ Clear purpose and front loading, ▪ Continuous engagement, capacity building, and feedback. ▪ Open process, open source, and open data. ▪ Co-design, co-create, and co-produce. ▪ Privacy by design. • Thus the 4 roadmap (process) are done based on the 6 best practices (principles).

3	Business	• Collaboration for co-creating process in which all stakeholders can plan and design physical interventions in cities	• The business layer entails collaboration for co-creating process in which all stakeholders can plan and design physical interventions in cities. The stakeholders comprise of: ▪ Municipalities/local government (project team and technical staff from different urban departments). ▪ Citizens (neighbors and sectoral associations). ▪ Researchers (university researchers and other research institutions). ▪ Professionals. • Private stakeholders (local business and professional bodies).
4	Application and data processing	• The +CityxChange online participatory platform • The catalog of physical tools • MyPoint based on CiviQ • Decidim • Consul • Video conferencing platform	• The +CityxChange online participatory platform allow a granular citizen verification system that integrates with existing municipal login systems. It comprises different online tools: ▪ Online accountability tool (Content Management Systems (CMS)) ▪ Online debate (discourse, polis, allourideas) ▪ Online proposals (existing online forms in CMS, online collection software) ▪ Participatory budgeting (PBStanford) ▪ Online Mapping (Ushahidi, Fixmystreet, OSM 2.0) ▪ Online Voting (Helios voting, Agora/nVotes, debordavote (debordavote.org) ▪ Collaborative Text (Etherpad, CodiMD, Decidim, Consul)

			● Next is the catalog of physical tools which comprises: ▪ Narrative tours tools ▪ Go and find citizens (sign-up campaigns) ▪ Focus working groups ▪ Mapping sessions ▪ Public engagement events (using platforms such as MyPoint based on CiviQ platform) ▪ Co-design workshops (using mural (online collaborative visual tool)) ▪ Gamification ● Other important tools comprise of MyPoint based on CiviQ, Decidim, Consul and Video conferencing platforms being used for co-creation workshops due to the pandemic.
5	Data space	● Data collected from citizens for analysis ● Open data ● Metadata ● Data from social media, email	● Several data sources are used to foster innovation. Among these data sources is data collected from citizens for analysis which involves data from LHC & FC survey, and Eurostat data ● Also, open and available data from data from online mapping tools (uploaded data from comments, videos and images on interactive map and pin location) are used. As well as census databases and existing municipality data. ▪ Data from social media and email and metadata are also used. Since these data sources are from citizens. The data must be secured, and privacy should be ensured. The use and download of these data should be logged/recorded to ensure providence.

6	Technologies	• Remote Server Software as a service (SaaS) • Free WI-FI hotspots	Technologies such as SaaS remote server which are open source solutions are deployed to support open innovation within the PEB/PED as quick and affordable tools. Besides, free WI-FI hotspots can be deployed to provide internet access for citizens to support co-creation within the city.
7	Physical infrastructures	• Places • Mobile units • Desktop devices • Smartphone • Sockets for mobile phone charging	• In regard to citizen participation the physical Infrastructure entails the places both physical and virtual locations where innovation takes place. The places can be physical observatory, physical places, innovation districts, innovation lab, etc. • It also involves the mobile units that provides information around the city/neighborhood, desktop devices, smartphone, and sockets for mobile phone charging.

Table A.4: Description of the delivery of the citizen participation playbook use case

A.5 Framework for an Innovation Playground Use case

Use case Summary/Overview

The framework for an innovation playground describes a spatial and socio-economic framework for innovation playgrounds related to the energy transition that can be localized to any town or city [47].
The Framework is made up of three parts: a System, a Journey, and a Localised Innovation Playground.

Case Description

This use case provides a spatial and socio-economic "Framework for Innovation Playgrounds", including an overview and practical guidance on putting an Innovation Playground in place [47]. The use case for innovation playground is based on D3.3.
Outputs of an Innovation Playground will include new ways of doing things; new partnerships, places, tools and activities. The key stakeholders who will use an Innovation Playground include building owners and occupants, citizens/communities,

civil society organisations (CSOs), local government, universities/research groups, entrepreneurs and other innovators.

The framework for an innovation playground use case modelled in the EAF is shown in Figure A.6 and a description of the use case is shown in Table A.5.

Generic Use case for Framework For an Innovation Playground

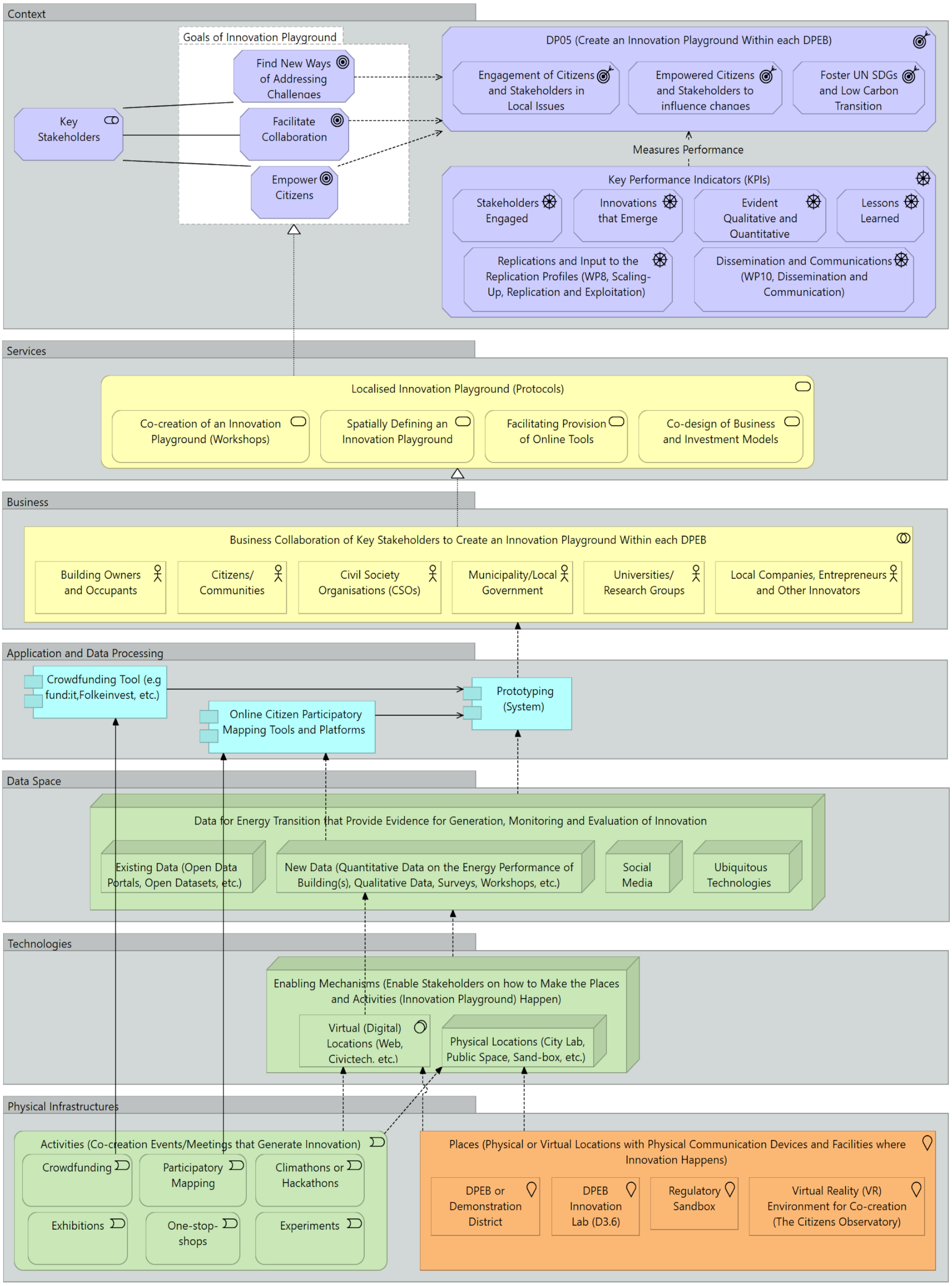

Fig. A.6: Generic use case for framework for an innovation playground

No	EA Layer	Components	Description
1	Context	• Stakeholders • Goals of innovation playground • Key Performance Indicators (KPIs) • DP05	• The context in this use case involves how key stakeholders achieve the goals of innovation playground via ▪ Finding new ways of addressing challenges. ▪ Facilitating collaboration. ▪ Empowering citizens. • Then, the goals of innovation playground help to attain DP05 which is the creation of an Innovation playground within each DPEB. This is achieved by: ▪ Engagement of citizens and stakeholders in local issues. ▪ Empowering of citizens and stakeholders to influence changes. ▪ Fostering UN SDGs and low carbon transition. • Lastly in due time DP05 is assessed based on the KPIs which includes: ▪ Stakeholders engaged. ▪ Innovations that emerges. ▪ Evident qualitative and quantitative changes. ▪ Lessons learned. ▪ Replications and input to the replication profiles (WP8, scaling-up, replication and exploitation) • Dissemination and communications (WP10).
2	Services	• Localized Innovation Playground (Protocols)	• These are localized innovation playground also referred to as the protocols, which includes: ▪ Co-creation of an innovation playground (workshops). ▪ Spatially defining an innovation playground.

			▪ Facilitating provision of online tools. ● Co-design of business and investment models.
3	Business	● Business collaboration of key stakeholders	● Entails collaboration of key stakeholders to create an innovation playground within each DPEB. The stakeholders include: ▪ Building owners and occupants. ▪ Citizens/communities. ▪ Civil Society Organisations (CSOs). ▪ Municipality/local government. ▪ Universities/research groups. ● Local companies, entrepreneurs, and other innovators.
4	Application and data processing	● Crowdfunding tool ● Online citizen participatory mapping tools ● Prototyping	● The applications required in the framework for an innovation playground comprises: ▪ A crowdfunding tool such as fund:it (an Irish-based not-for-profit crowdfunding platform) ▪ Folkeinvest which helps with the initial setup of the company, as company status is necessary to crowdfund in Norway, etc. ● Online citizen participatory mapping tools and platforms such as Survey123, CivicInsight, CoUrbanize, CitizenLab, CitizenSpace, Civocracy, etc. ▪ A prototyping system which involves developing a mock-up of innovation in the online or offline 'places' of the innovation playground in a particular town or city.
5	Data space	● Data for energy transition	● The data required for energy transition that provide evidence for generation, monitoring and

			evaluation for the innovation framework comprises: ▪ Existing data (open data portals, open datasets, etc.) ▪ New data (quantitative data on the energy performance of building(s), qualitative data, surveys, workshops, etc.). ▪ Also, the new data provided data that is been used by the online citizen participatory mapping tools and platforms. ▪ Social media. ▪ Ubiquitous technologies.
6	Technologies	• Enabling mechanisms	• The enabling mechanisms enable stakeholders on how to make the places and activities (innovation playground) happen. These enabling mechanisms comprises: ▪ Virtual (digital) locations via web, Civictech, etc. which sends data to the new database. ▪ Physical locations such as city lab, public space, sandbox, etc.
7	Physical infrastructures	• Activities • Places	• The "activities" involve co-creation events/meetings that generate innovation. This includes: ▪ Crowdfunding ▪ Participatory mapping ▪ Climathons or hackathons ▪ Exhibitions ▪ One-stop-shops ▪ Experiments • Next is the "places" which may be physical or virtual locations with physical communication devices and facilities where innovation happens. This includes: ▪ DPEB or demonstration district. ▪ DPEB innovation lab. ▪ Regulatory sandbox.

			▪ Virtual Reality (VR) environment for co-creation such as the citizens observatory in T4.3 and T5.3.

Table A.5: Description of the framework for an innovation playground use case

A.6 MPower Tool Use case

Use case Summary/Overview

The MPower tool is based on a community grid optimization model responsible for grid balancing. It is based on a bottom-up approach by collecting real time data from loads and generation sources from the community grid. The MPower tool model feed in data about the availability of energy and flexibility, its source, type, and amount. The model communicates directly with the "MPower enerXchange platform" that enables energy and flexibility trading inside the community grid and with a grid stabilizer for optimization and balancing purposes. The MPower tool and MPower enerXchange platform is demonstrated in Limerick [45].

Case Description

This case involves the MPower's tool which is a model that supports real-time monitoring of all prosumers, power generators and market trades within a Community Grid, with the aim to show how Disturbance Neutral the Community Grid is, and what actions need to be taken in the Community Grid in real-time to ensure Disturbance Neutrality, like enabling Dissipation. The model will communicate with MPower's enerXChange platform to ensure Disturbance Neutrality. While, the model is responsible for monitoring and reporting, the MPower enerXChange is responsible for controlling certain Community Grid elements, and for facilitating all trades in the Community Grid [45]. The use case for MPower tool is part of D2.2.

The MPower tool use case modelled in the EAF is shown in Figure A.7 and a description of the use case is shown in Table A.6.

Use case for MPower Tool (Community Grid Optimization Model)

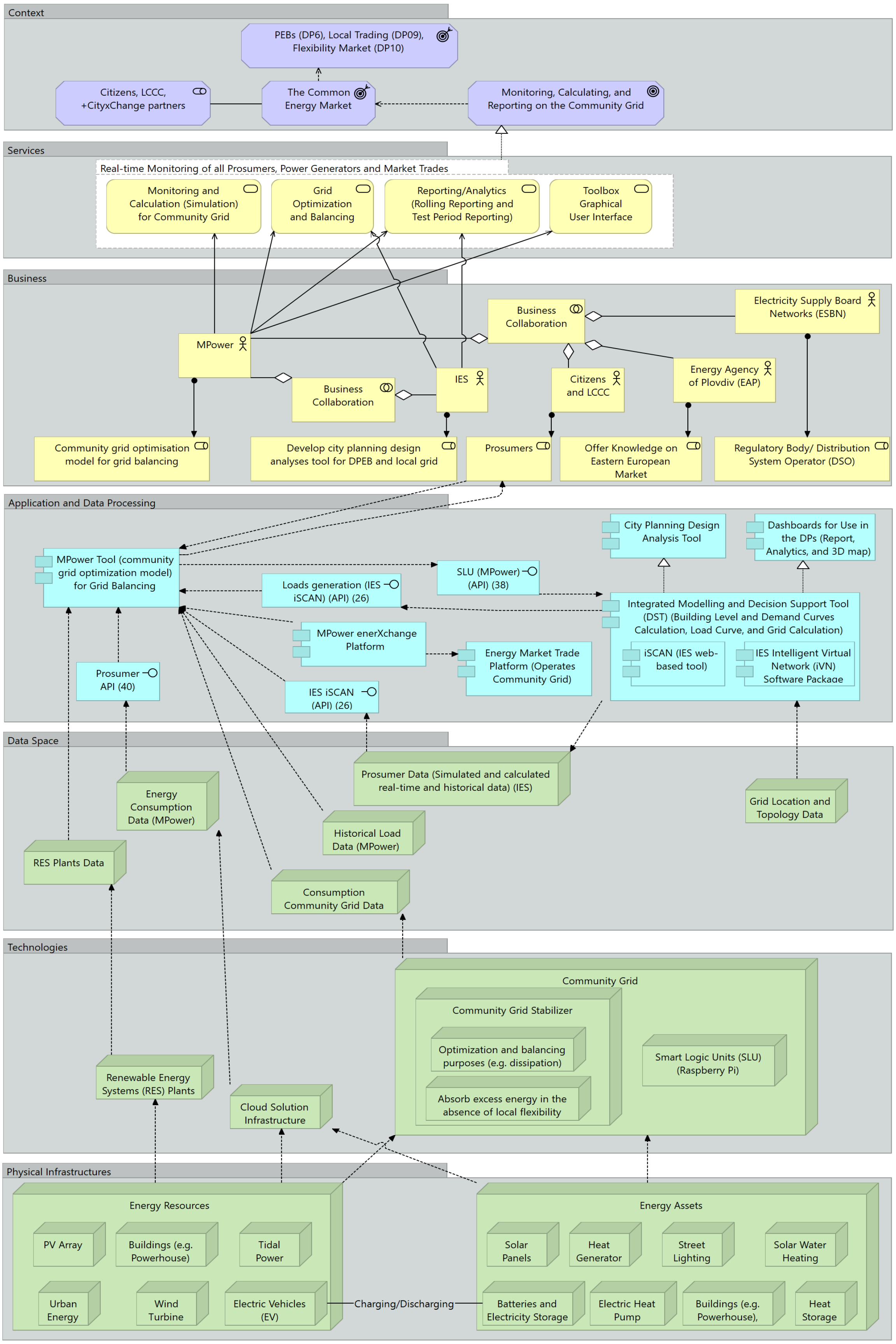

Fig. A.7: Use case for MPower tool

No	EA Layer	Components	Description
1	Context	• Citizens, LCCC, +CityxChange partners • Monitoring, calculating, and reporting on the community grid • The common energy market • Microgrids (DP07)	• Aims to achieve "PEBs (DP6), Local Trading (DP09), and Flexibility Market (DP10). This is based on the involvement of Citizens, LCCC, +CityxChange partners for the common energy market. Which entails monitoring, calculating, and reporting on the community grid.
2	Services	• Real-time monitoring of all prosumers, power generators and market trades	• To provide real-time monitoring of all prosumers, power generators and market trades. The MPower tool provides the following services; ▪ Monitoring and calculation (simulation) for community grid. ▪ Grid optimization and balancing. ▪ Reporting/analytics (rolling reporting and test period reporting). • Toolbox graphical user interface.
3	Business	• MPower • IES • Citizens and LCCC • Energy Agency of Plovdiv (EAP) • Electricity Supply Board Networks (ESBN)	• Comprises all the partners that collaborates and are involved in the MPower tool and they include; • MPower which provides community grid optimization model for grid balancing. • IES develop city planning design analyses tool for DPEB and local grid. • Citizens and LCCC are the prosumers. • EAP offers knowledge on eastern European market. • ESBN serves as regulatory body and Distribution System Operator (DSO).
4	Application and data processing	• MPower tool • MPower enerXchange platform	• MPower tool provides community grid optimization model for grid balancing in DPEB.

		• Energy market trade platform • Integrated modelling and DST	• The MPower tool collects data from RES plants data, energy consumption data (via Prosumer API (40)), consumption community grid data, historical load data, and prosumer data (via IES iSCAN API (26). • The MPower tool also sends and receives data to prosumers. It also sends data to DST (via SLU API (38). • Likewise, the MPower tool sends data to the MPower enerXchange platform which then sends data to the energy market trade platform which is used to operate the community grid. • The integrated modelling and DST aids to provide building level and demand curves calculation, load curve, and grid calculation of the DPEB for; ▪ City planning design analysis tool • Dashboards for use in the DPs (report, analytics, and 3D map) which is sent to the MPower tool via iSCAN API (26).
5	Data space	• RES Plants Data • Energy consumption data • Prosumer data • Historical load data • Consumption Community grid data • Grid location and topology data	• “RES plants data” stores data from RES in the DPEB. • “Energy consumption data” stores energy resources and energy assets via cloud solution infrastructure and is managed by MPower. • “Prosumer data” comprises simulated and calculated real-time and historical data provided by IES via an API (IES iSCAN (API) (26)). It also gets data from the DST. • “Historical load data” provides prior grid related data to be used by the MPower tool and is maintained by MPower. • “Consumption community grid data” stores data from the community grid. • Then, the “grid location and topology data” provided data on Georgian

			Innovation District to be used by the DST.
6	Technologies	● Community grid ● Renewable Energy Systems (RES) plants ● Cloud solution infrastructure	● Data from energy resources and energy assets are sent to RES, cloud solution infrastructure, and the community grid. ● The community grid comprises; ▪ Community grid stabilizer which; ○ Carryout optimization and balancing purposes (e.g. dissipation). ○ Absorb excess energy in the absence of local flexibility. ▪ Smart Logic Units (SLU) (deployed as Raspberry Pi)
7	Physical infrastructures	● Energy resources ● Energy assets	● The energy resources comprise of: ▪ PV array ▪ Buildings (e.g. Powerhouse) ▪ Tidal power ▪ Urban energy ▪ Wind turbine ▪ Electric Vehicles (EV) ● Similarly, the energy assets comprise of: ▪ Solar panels ▪ Heat generator ▪ Street lighting ▪ Solar water heating ▪ Batteries and electricity storage ▪ Electric heat pump ▪ Buildings (e.g. powerhouse), ▪ Heat storage ● As seen in Figure A.7 EVs are connected to the batteries and electricity storage which charge/discharge energy.

Table A.6: Description of MPower tool use case

The MPower tool uses different APIs (26, 38, 40) which are discussed in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39].

A.7 Powel Tool – (Grid Operation Tool) Design and Operation of Local Energy System Use case

Use case Summary/Overview

The Powel tool is a model for design and operation of a local energy system that supports management and operation of a PEB. The tool models dimensioning of energy resources required to enable PEB when historical consumption, climate data, and resource characteristics including flexibility that are available. The tool model calculates how available energy resources will be applied the best way for next day hour by hour forecast based on availability and predictions (weather forecasts, load forecasts, etc.) [45].

Case Description

This case illustrates the Powel tool which is a model for design and operation of a local energy system that supports management and operation of a PEB. The tool models dimensioning of energy resources required to enable PEB when historical consumption, climate data and resource characteristics including flexibility are available. The Powel model is developed as an IT platform which manages import, export, general calculations, design features and operation related features. The integration is executed through the import and export modules either in file formats or through APIs as seen in Figure A.8. The platform supports the design process and the operation process [45]. The use case for Powel tool is part of D2.2.

The Powel tool is demonstrated in LHC Trondheim. The use case for Powel tool modelled in the EAF is shown in Figure A.8 and a description of the use case is shown in Table A.7.

Use case for Powel Tool (Grid Operation Tool) Design and Operation

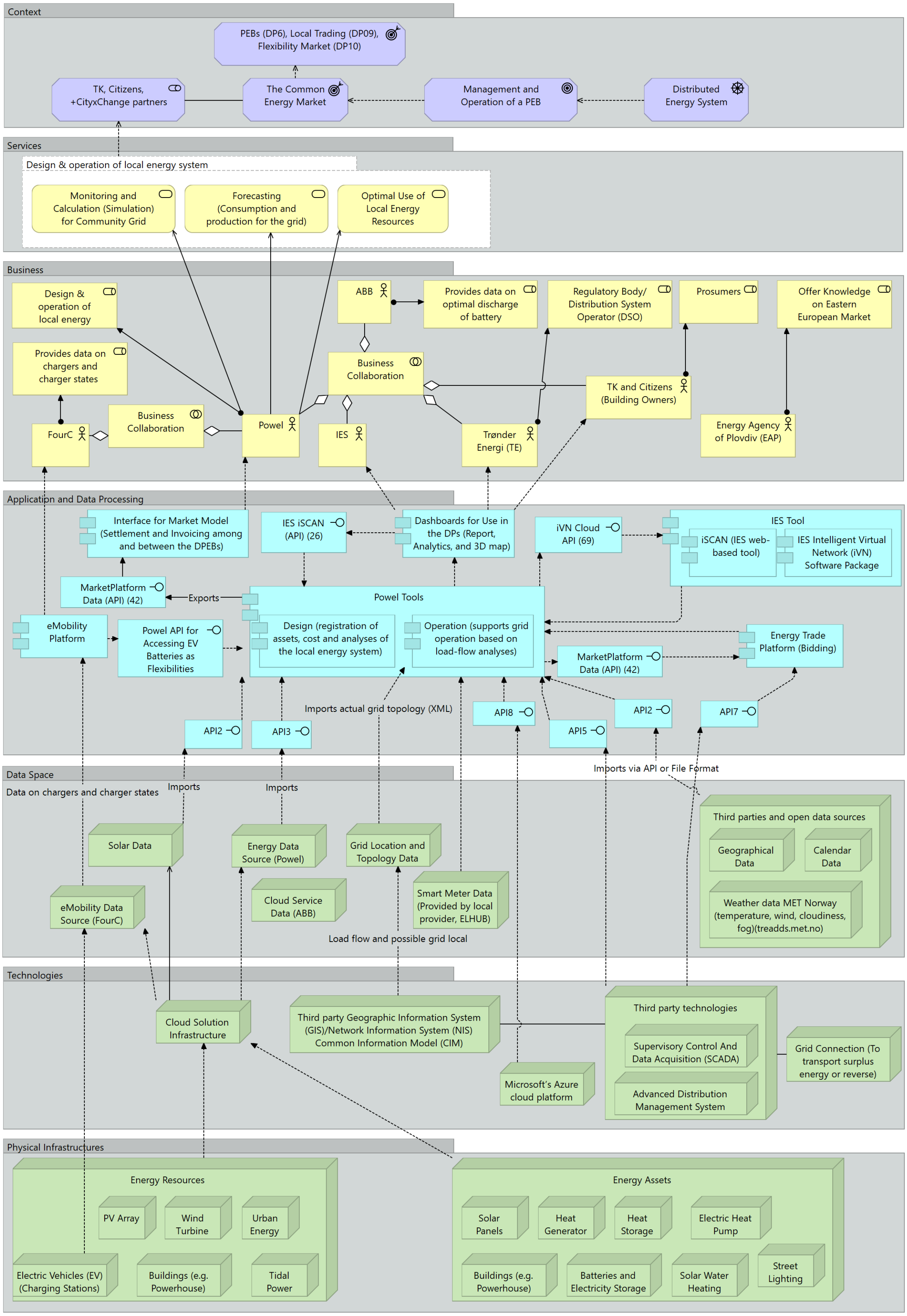

Fig. A.8: Use case for Powel tool

No	EA Layer	Components	Description
1	Context	● TK, citizens, +CityxChange partners ● Management and operation of a PEB ● Distributed energy system ● The common energy market ● Microgrids (DP07) ● eMaaS (DP08)	● "Aims to achieve PEBs (DP6), Local Trading (DP09), and Flexibility Market (DP10)" by integrating seamless e-mobility within the PEB. It is linked to the common energy market which is influenced by the interaction of TK, citizens, +CityxChange partners and the management and operation of a PEB linked to distributed energy system deployed in the DPEB.
2	Services	● Design and operation of local energy system	● The design and operation of local energy system services provided by the Powel tools comprises; ▪ Monitoring and calculation (simulation) for community grid. ▪ Forecasting (consumption and production for the grid). ● Optimal use of local energy resources calculation.
3	Business	● FourC ● Powel ● IES ● ABB ● Trønder Energi (TE) ● TK and citizens (building owners) ● EAP	● FourC provides data on chargers and charger states via the eMobility platform. ● Powel offers the design and operation of local energy system and also provide an Interface for market model (settlement and invoicing among and between the DPEBs). ● IES provide dashboards for use in the DPs for report, analytics, and 3D map. ● ABB provides data on optimal discharge of battery. ● Trønder Energi (TE) acts as a regulatory body/DSO. ● TK and citizens (building owners) are the prosumers in the DPEB. ● EAP offers knowledge on Eastern European market.

4	Application and data processing	• Powel tools • Interface for market Model • eMobility platform • Dashboards for use in the DPs • Energy trade platform (bidding) • IES tool	• Powel tools comprises two main tools; ▪ Design (registration of assets, cost and analyses of the local energy system). ▪ Operation (supports grid operation based on load-flow analyses). • The Powel tools exports data to interface for market model (settlement and invoicing among and between the DPEBs) via MarketPlatformData API (42). • The eMobility platform connects to the Powel tool via a "Powel API" which helps for accessing EV batteries as flexibilities. • The Powel tool connects to the IES dashboards for use in the DPs for report, analytics, and 3D map via IES iSCAN API (26). • The Powel tool also connects to the IES Tool via iVN Cloud API (69) and also connects to the energy trade platform for Bidding via MarketPlatformData API (42). • The Powel tools imports solar data, and energy data source via APIs. It imports actual grid topology via XML from the grid location and topology database. • Microsoft's Azure cloud platform also connects to the Powel tool via an API. It also Imports data via API or File Format from third party technologies (SCADA, ADMS, etc.).
5	Data space	• eMobility data source • Solar data • Energy data source • Cloud service data • Grid location and topology data • Smart meter data	• The eMobility data source gets data from the EV (charging stations) and cloud solution infrastructure. • "Solar data" comprises data from PV array cloud collected from the solution infrastructure • "Energy data source" provided by Powel comprises data of energy

<table>
<tr><td></td><td></td><td>Third parties and open data sources</td><td>resources collected from the solution infrastructure
“Grid location and topology data” comprises saved data of load flow and possible grid local of the DPEB.
The smart meter data comprises data of citizens (building owners) in Trondheim provided by local provider or gotten from ELHUB.
The third parties and open data sources comprises;
Geographical data
Calendar data
Weather data from MET Norway which includes temperature, wind, cloudiness, fog (treadds.met.no).</td></tr>
<tr><td>6</td><td>Technologies</td><td>Cloud solution infrastructure
Third party Geographic Information System (GIS)/Network Information System (NIS) Common Information Model (CIM)
Microsoft’s Azure cloud platform
Third party technologies
Grid connection</td><td>Cloud solution infrastructure collects data from energy resources and energy assets.
The third-party GIS/NIS CIM are used by Powel tool to determine load flow and possible grid local within DPEB.
The Powel grid operation tool services are designed to run on Microsoft Azure cloud platform via an API.
The third party technologies comprise of;
Supervisory Control and Data Acquisition (SCADA)
Advanced Distribution Management System (ADMS)
The third party technologies are linked to the grid connection which transport surplus energy or reverse energy within the DPEB.</td></tr>
<tr><td>7</td><td>Physical infrastructures</td><td>Energy resources
Energy assets</td><td>Energy resources used in the DPEB includes;
PV array
Wind turbine
Urban energy
EV (charging stations)</td></tr>
</table>

			▪ Buildings (e.g. powerhouse) ▪ Tidal ● Energy assets used in the DPEB includes; ▪ Solar panels ▪ Heat generator ▪ Heat storage ▪ Electric heat pump ▪ Street lighting ▪ Batteries and electricity storage ▪ Buildings (e.g. powerhouse) ● Solar water heating

Table A.7: Description of Powel tool use case

The Powel tool uses different APIs (42, 26, 69, etc.) which are described in D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39].

A.8. The Common Energy Market Use case

Use case Summary/Overview

The common energy market use case comprises Power tools, MPower Tool, and IES integrated modelling and decision support tool. This use case aims to show how all the 3 tools works together to achieve a common energy market in a DPEB.

Case Description

This case entails the operation of the common energy market as presented in D2.2-Toolbox for design of DPEB including eMobility and distributed energy resources [45]. As seen in Figure A.9 Power tools and MPower Tool assess data from IES integrated modelling and decision support tool. Using same API (iVN Cloud API (69)). Likewise, the Energy Data Source in the data space layer is used by Power tools, MPower Tool, and the IES DST. The use case for the common energy market is part of D2.2.

The common energy market use case modelled in the EAF is shown in Figure A.9 and a description of the use case is shown in Table A.8.

Use case for Common Energy Market (Power+MPower+IES)

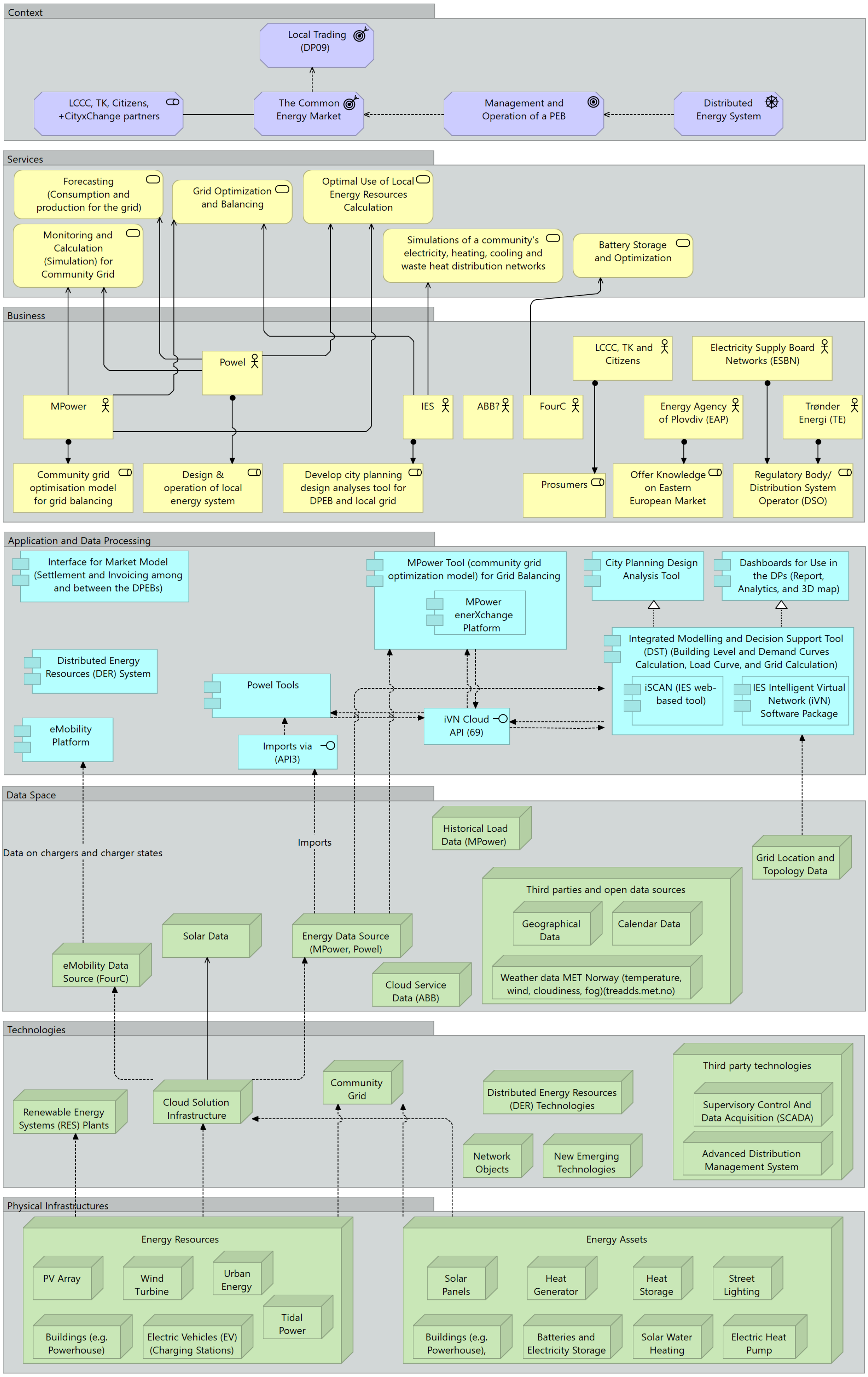

Fig. A.9: Use case for common energy market (Power+MPower+IES)

No	EA Layer	Components	Description
1	Context	• TK, citizens, +CityxChange partners • Management and operation of a PEB • Distributed energy system • The common energy market • Microgrids (DP07)	• "Local Trading (DP09)" Enable Peer-to-Peer trading within the PEB is linked to the common energy market which is influenced by the interaction of TK, citizens, +CityxChange partners and the management and operation of a PEB linked to distributed energy system deployed in the DPEB.
2	Service	• Forecasting • Monitoring and Calculation • Grid optimization and balancing • Optimal use • Simulations • Battery storage and optimization	• Forecasting comprise of consumption and production for the grid is provided by Powel • Monitoring and calculation involve the simulation for community grid is provided by MPower and Powel. • Grid optimization and balancing of energy within the DPEB is supported by both MPower and IES. • Optimal use of local energy resources calculation is provided by MPower and Powel. • Simulations of a community's electricity, heating, cooling, and waste heat distribution networks is provided by IES. • Battery storage and optimization is provided by FourC as flexibilities to suppose actualization of DPEB and PED.
3	Business	• FourC • Powel • MPower • IES • ABB • Trønder Energi (TE)/Electricity	• FourC provides data on chargers and charger states via the eMobility platform. • Powel provides the design & operation of local energy system. • MPower provides community grid optimization model for grid balancing

		Supply Board Networks (ESBN) ● LCCC, TK and citizens (building owners) ● Energy Agency of Plovdiv (EAP)	● IES develops city planning design analyses tool for DPEB and local grid. ● ABB provides data on optimal discharge of battery. ● TE/ESBN acts as a regulatory body/DSO. ● TK and citizens (building owners) are the prosumers in the DPEB. ● EAP offers knowledge on Eastern European market.
4	Application and data processing	● Interface for market model ● Distributed Energy Resources (DER) System ● eMobility platform ● Powel tools ● MPower tool ● Integrated modelling and decision support tool	● Interface for market model enables settlement and invoicing among and between the DPEBs. ● DER system provides an interface for all energy resources deployed within the DPEB. ● eMobility Platform is the eMaaS application provided by FourC which provides energy from EV batteries as flexibilities within the DPEB. ● Powel tools enables design & operation of local energy system. ● MPower tool supports community grid optimization model for grid balancing and is deployed with the MPower enerXchange platform. ● Integrated Modelling and DST aids visualization of building level and demand curves calculation, load curve, and grid calculation.
5	Data space	● eMobility data source ● Solar data ● Energy data source ● Cloud service data ● Grid location and topology data ● Third parties and open data sources ● Historical load data	● The eMobility data source provides data on chargers and charger states to the eMobility platform. ● “Solar data” comprises data from PV array cloud collected from the solution infrastructure. ● “Energy data source” provided by Powel comprises data of energy resources collected from the solution infrastructure. This data is used by Powel tools and MPower tool.

			• "Grid location and topology data" comprises saved data of load flow and possible grid local of the DPEB which is feed into the DST. • The smart meter data comprises data of citizens (building owners) in Trondheim provided by local provider or gotten from ELHUB. • The third parties and open data sources comprises Geographical data, etc. • Weather data from MET Norway which includes temperature, wind, cloudiness, fog (treadds.met.no). • Historical load data is used by MPower for grid balancing.
6	Technologies	• Renewable Energy Systems (RES) plants • Cloud solution infrastructure • Third party technologies • Community grid • Network Objects • Distributed Energy Resources (DER) Technologies • New Emerging Technologies	• Comprises technologies deployed to generate renewable energy from renewable sources such as solar, wind, etc. • Cloud solution infrastructure collects data from energy resources and energy assets. • The third party technologies comprise of SCADA and ADMS deployed to manage energy usage in buildings. • Next, is the community grid which connect all other energy systems in the DPEB/DPED. • Other technologies that support the common energy market includes network objects, DER technologies, and new emerging technologies.
7	Physical infrastructures	• Energy resources • Energy assets	• Energy resources includes PV array, Wind turbine, Urban energy, EV (charging stations), Buildings (e.g. powerhouse), and Tidal. • Energy assets includes Solar panels, Heat generator, Heat storage, Electric heat pump, Street lighting, Batteries

			and electricity storage, Buildings (e.g. powerhouse) and Solar water heating.

Table A.9: Description of common energy market (Power+MPower+IES) use case

The common energy market use case employs different APIs (e.g iVN Cloud API (69), etc.). Do refer to D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39], for description of APIs.

A.9. Community-led Open Innovation (Framework for DPEB Innovation Labs) Use case

Use case Summary/Overview

Innovation lab as defined in the +CityxChange project is a dedicated centre for digital innovation within a city focused on the creation and replication of DPEBs. It comprises a programme and a physical space or network of spaces where implementation of the +CityxChange innovation playground can become manifest. The community led open innovation is located physically and conceptually within the +CityxChange innovation playground, key stakeholders and users of DPEB Innovation Labs include government, academia, business, and civil society representing the four actors of the quadruple helix model of innovation [48].

Case Description

This case describes a framework for the implementation of DPEB innovation labs in +CityxChange LHCs and FCs and the enhancement of existing centres where they exist. The community led open innovation data comprises visualization tools including the DST (see section A.3). It has a collaborative operating structure and supports an Open Innovation 2.0 ecosystem for entrepreneurs and start-ups. It can include a small prototyping lab where DIT (Do-It-Together) RES projects are designed, piloted and delivered [48]. The use case for community-led open innovation use case is part of D3.6.

The community-led open innovation use case modelled in the EAF is shown in Figure A.10 and a description of the use case is shown in Table A.9.

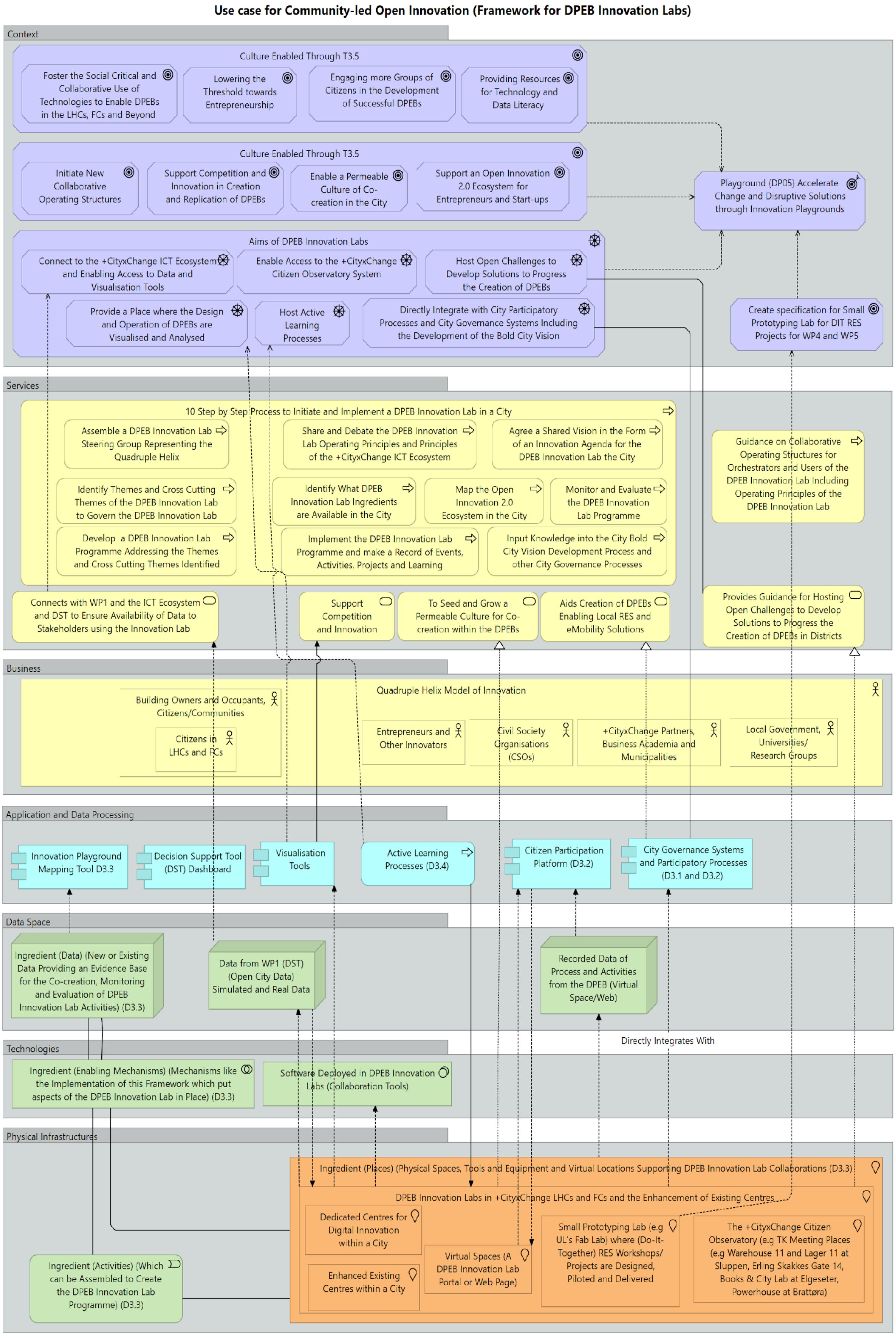
Use case for Community-led Open Innovation (Framework for DPEB Innovation Labs)
Context
Culture Enabled Through T3.5
Foster the Social Critical and Collaborative Use of Technologies to Enable DPEBs in the LHCs, FCs and Beyond
Lowering the Threshold towards Entrepreneurship
Engaging more Groups of Citizens in the Development of Successful DPEBs
Providing Resources for Technology and Data Literacy
Culture Enabled Through T3.5
Initiate New Collaborative Operating Structures
Support Competition and Innovation in Creation and Replication of DPEBs
Enable a Permeable Culture of Co-creation in the City
Support an Open Innovation 2.0 Ecosystem for Entrepreneurs and Start-ups
Playground (DP05) Accelerate Change and Disruptive Solutions through Innovation Playgrounds
Aims of DPEB Innovation Labs
Connect to the +CityxChange ICT Ecosystem and Enabling Access to Data and Visualisation Tools
Enable Access to the +CityxChange Citizen Observatory System
Host Open Challenges to Develop Solutions to Progress the Creation of DPEBs
Provide a Place where the Design and Operation of DPEBs are Visualised and Analysed
Host Active Learning Processes
Directly Integrate with City Participatory Processes and City Governance Systems Including the Development of the Bold City Vision
Create specification for Small Prototyping Lab for DIT RES Projects for WP4 and WP5
Services
10 Step by Step Process to Initiate and Implement a DPEB Innovation Lab in a City
Assemble a DPEB Innovation Lab Steering Group Representing the Quadruple Helix
Share and Debate the DPEB Innovation Lab Operating Principles and Principles of the +CityxChange ICT Ecosystem
Agree a Shared Vision in the Form of an Innovation Agenda for the DPEB Innovation Lab the City
Identify Themes and Cross Cutting Themes of the DPEB Innovation Lab to Govern the DPEB Innovation Lab
Identify What DPEB Innovation Lab Ingredients are Available in the City
Map the Open Innovation 2.0 Ecosystem in the City
Monitor and Evaluate the DPEB Innovation Lab Programme
Develop a DPEB Innovation Lab Programme Addressing the Themes and Cross Cutting Themes Identified
Implement the DPEB Innovation Lab Programme and make a Record of Events, Activities, Projects and Learning
Input Knowledge into the City Bold City Vision Development Process and other City Governance Processes
Guidance on Collaborative Operating Structures for Orchestrators and Users of the DPEB Innovation Lab Including Operating Principles of the DPEB Innovation Lab
Connects with WP1 and the ICT Ecosystem and DST to Ensure Availability of Data to Stakeholders using the Innovation Lab
Support Competition and Innovation
To Seed and Grow a Permeable Culture for Co-creation within the DPEBs
Aids Creation of DPEBs Enabling Local RES and eMobility Solutions
Provides Guidance for Hosting Open Challenges to Develop Solutions to Progress the Creation of DPEBs in Districts
Business
Quadruple Helix Model of Innovation
Building Owners and Occupants, Citizens/Communities
Citizens in LHCs and FCs
Entrepreneurs and Other Innovators
Civil Society Organisations (CSOs)
+CityxChange Partners, Business Academia and Municipalities
Local Government, Universities/ Research Groups
Application and Data Processing
Innovation Playground Mapping Tool D3.3
Decision Support Tool (DST) Dashboard
Visualisation Tools
Active Learning Processes (D3.4)
Citizen Participation Platform (D3.2)
City Governance Systems and Participatory Processes (D3.1 and D3.2)
Data Space
Ingredient (Data) (New or Existing Data Providing an Evidence Base for the Co-creation, Monitoring and Evaluation of DPEB Innovation Lab Activities) (D3.3)
Data from WP1 (DST) (Open City Data) Simulated and Real Data
Recorded Data of Process and Activities from the DPEB (Virtual Space/Web)
Directly Integrates With
Technologies
Ingredient (Enabling Mechanisms) (Mechanisms like the Implementation of this Framework which put aspects of the DPEB Innovation Lab in Place) (D3.3)
Software Deployed in DPEB Innovation Labs (Collaboration Tools)
Physical Infrastructures
Ingredient (Places) (Physical Spaces, Tools and Equipment and Virtual Locations Supporting DPEB Innovation Lab Collaborations (D3.3)
DPEB Innovation Labs in +CityxChange LHCs and FCs and the Enhancement of Existing Centres
Dedicated Centres for Digital Innovation within a City
Enhanced Existing Centres within a City
Virtual Spaces (A DPEB Innovation Lab Portal or Web Page)
Small Prototyping Lab (e.g UL's Fab Lab) where (Do-It-Together) RES Workshops/ Projects are Designed, Piloted and Delivered
The +CityxChange Citizen Observatory (e.g TK Meeting Places (e.g Warehouse 11 and Lager 11 at Sluppen, Erling Skakkes Gate 14, Books & City Lab at Elgeseter, Powerhouse at Brattøra)
Ingredient (Activities) (Which can be Assembled to Create the DPEB Innovation Lab Programme) (D3.3)

Fig. A.10: Use case for community-led open innovation

No	EA Layer	Components	Description
1	Context	• Playground (DP05) accelerate change and disruptive solutions through innovation playgrounds • Create specification for small prototyping lab for DIT RES projects for WP4 and WP5 • Culture enabled through T3.5 • Culture enabled through T3.5 • Aims of DPEB innovation labs	• In this use case for community-led open innovation (framework for DPEB innovation labs), the context layers capture how Playground (DP05) is achieved based on different requirements as seen in Figure A.10.
2	Service	• 10 step by step process to initiate and implement a DPEB innovation lab in a city • Connects with WP1 and the ICT Eco-system and DST to ensure availability of data to stakeholders using the innovation lab	• Involves the 10 step by step process to be adopted in a DPEB innovation lab within a city which is linked to data from WP1 (DST) (open city data) simulated and real-world data. • Also, the services comprise of support competition and innovation, seeding and growing of a permeable culture for co-creation within the DPEBs and aiding the creation of DPEBs to enabling local RES and eMobility solutions. • Guidance are provided on collaborative operating structures for orchestrators and users of the DPEB Innovation lab including operating principles of the DPEB innovation lab. • Lastly, it involves the provision of guidance for hosting open challenges to develop solutions to progress the creation of DPEBs in districts.

3	Business	● Quadruple Helix Model of Innovation	● The quadruple helix for community-led open innovation includes; ▪ Building owners and occupants, citizens/communities (citizens in LHCs and FCs). ▪ Entrepreneurs and other innovators. ▪ Civil Society Organisations (CSOs). ▪ +CityxChange partners, business academia and municipalities. ▪ Local government, universities/research groups.
4	Application and data processing	● Innovation Playground Mapping Tool in D3.3 ● DST dashboard ● Visualisation tools ● Active learning processes (D3.4) ● Citizen participation platform (D3.4) ● City governance systems and participatory processes (D3.1 and D3.2)	● The generic applications employed for community-led open innovation includes systems from D3.1, D3.2, D3.3, and D3.4. These applications are all connected to the DST as seen in Figure A.10.
5	Data space	● Ingredient (Data) ● Data from WP1 (DST) (Open City Data) simulated and real data ● Recorded Data of Process and Activities from the DPEB (Virtual Space/Web)	● Ingredient (data) comprises new or existing data providing an evidence base for the co-creation, monitoring, and evaluation of DPEB innovation lab activities) (D3.3). This data is utilized by the innovation playground mapping tool in D3.3. ● Data from WP1 (DST) and open city data) simulated and real data used to connect to the +CityxChange ICT Eco-system and enabling access to data and visualisation tools. ● Recorded data of process and activities from the DPEB as virtual

			space/web utilized by the citizen participation platform in D3.2.
6	Technologies	• Ingredient (enabling mechanisms) • Software deployed in DPEB innovation labs	• Involves the ingredient that enables mechanisms like the implementation of this framework which put aspects of the DPEB Innovation lab in place as presented in D3.3. • Also, involves software deployed in DPEB innovation labs as well as collaboration tools used for community-led open innovation.
7	Physical infrastructures	• Ingredient (activities) • Ingredient (places)	• Ingredient (activities) can be assembled to create the DPEB innovation lab programme as discussed in D3.3. • Ingredient (places) comprises physical spaces, tools and equipment and virtual locations supporting DPEB innovation lab collaborations as discussed in D3.3. It also comprises DPEB innovation labs in +CityxChange LHCs and FCs and the enhancement of existing centers in the DPED/DPED. These places in +CityxChange LHCs includes; ▪ Dedicated centres for digital innovation within a city. ▪ Enhanced existing centers within a city. ▪ Virtual spaces (A DPEB innovation lab portal or web page). ▪ Small prototyping lab (e.g University of Limerick's (UL) Fab Lab) where (Do-It-Together) RES workshops/projects are designed, piloted and delivered. ▪ The +CityxChange citizen observatory (e.g TK Meeting Places (e.g Warehouse 11 and Lager 11 at Sluppen, Erling Skakkes Gate 14,

			Books & City Lab at Elgeseter, Powerhouse at Brattøra).

Table A.9: Description of community-led open innovation use case

A.10. The IOTA module for Traded Flexibility Energy Marketplace Use case

Use case Summary/Overview

The IOTA module for traded flexibility energy marketplace is a prototype hardware and software solution (named IOTA module) that supports the integration of energy assets (prosumers, producers, and consumers) into an automatically traded flexibility energy marketplace. The IOTA module will allow energy assets to locally measure demand for and offer of energy, and also share this information with the marketplace. Based on the collected assets' information, the marketplace matches energy demand and offer, thus increasing energy flexibility. Once an energy transfer is agreed, by connecting to the IOTA module, the marketplace enables a direct payment between the two involved assets, from consumer to producer. The provided module shall allow to process direct peer-to-peer payments between assets using IOTA digital currency [49].

Case Description

This case defines the IOTA module for traded flexibility energy marketplace, locally deployed at prosumer level, which gathers required marketplace data and shares it using the IOTA ledger. This automatically guarantees data integrity and immutability. The marketplace monitors that the exchange of energy takes place. Once the bid is fulfilled it requests a payment to be sent from the IOTA asset module connected to the consuming asset towards the producing asset. For the assets connected using the provided module, the marketplace can also request payments in IOTA tokens directly from asset to asset. Payment requests between assets are shared using the IOTA ledger to ensure auditability [49]. The use case for the IOTA module for traded flexibility energy marketplace is based on D2.7.

The IOTA module for traded flexibility energy marketplace use case modelled in the EAF is shown in Figure A.11 and a description of the use case is shown in Table A.10.

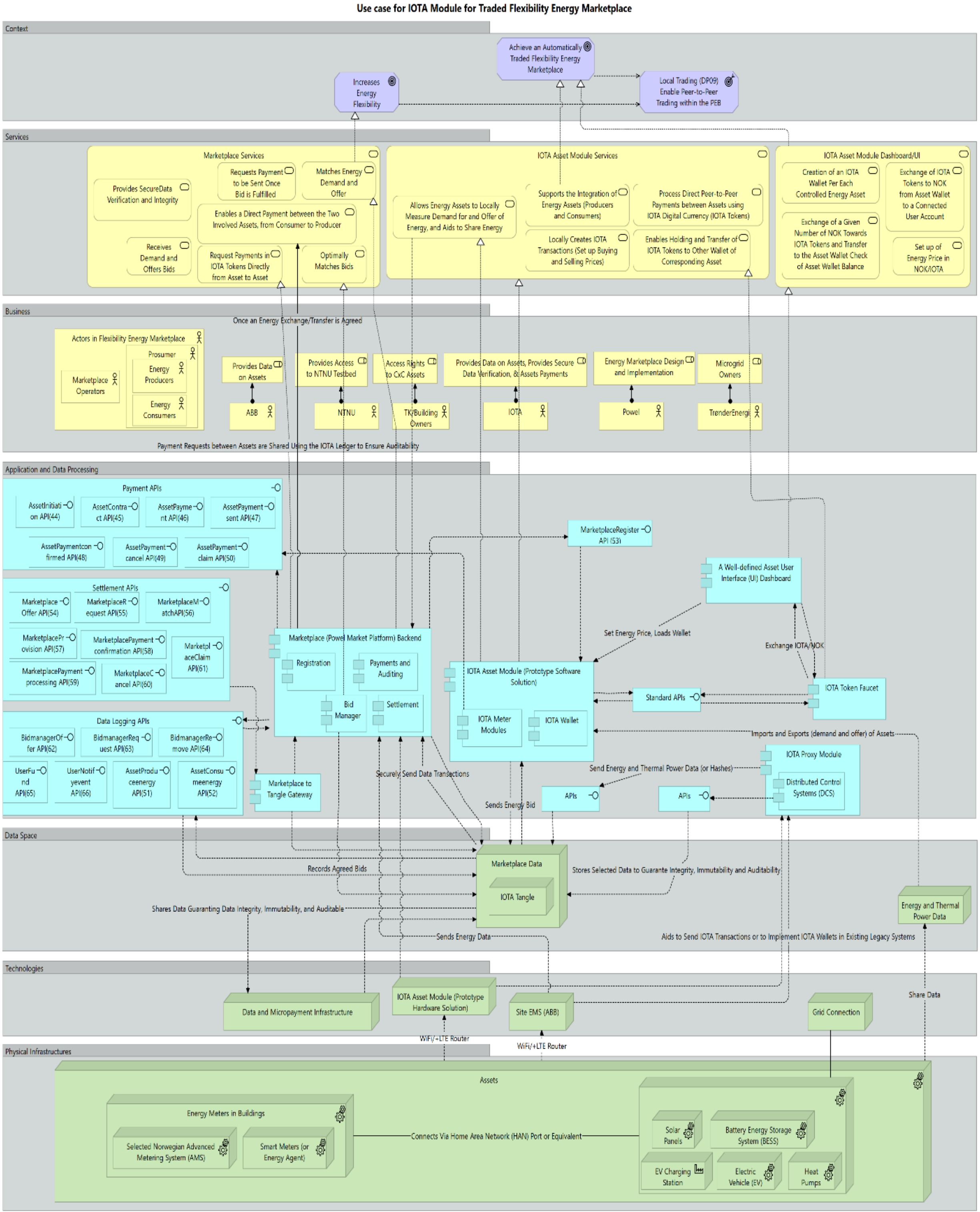

Fig. A.11: Use case for IOTA module for traded flexibility energy marketplace

No	EA Layer	Components	Description
1	Context	• Increases energy flexibility • Achieve an automatically traded flexibility energy marketplace • Local trading (DP09) enable peer-to-peer trading within the PEB	• This layer captures the how the "Local trading (DP09)" is achieved in the marketplace to support matches bids in the optimal way and communicates the decision to the involved IOTA asset modules.
2	Service	• Marketplace services • IOTA asset module services • IOTA asset module dashboard/UI	• The marketplace services entails: ▪ Providing secure data verification and integrity. ▪ Receiving demand and offers bids. ▪ Requests payment to be sent once bid is fulfilled. ▪ Matching energy demand and offer ▪ Enabling a direct payment between the two involved assets, from consumer to producer. ▪ Requesting payments in IOTA tokens directly from asset to asset. ▪ Optimally matching bids. • The IOTA asset module services comprise of: ▪ Allowing energy assets to locally measure demand for and offer of energy, and aids to share energy. ▪ Supporting the integration of energy assets (producers and consumers). ▪ Locally creating IOTA transactions (set up buying and selling prices). ▪ Processing direct peer-to-peer payments between assets using IOTA digital currency (IOTA tokens).

			▪ Enabling holding and transfer of IOTA tokens to other wallet of corresponding asset. ● IOTA asset module dashboard/UI. ● Creation of an IOTA wallet per each controlled energy asset. ▪ Exchange of IOTA tokens to NOK from asset wallet to a connected user account. ▪ Exchange of a given number of NOK towards IOTA tokens and transfer to the asset wallet check of asset wallet balance. ▪ Set up of energy price in NOK/IOTA.
3	Business	● Actors in flexibility energy marketplace ● ABB ● NTNU ● TK/building owners ● IOTA ● Powel ● TrønderEnergi	● Actors in flexibility energy marketplace comprises; ▪ Marketplace operators ▪ Prosumer o Energy producers o Energy consumers ● ABB provides data on assets. ● NTNU provides access to NTNU testbed. ● TK/building owners provides access. rights to +CityxChange assets. ● IOTA provides data on assets, provides secure data verification, & assets payments. ● Powel provides energy marketplace design and implementation. ● TrønderEnergi are the microgrid owners.
4	Application and data processing	● Marketplace (Powel market platform) backend ● Marketplace to tangle gateway ● IOTA asset module (prototype software solution)	● The marketplace enables a direct payment between the two involved assets, from consumer to producer. The provided module shall allow to process direct peer-to-peer payments between assets using IOTA digital currency. The marketplace can also request payments in IOTA tokens directly from asset to asset. The

		● A well-defined asset User Interface (UI) dashboard ● IOTA token faucet ● IOTA proxy module	marketplace business logic is being developed by POWEL and it comprises; ▪ Registration ▪ Payments and auditing ▪ Bid manager ▪ Settlement ● The IOTA asset module allows the connected device to measure the requested and produced energy. The IOTA asset module also features an IOTA wallet to process asset to asset payments. Also, IOTA asset module comprises hardware and software design for integrating modules into Powel flexibility energy trading marketplace and direct IOTA/NOK conversion, finalized, costed, and signed off internally. It comprises; ▪ IOTA meter modules ▪ IOTA wallet ● Marketplace to tangle gateway connects to the marketplace (Powel market platform) backend and marketplace data (IOTA tangle). ● A well-defined asset UI dashboard connects to the IOTA token faucet. ● IOTA token faucet connects to the IOTA asset module and the asset UI dashboard. ● IOTA proxy module sends energy and thermal power data to the marketplace database. ● Distributed Control Systems (DCS) sends and stores selected data to guarantee integrity, immutability, and auditability to marketplace data.
5	Data space	● Marketplace data ● Energy and thermal power data	● The marketplace data (IOTA tangle) gets data from different APIs as seen in Figure A.11. Each APIs shown in Figure A.11 are well discussed in D1.3 deliverable [39]. The marketplace data

			also records agreed bids data to the Bid Manager, sends securely send data transactions to marketplace backend. Additionally, the Bid Manager sends energy bid to IOTA asset module. ● Energy and thermal power data receive data from the energy assets and sends the data to IOTA asset module via importing and exporting demand and offer of assets.
6	Technologies	● Data and micropayment infrastructure ● IOTA asset module ● Site EMS (ABB) ● Grid connection	● The data and micropayment infrastructure receive and sends shares data guaranting data integrity, immutability, and auditable to marketplace database. ● IOTA asset module is the prototype hardware solution which connects to the assets in the infrastructure layer via WiFi/+LTE Router. It also sends data to the marketplace backend and IOTA proxy module. ● The Site EMS send IOTA transactions or to implement IOTA wallets in existing legacy systems to the IOTA proxy module. It also sends energy data to the marketplace backend. ● Lastly, the grid connection is connected to the energy assets in the DPEB/DPED.
7	Physical infrastructures	● Assets ▪ Energy meters in buildings ▪ Energy assets	Energy meters in buildings are connected to the energy assets via Home Area Network (HAN) port or equivalent. ● Also, the energy meters in buildings comprises Selected Norwegian Advanced Metering System (AMS) and Smart Meters (or Energy Agent) ● Whereas energy assets comprise of solar panels, Battery Energy Storage System (BESS), EV charging station, EV, and heat pumps in the DPEB/DPED.

Table A.10: Description of IOTA module for traded flexibility energy marketplace use case

The IOTA module for traded flexibility energy marketplace employs different APIs clustered as (e.g Payment APIs (API44-API50), Settlement APIs (API54-AP61), Data Logging APIs (API51, AP52, API62-API66), MarketplaceRegister API (53), etc.). Do refer to D1.3 deliverable (D1.3-Report and catalogue on the ICT data integration and interoperability) [39], for description of APIs.
Additionally, data governance and security is achieved in this use case where data is store onto the IOTA Tangle, thus guaranteeing integrity, immutability and auditability. Additionally, a unique digital identity is received by the Marketplace backend to verify the authenticity of shared data. The Bid Manager uses agreed and standardized data model and simple matching policy for bid management [49].

A.11. Local DPEB Trading Market Demonstration Tool Use case

Use case Summary/Overview

This use case is for the local DPEB trading market demonstration tool (trade operation software) which will use all collected and managed data from the DPEB connected points like the local grid, local energy resources (PV, heat, chargers, demand response, storage etc.), consumption and other commodities to create a local market for energy and flexibility [49].The tool aims to represent all data points as individual market participants with their typical cost/value for each time step with a granularity of one hour or less.
The DPEB trading market will be operated continuously based on automatic routines and rules developed for the DPEB and the actual Community Grid [49].
The tool leverages data available from the balancing and optimization strategies of T2.1 [29], and the eMaaS platform and charging technologies in D2.5 (see section A.1) [43].

Case Description

This case defines the local DPEB trading market demonstration tool which is based on the IOTA ecosystem (IOTA module), and further developed into an actual local market. It aims to enable secure data transfer and zero fee micropayments between connected and traded resources [49]. It is set up in terms of machine to machine transactions with compatible agents/IoT devices and players inside the DPEB for demonstration of local trade, e.g. trades between buildings and EVs or other future IoT connected devices. Trade services are integrated with the ecosystem and made available for the DPEB as overview of settled trade and cost/benefit for the involved resources. The solution also includes the possibility to trade between DPEBs [49]. The use case for the local DPEB trading market demonstration tool is based on D2.7.

The current version of the local DPEB trading market demonstration tool use case modelled in the EAF at the time of writing of this report in M24 of the +CityxChange project is shown in Figure A.12 and a description of the use case is shown in Table A.11.

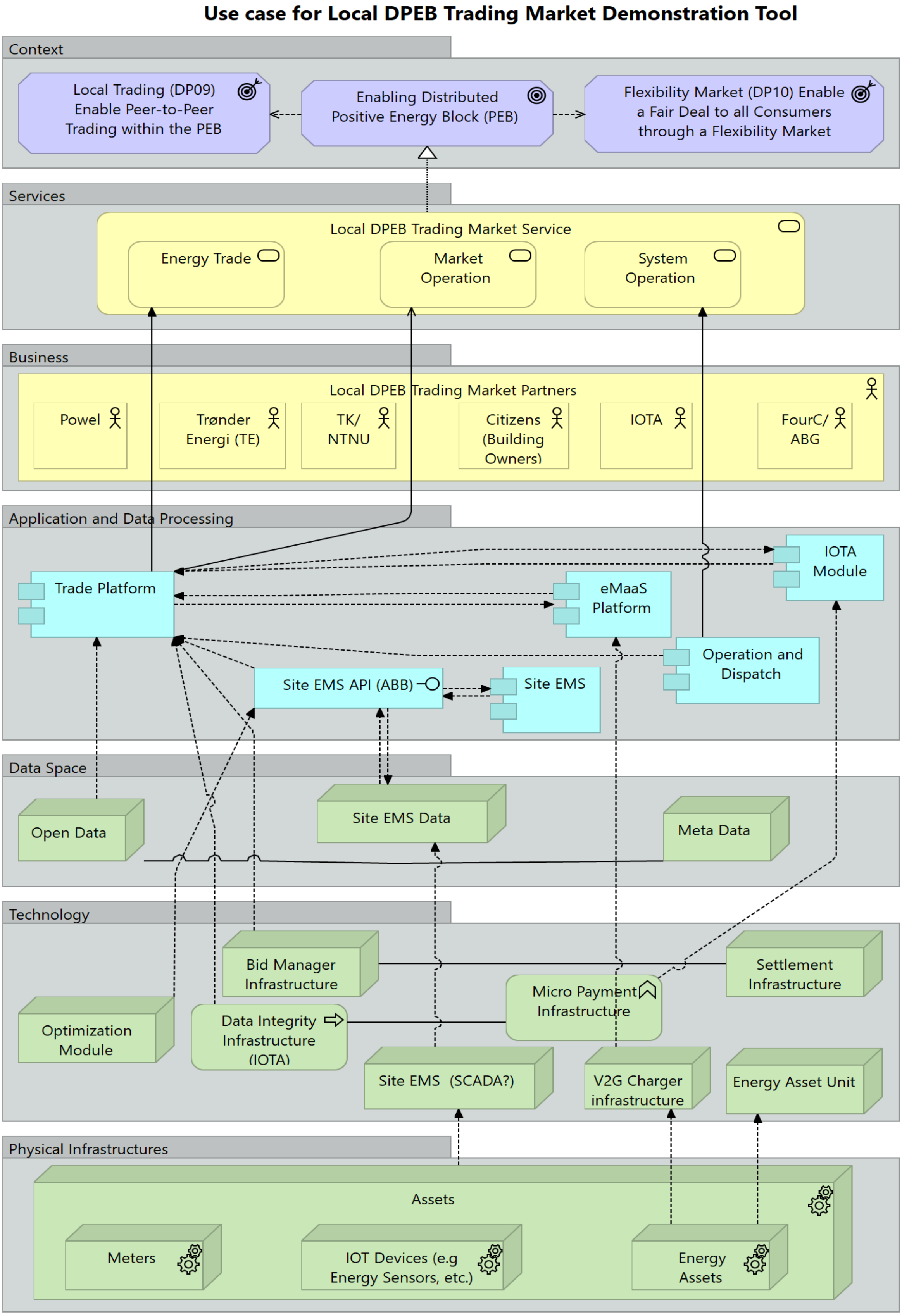

Fig. A.12: Use case for local DPEB trading market demonstration tool

No	EA Layer	Components	Description
1	Context	• Enabling Distributed Positive Energy Block (PEB) • Local trading (DP09) • Flexibility market (DP10)	• Aims to enabling Distributed Positive Energy Block (PEB) in achieving "local trading (DP09)" enable peer-to-peer trading within the PEB and "flexibility market (DP10)" enable a fair deal to all consumers through a flexibility market
2	Service	• Local DPEB trading market service	• The local DPEB trading market service comprises energy trade, market operation, and system operation.
3	Business	• Powel • Trønder Energi (TE) • TK/NTNU • Citizens • IOTA • FourC/ABG	• Powel develop the interface for the trading platform. • TE is the microgrid owners and regulators. • NTNU/TK supports with respect to pricing structures and mechanisms. • Citizens are prosumer as well as building owners. • IOTA provides DLT and micro-payment crypto-currency infrastructure. • FourC and ABG ensure that the trade platform connects with the eMaaS platform and V2G technologies.
4	Application and data processing	• Trade platform • Site EMS • eMaaS platform • Operation and dispatch • IOTA module	This layer captures all the applications that works together for the deployment of the local DPEB trading market demonstration tool such as the IOTA module for traded flexibility energy marketplace use case; see section A.10, D2.7 [49]. Besides, other application that connects to the trade platform comprises the Site EMS (see section A.12) provided by ABB that provide data on energy assets in the DPEB, eMaaS platform (see section A.1) that provide state of EVs. This layer also involves the operation and dispatch application that support energy trading.

5	Data space	• Open data • Site EMS data • Meta data	• Used by the trading platform to carryout energy trading in the DPEB. Data is gotten from the Site EMS data via API as discussed in D1.3, and from other sources (open data sources, meta data) as seen in section A.7 (Powel Tool) [45].
6	Technologies	• Optimization module • Bid manager infrastructure • Data integrity infrastructure (IOTA) • Site EMS (SCADA?) • Micro payment Infrastructure • V2G charger infrastructure • Settlement infrastructure • Energy asset unit	• Optimization module supports energy optimization and send data to Site EMS via the Site EMS API. • Bid manager infrastructure aids in energy bidding in the energy marketplace as discussed in section A.10. • Data integrity infrastructure (IOTA) aims to ensure sharing of data, guaranting data integrity, immutability, and auditable as discussed in section A.10. • Bid manager. • Site EMS (SCADA) connects to assets and sends data of the state of energy assets to site EMS database. • Micro payment infrastructure supports micro payment and is managed by the IOTA module. • V2G charger infrastructure provides data to FourC eMobility platform on the state of the EV batteries. • Settlement infrastructure connects to the bid manger infrastructure to process bid payment for energy. • Energy asset unit is the technologies that manages the assets deployed in the DPEB involves in local trading.
7	Physical infrastructures	• Assets	• The assets require in the DPEB for trading market comprises meters, IOT devices, (e.g energy sensors, etc.), and energy assets as discussed in section A.10.

Table A.11: Description of local DPEB trading market demonstration tool use case

The different APIs deployed in the local DPEB trading market demonstration tool use case as seen in Figure A.12 (Site EMS API by ABB), is described in D1.3 deliverable [39].

A.12. Continuous Intraday Trading: Integration Between Project Partners Use case

Use case Summary/Overview

This use case is continuous intraday trading (integration between project partners) as designed by ABB. It aims to support local energy market that includes flexible local energy resources which comprises PV, charges, batteries, heat, flexible load, and others. The continuous intraday trading support how to operate a community grid and local energy system with the actual available energy resources including flexible consumption. The integration between project partners is aligned with the deployment of the Energy Trading Market (T5.9) and the Local Flexibility Market (T5.10) which also involves equipment installations and integration, deployed in the Brattøra DPEB in Trondheim, upon Brattøra becoming energy positive in M30 of the +CityxChange project. The continuous intraday trading use case comprises the ABB Ability platform, Microgrid+ and the EV platform which ensures the integration with buildings in the DPEB.

Case Description

This case models how ABB ensure connection of all data from and to ABB ability necessary for an operational local trading market in DPEB. Also, the continuous intraday trading by ABB ensures the cloud solution can connect to available off-the-shelf as well as new and emerging technologies coming in the near future. This is achieved by ABB in installing microgrid and building controllers to support small-scale testing. The integration involves the installation of EV chargers ensuring and securing the V2B/V2G connections and connect them to the cloud solution in providing DPEB connections. Thus, this facilitates the creation of the DPEBs in Trondheim through technology integration, testing of new systems for the energy system and creation of new products and services for emerging markets. The use case for the continuous intraday trading is a part of D2.7 and D5.5.

The continuous intraday trading (integration between project partners) use case modelled in the EAF is shown in Figure A.13 and a description of the use case is shown in Table A.12.

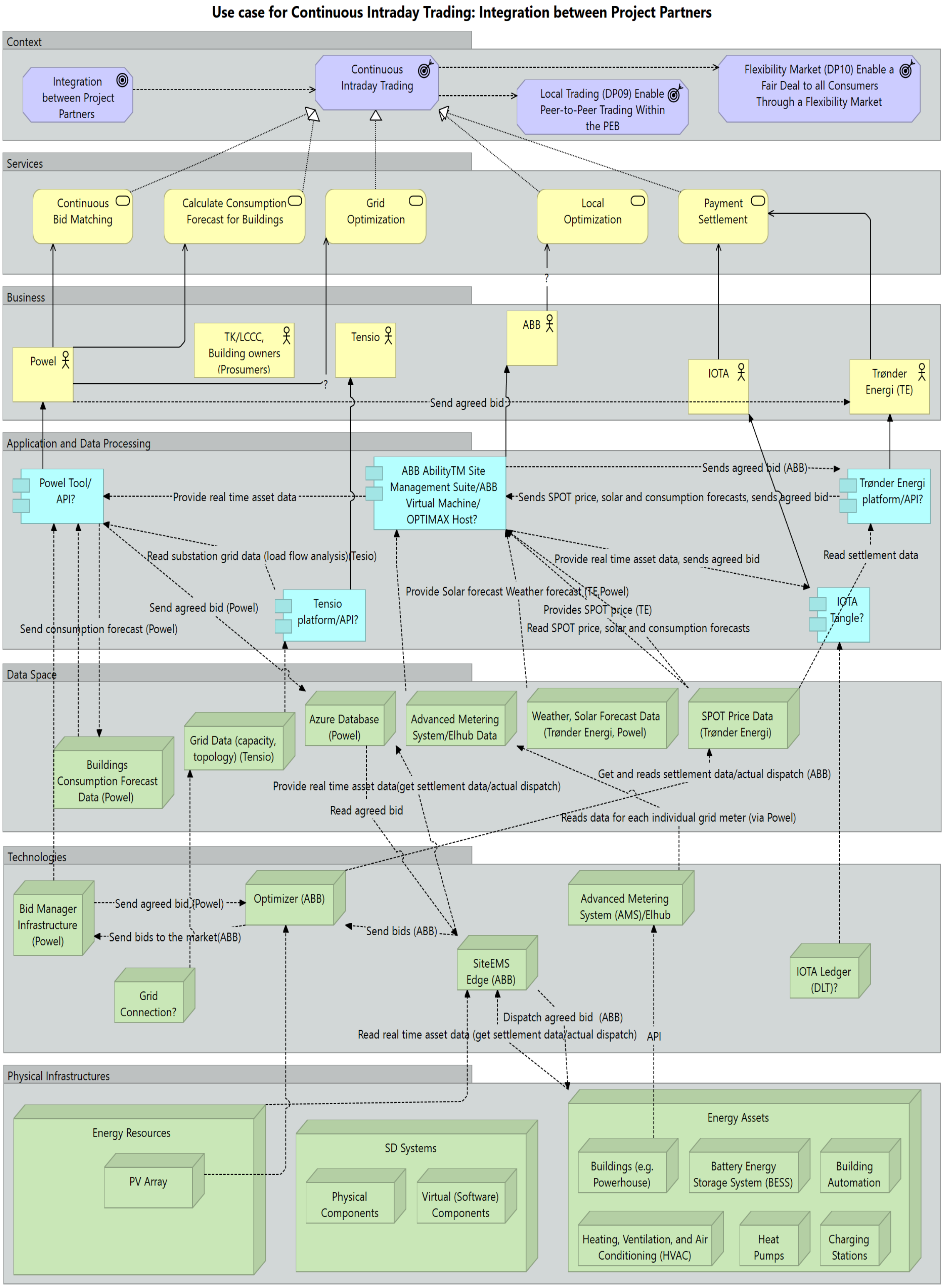

Fig. A.13: Use case for continuous intraday trading (integration between project partners)

No	EA Layer	Components	Description
1	Context	● Integration between project partners ● Continuous intraday trading ● Local trading (DP09) Flexibility market (DP10)	● The context aims to achieve integration between project partners for continuous intraday trading. This will contribute towards "local trading (DP09)" to enable peer-to-peer trading within the PEB as well as "flexibility market (DP10)" to enable a fair deal to all consumers through a flexibility market.
2	Services	● Continuous bid matching ● Calculate consumption forecast for buildings ● Grid optimization ● Local optimization ● Payment settlement	● These services are provided by partners that collaborate to ensure integration between project partners for continuous intraday trading.
3	Business	● Powel ● TK/LCCC, building owners ● Tensio ● ABB ● IOTA ● Trønder Energi (TE)	● Powel provides the trade platform as discussed in section A.11, Local DPEB Trading Market Demonstration Tool. Powel also provide continuous bid matching via the bid manager (see section A.10. The IOTA module for Traded Flexibility Energy Marketplace), calculate consumption forecast for buildings and provides grid optimization (see section A.7, Powel Tools) ● TK/LCCC, building owners are the prosumers in the DPEB. ● Tensio read substation grid data and load flow analysis and sends data to Powel tool. ● ABB provides ABB AbilityTM Site Management Suite enable integration.

			• IOTA supports Payment Settlement via DLT as discussed in section A.10 "The IOTA module for Traded Flexibility Energy Marketplace". • TE Sends SPOT price, solar and consumption forecasts, sends agreed bid to ABB AbilityTM Site Management Suite and receive agreed bid from ABB.
4	Application and data processing	• Powel Tool/API • Tensio platform/API • ABB AbilityTM Site Management Suite • IOTA Tangle • Trønder Energi platform/API	• Powel Tool provided connection to ABB via an API to receive real time asset data. Also, send agreed bid to Azure Database (owned by Powel). • Tensio platform via an API Read substation grid data (load flow analysis) to Powel Tool and connects to Grid (capacity, topology) database. • ABB AbilityTM Site Management Suite provide real time asset data, sends agreed bid to IOTA tangle. Also, provide solar forecast weather forecast from TE, Powel, SPOT price from TE. Lastly, read SPOT price, solar and consumption forecasts data are also provided. • IOTA Tangle read settlement data and ensures payment settlement is carried out. • Trønder Energi platform via an API sends SPOT price, solar and consumption forecasts, sends agreed bid to ABB, read settlement data, and sends agreed bid with ABB.
5	Data space	• Buildings consumption forecast data • Grid data • Azure database • Advanced metering system/Elhub data	• Buildings consumption forecast data is used by Powel to get and send consumption forecast to Powel tool. • Grid Data capacity, topology is used by Tensio to get information on building in the DPEB connected to the grid.

		• Weather, solar forecast data • SPOT price data	• Azure database is used by Powel to Read agreed bid from the Site EMS deployed by ABB. • Advanced Metering System/Elhub Data provide data on Advanced Metering System (AMS)/Elhub based on energy consumption of building are deployed in the DPEB. Thus, reading data for each individual grid meter (via Powel). • Weather, solar forecast data is provided by Trønder Energi, and Powel to send solar forecast weather forecast to ABB AbilityTM Site Management Suite. • SPOT price data are provided by TE to read SPOT price, solar and consumption forecasts and also provides SPOT price to TE.
6	Technologies	• Bid Manager infrastructure • Grid connection • Optimizer • SiteEMS Edge • Advanced Metering System (AMS)/Elhub • IOTA ledger (DLT)	• Bid manager infrastructure is provided by Powel as described in section A.10 “The IOTA module for Traded Flexibility Energy Marketplace” which mostly manages energy bids and sends bids to Powel Tool via an API. Besides, bid manager infrastructure send agreed bid to optimizer by ABB. • Grid connection provides grid data on capacity, topology. • Optimizer (ABB) send bids to the marketplace via the bid manager infrastructure. It also gets and reads settlement data/actual dispatch to SPOT price data to be used by TE. • SiteEMS Edge deployed by ABB dispatch agreed bid to energy assets. It also provides real time asset data, get settlement data/actual dispatch to Azure Database used by Powel Tool. • AMS/Elhub receives data from buildings (e.g. Powerhouse) via an API and also reads data for each individual

			grid meter (via Powel) to be sent to the AMS/Elhub database. ● IOTA Ledger (DLT) shares data guaranting data integrity, immutability, and auditable.
7	Physical infrastructures	● Energy resources ● SD systems ● Energy assets	● Energy resources includes PV array. ● SD systems comprises physical components and virtual (software) components. ● Energy assets comprises buildings (e.g. powerhouse), Battery Energy Storage System (BESS), building automation, heating, Ventilation, and Air Conditioning (HVAC), heat pumps, and charging stations. ● The PV Array sends data to the optimizer and the energy resources sends data to the SiteEMS Edge. ● Also, energy assets read real time asset data (get settlement data/actual dispatch) to SiteEMS Edge.

Table A.12: Description of continuous intraday trading (integration between project partners) use case

All APIs deployed in the continuous intraday trading (integration between project partners) use case by ABB and other +CityxChange partners as seen in Figure A.13 are described in D1.3 deliverable [39].

A.13. Optimization Model (Microgrid Balancing and Optimization) Use case

Use case Summary/Overview

This use case involves the development of a top-level analysis and optimization model for the campus microgrid, with the ambition to develop the Gløshaugen campus NTNU area towards becoming a DPEB. The optimization model gives +CityxChange partner (NTNU) the opportunity to optimize energy related costs and/or environmental footprint, by smart control of energy use, exchange, production, and storage. The optimization model connects to live data sources for the regional energy

market, including forecast supply mix in the local bidding area, as well as price forecasts.

Case Description

The optimization model provides energy demand forecasting model in combination with live forecasting of future energy supply mix and prices, and allow for evaluation and optimization of storage solutions, different integration projects, refurbishments etc. with estimates for cost and environmental performance. The optimization model is demonstrated for use in long-term planning and project evaluation to demonstrate and customize energy forecasting model in building level, integration with live data sources (meteorological forecasts, calendar data, energy market data), model set-up for demonstrating PEB technologies and operation and evaluation. The use case for the optimization model is a part of D5.3.

The optimization model (microgrid balancing and optimization) use case modelled in the EAF is shown in Figure A.14 and a description of the use case is shown in Table A.13.

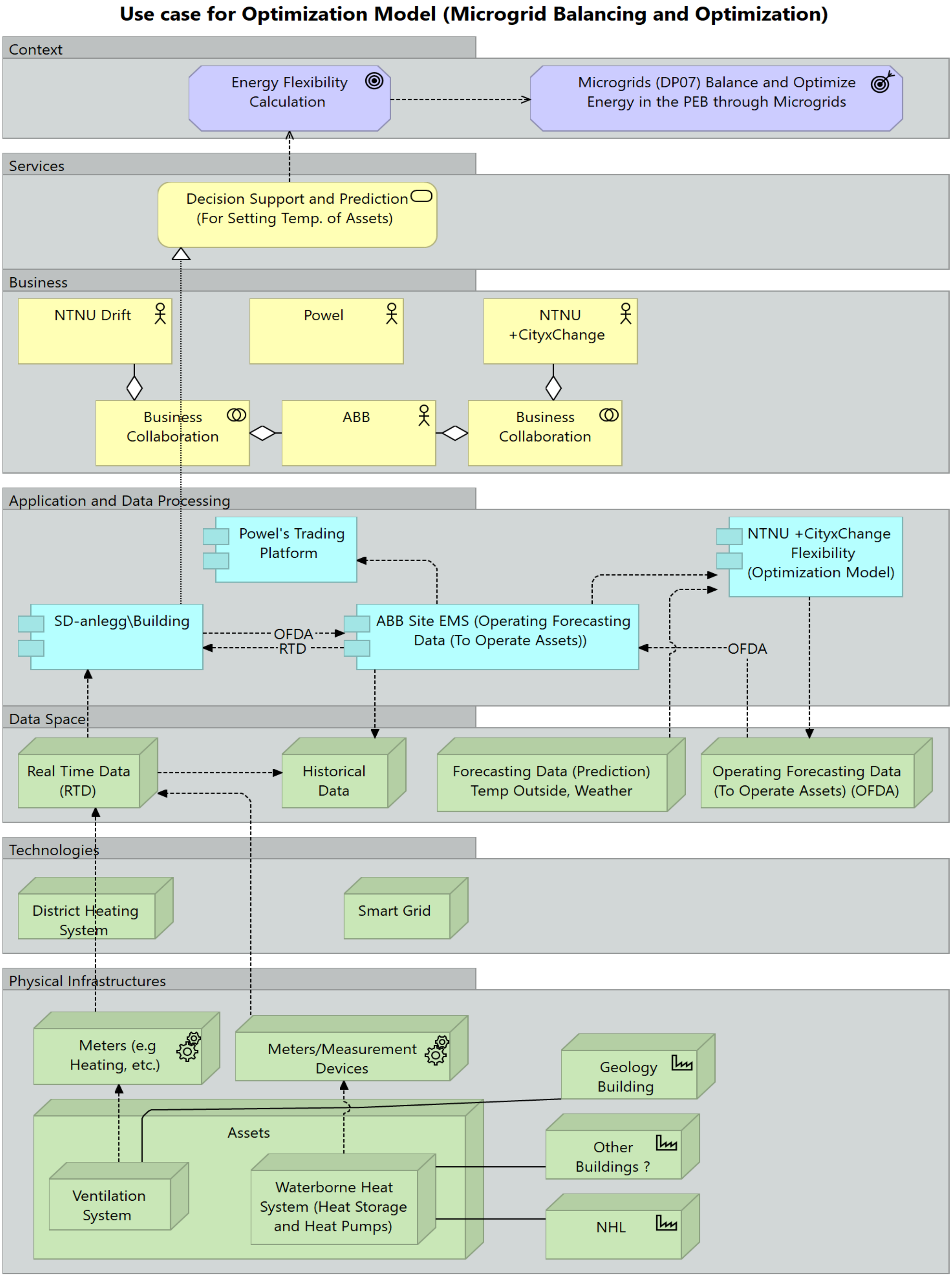

Fig. A.14: Use case for optimization model (microgrid balancing and optimization)

No	EA Layer	Components	Description
1	Context	• Energy flexibility calculation • Microgrids (DP07)	• The developed optimization model for microgrid balancing and optimization aims to support energy flexibility calculation towards "Microgrids (DP07)".
2	Services	• Decision support and prediction	• Decision support and prediction for setting temperature of assets in buildings within the DPEB.
3	Business	• NTNU Drift • TK • Powel • ABB • NTNU +CityxChange • TE/Statkraft Varme AS (SV)	• NTNU Drift manages NTNU assets energy use for ventilation system, heat storage and heat pumps. Thus, NTNU is the building and microgrid provider and will also develop the microgrid analysis and optimization model. • TK will support knowledge transfer to Brattøra and Sluppen in Trondheim. • Powel provide input to analyze and optimize the microgrid linked to the trading. Also, Powel provides the trading platform. • ABB will install microgrid and building controllers to support small-scale testing. Also, ABB supports integration of systems. • NTNU +CityxChange deploys the optimization model. • TE and SV make up the connection to outside local energy markets and participate in the exploration/testing.
4	Application and data processing	• SD-anlegg\building • Powel's trading Platform • ABB Site EMS • NTNU +CityxChange flexibility	• SD-anlegg\building is the system controller installed that manages energy usage in the building. • Powel's trading platform manages energy trading within the DPEB as

			discussed in Section A.11, “Local DPEB Trading Market Demonstration Tool”. ● ABB Site EMS for operating forecasting data to operate assets in the DPEB as discussed in Section A.12 “Continuous Intraday Trading: Integration Between Project Partners”. ● NTNU +CityxChange flexibility optimization model provides microgrid balancing and optimization.
5	Data space	● Real Time Data (RTD) ● Historical data ● Forecasting data ● Operating Forecasting data (To Operate Assets) (OFDA)	● RTD is produced from meters (e.g heating, etc., and meters/measurement. ● Historical data refers to prior generated real data used for prediction. Historical data is also provided from ABB Site EMS. ● Forecasting data are data use for prediction. It is mostly based on the temp outside, weather. The forecasting data is used by the NTNU +CityxChange flexibility optimization model. ● OFDA is produced by NTNU +CityxChange flexibility optimization model and utilized by ABB Site EMS to operate assets.
6	Technologies	● District heating system ● Smart grid	● District heating system is the infrastructure deployed to manage heating of building within the DPEB. ● Smart grid manages the consumption and generation of energy within the DPEB.
7	Physical infrastructures	● Meters (e.g heating, etc.) ● Meters/measurement devices ● Assets (ventilation System, waterborne heat system (heat	● Meters (e.g Heating, etc.) produces data. ● Meters/measurement devices records produced data. ● Assets (ventilation system, waterborne heat system (heat storage and heat pumps).

		storage and heat pumps). ● Geology building ● Other buildings ● NHL	● Buildings included in the optimization model comprises Geology building, NHL, and other buildings. ● The Geology building has a ventilation system which is connected to meters (e.g which measures heating, etc.). ● Whereas NHL and other buildings have waterborne heat system for heat storage and heat pumps which are connected to meters/measurement devices.

Table A.13: Description of optimization model (microgrid balancing and optimization) use case

A.14. (Integrated) Booking System for Space Use case

Use case Summary/Overview

This use case involves the booking system for events in open city spaces in Trondheim municipality to create an innovation playground within each DPEB. This will create both a virtual and physical space that will engage communities within the DPEB and enable innovation to happen through an Innovation 2.0 framework. Through DP05, companies will be able to show case innovative solutions, create case studies of success and accelerate this innovation to market.

Case Description

The booking system provide an application where virtual and physical events can be booked for citizens and local business to try out their own ideas and help co-create the future, they want to live in.
The event (playground) will be used by the municipal authorities, energy providers, business environment, and citizens to connect, test and prototype innovative ideas to allow a movement towards Positive Energy Districts at scale across the city. The event (playground) will also be used to consult with citizens any potential new innovations, which will be piloted as part of the special regulatory zone, to ensure citizens are engaged and willing to accept these trial period solutions for a short period of time.
The use case for the (Integrated) booking system for space is a part of D5.8.

The (Integrated) booking system for space use case modelled in the EAF is shown in Figure A.15 and a description of the use case is shown in Table A.14.

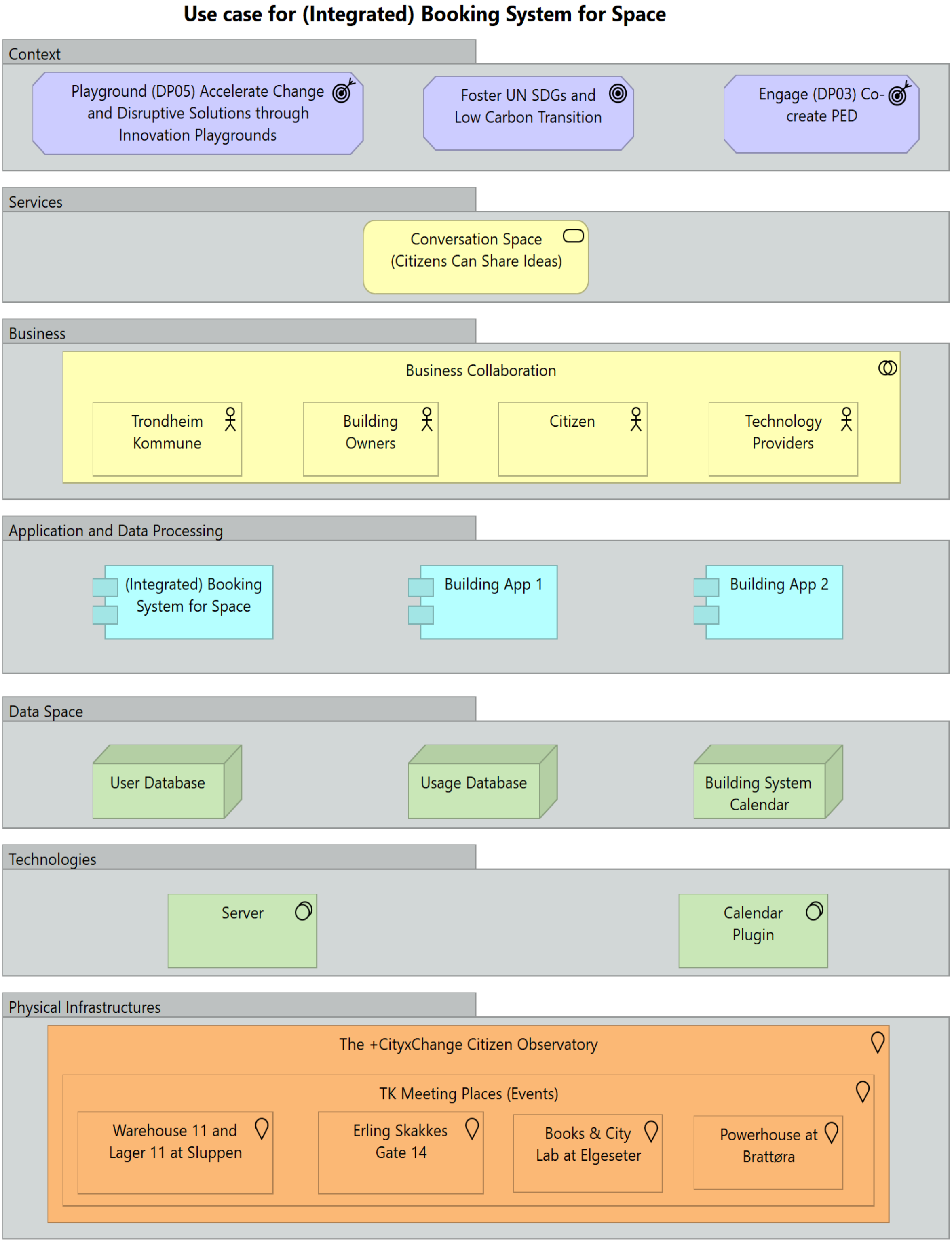

Fig. A.15: Use case for (Integrated) booking system for space

No	EA Layer	Components	Description
1	Context	• Foster United Nations Sustainable Development Goals (UN SDGs) and low carbon transition • Playground (DP05) • Engage (DP03)	• Aims to foster UN SDGs and low carbon transition towards attaining "Playground (DP05)" accelerate change and disruptive solutions through innovation playgrounds and "Engage (DP03)" co-create PED.
2	Services	• Conversation space	• Conversation space where citizens can share ideas.
3	Business	• Trondheim Kommune • Building owners • Citizen • Technology providers	• These are all the stakeholders that involved in the event where innovation takes place.
4	Application and data processing	• (Integrated) Booking System for Space • Building App 1 & 2	• Involves the applications used in each of the event location to book space for innovation.
5	Data space	• User database • Usage database • Building system calendar	• Includes the user database of citizens and stakeholders involved in the innovation. • Usage database saves data on the usage of the booking application • Building system calendar shows information of events booked and spaces or location where the innovation will take place.
6	Technologies	• Server • Calendar plugin	• Incudes the Booking System web server as well as the calendar plugin used by the booking system.
7	Physical infrastructures	• The +CityxChange citizen observatory	• Comprises TK meeting places (events) where innovation takes place (e.g Warehouse 11 and Lager 11 at Sluppen, Erling Skakkes Gate 14,

			Books & City Lab at Elgeseter, Powerhouse at Brattøra).

Table A.14: Description of (Integrated) booking system for space use case

A.15. Citizen Power Platform (DECIDIM (Playable Trondheim) Use case

Use case Summary/Overview

This use case aims to support the acceleration of becoming a positive energy city, as such demonstration of the citizen observatory is implemented as a digital platform "(DECIDIM (Playable Trondheim)" for increased citizen understanding, ownership and active participation including interactive mapping that will be put in place. The (DECIDIM (Playable Trondheim) platforms also exploit the information and data from the baseline model and monitoring and evaluation data from the project.

Case Description

This case involves the citizen observatory demos include a digital platform ("Playable Trondheim") for increased citizen understanding, ownership and active participation including interactive mapping that enables a 2-way dialogue regarding the aims, goals, motivations and ambitions of the communities with the urban authorities. This case describes the implementation of (DECIDIM (Playable Trondheim) for Citizen Observatories located at and linked to the DPEBs in four sites in Trondheim (e.g Warehouse 11 and Lager 11 at Sluppen, Erling Skakkes Gate 14, Books & City Lab at Elgeseter, Powerhouse at Brattøra) as captured in Figure A.16. The use case for Citizen power platform (DECIDIM (Playable Trondheim) is a part of D5.8.

The Citizen power platform (DECIDIM (Playable Trondheim) use case modelled in the EAF is shown in Figure A.16 and a description of the use case is shown in Table A.15.

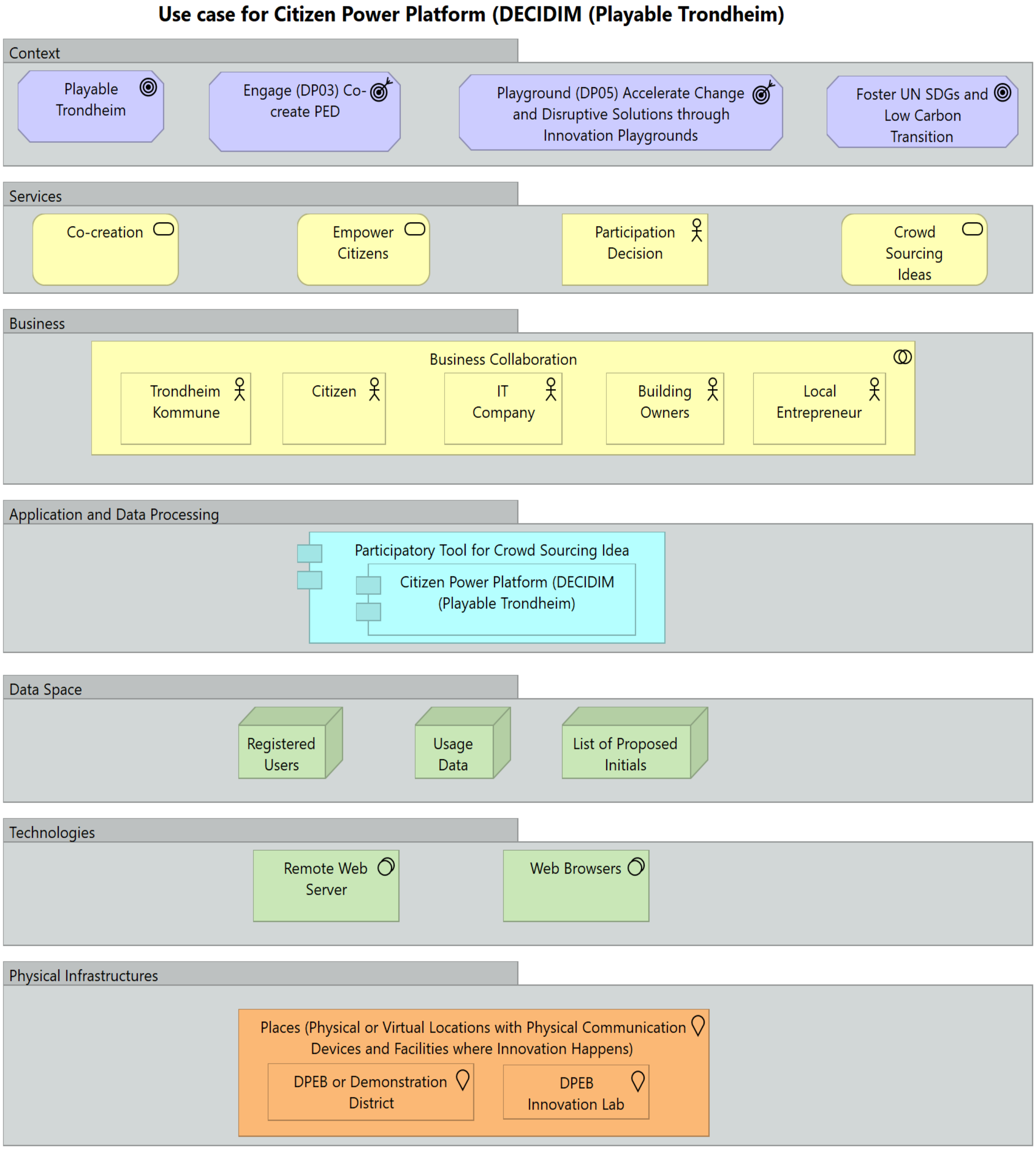

Fig. A.16: Use case for citizen power platform (DECIDIM (Playable Trondheim)

No	EA Layer	Components	Description
1	Context	• Playable Trondheim • Foster UN SDGs and low carbon transition • Engage (DP03) Co-create PED • Playground (DP05) Accelerate change and disruptive solutions through innovation playgrounds	• The context aims to achieve Playable Trondheim to foster UN SDGs and low carbon transition towards "Engage (DP03)" co-create PED and "Playground (DP05)" accelerate change and disruptive solutions through innovation playgrounds.
2	Services	• Co-creation • Empower citizens • Participation decision • Crowd sourcing ideas	• The services provided by the participatory tool for crowd sourcing idea for citizen power platform (DECIDIM (Playable Trondheim)).
3	Business	• Trondheim Kommune • Citizen • IT Company • Building Owners • Local Entrepreneur	• The business layer comprises the business collaboration of all stakeholders involved in the +CityxChange citizen observatory.
4	Application and data processing	• Participatory tool for crowd sourcing idea	• The application comprises participatory tool for crowd sourcing Idea which is citizen power platform (DECIDIM (Playable Trondheim)).
5	Data space	• Registered users • Usage data • List of proposed initials	• The databases utilize by DECIDIM (Playable Trondheim) in providing co-creation, empower citizens, participation decision, and crowd sourcing ideas.

6	Technologies	• Remote web server • Web browsers	• Involves the remote web server and web browsers utilized by the DECIDIM (Playable Trondheim).
7	Physical infrastructures	• Places	• The places comprise of physical or virtual locations with physical communication devices and facilities where innovation happens. It includes DPEB or demonstration district and DPEB innovation lab.

Table A.15: Description of citizen power platform (DECIDIM (Playable Trondheim) use case

A.16. Integrated Investment Model

Use case Summary/Overview

This use case entails a new business and investment models and concepts to create and operate Distributed Positive Energy Blocks (PEBs), with the objective of optimizing the bankability of the required investments [50].
This case represents the foundation for the further development and implementation of business and investment models, in the Lighthouse cities Limerick (WP4) and Trondheim (WP5) initially and in follower cities afterwards (WP6). The conceptualization and development in this case is used as a starting point for business-related "Scaling-up, Replication and Exploitation" of the +CityxChange solutions (WP8).

Case Description

This case proposed as "integrated investment model", aims to support +CityxChange in getting access to the necessary funding and financing sources, being them private capital or public funds; customized financing mix and bespoke investment models can be extrapolated from the integrated model. Thus, designing sub-models the meet the peculiarities of the different sub-projects as well as national and local scenarios. In each city involved in the +CityxChange project, local and global stakeholders together with new potential players in the local market are expected to share investments and financial risks, in a common effort towards the energy transition to a low-carbon future, considering sustainability aspects and their adaptation to different socio-economic contexts. The model from this case support market players in developing and adopting financial solutions to invest in energy infrastructure facilities and services.
The use case for integrated investment model is a part of D2.4.

The integrated investment model use case modelled in the EAF is shown in Figure A.17 and a description of the use case is shown in Table A.16.

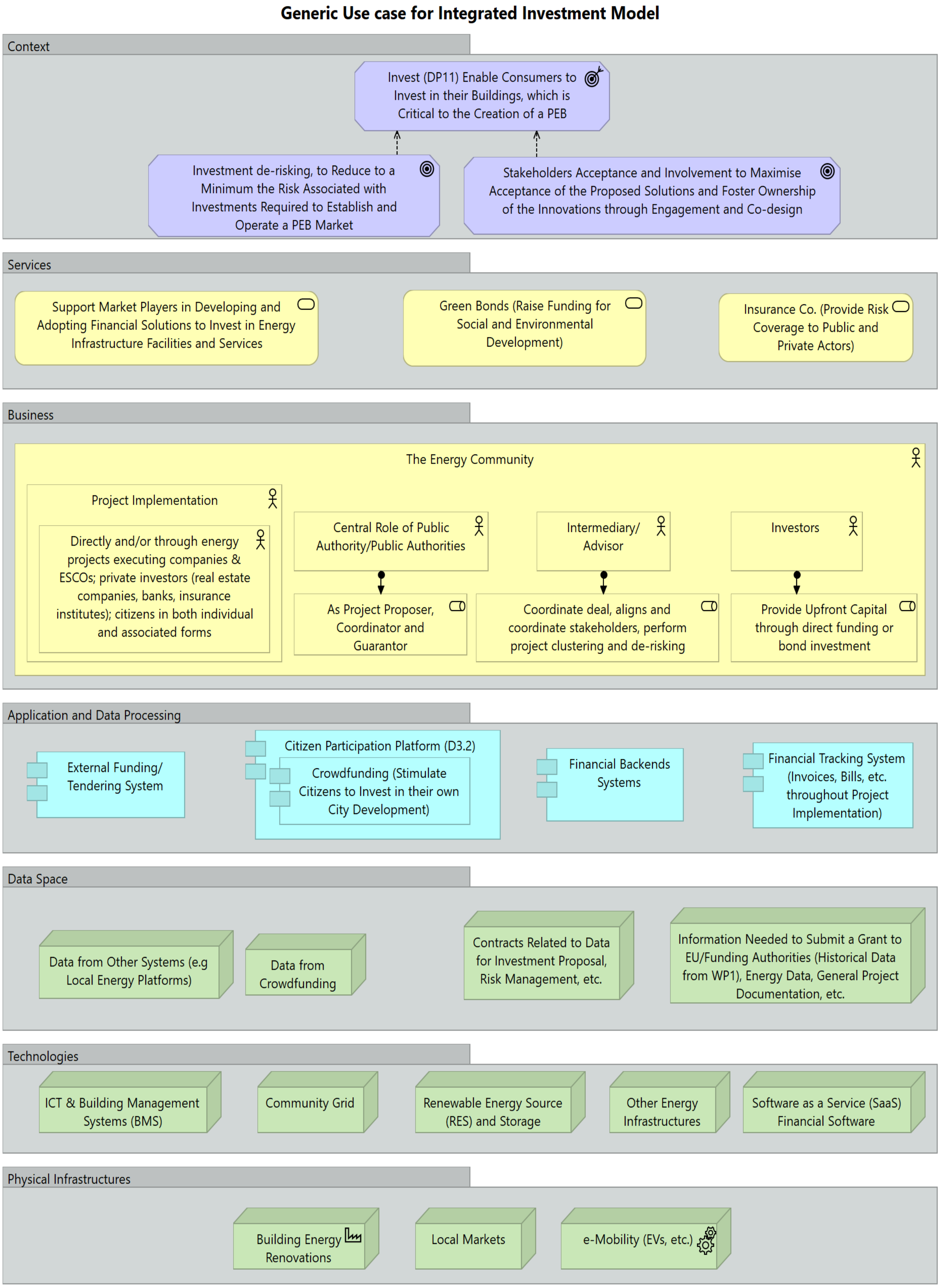

Fig. A.17: Use case for integrated investment model

No	EA Layer	Components	Description
1	Context	• Invest (DP11) • Investment de-risking, to reduce to a minimum the risk associated with investments required to establish and operate a PEB market • Stakeholders acceptance and involvement to maximize acceptance of the proposed solutions and foster ownership of the innovations through engagement and co-design	• Aims to achieve Invest (DP11) "Enable Consumers to Invest in their Buildings, which is Critical to the Creation of a PEB".
2	Services	• Support market players • Green Bonds • Insurance Co.	• Support market players in developing and adopting financial solutions to invest in energy infrastructure facilities and services. • Green Bonds (raise funding for social and environmental development). • Insurance Co. (provide risk coverage to public and private actors).
3	Business	• The energy community	The energy community comprises • Project Implementation which include; ○ Directly and/or through energy projects executing companies & ESCOs; private investors (real estate companies, banks, insurance institutes); citizens in both individual and associated forms.

			● Central role of public authority/public authorities as project proposer, coordinator and guarantor. ● Intermediary/advisor who coordinate deal, aligns and coordinate stakeholders, perform project clustering and de-risking. ● Investors who provide upfront capital through direct funding or bond investment.
4	Application and data processing	● External Funding/Tendering System ● Citizen Participation Platform (D3.2) ● Financial Backends Systems ● Financial Tracking System	Applications deployed in the integrated investment model comprises; ● External funding/tendering system ● Citizen participation platform (D3.2) ○ Crowdfunding (stimulate citizens to invest in their own city development) ● Financial backends systems ● Financial tracking system (invoices, bills, etc. throughout project implementation).
5	Data space	● Data from systems ● Crowdfunding data ● Contracts ● Information needed to submit a grant to EU/funding authorities	Data sources used by the integrated investment model involves; ● Data from other systems (e.g local energy platforms). ● Data from crowdfunding. ● Contracts related to data for investment proposal, risk management, etc. ● Information needed to submit a grant to EU/funding authorities (historical data from WP1), energy data, general project documentation, etc.
6	Technologis	● ICT & other systems ● Community grid ● Energy source and storage ● Other Energy Infrastructures ● Other software	Technologies deploy include; ● ICT & Building Management Systems (BMS). ● Community grid. ● Renewable Energy Source (RES) and storage. ● Other Energy Infrastructures.

			● Software as a Service (SaaS) financial software.
7	Physical infrastructures	● Building energy renovations ● Local markets ● e-Mobility (EVs, etc.)	Includes building energy renovations, local markets and e-Mobility assets.

Table A.16: Description of integrated investment model use case

Appendix B – Use case Template

Use Case Description

The starting point is a description of the use case to be designed. It needs to be verified that a use case description provides the sufficient information which is necessary for the replication. This information may include:

- Name, scope and objective
- EA diagram or use case diagram of the case
- EA layers and associated description
- Stakeholders and data perspective (shown in previous step)
- API specification
- IT/Business components names, types (business actors and system actors)
- Data which is exchanged among components

Name, scope and objective

Scope and objectives of use case	
Related business case	
Scope	
Objective(s)	
Case description (Executive summary)	
In scope	
Out of scope	

Enterprise architecture for *"enter case name here"*

Insert EA architecture diagram here

Enterprise architecture layers and descriptions

Context layer

Insert context layer diagram here

Description of context layer:

Enter description here...

Service layer

Insert service layer diagram here

Description of service layer:

Enter description here...

Business layer

Insert business layer diagram here

Description of business layer:

Enter description here...

Application and data processing layer

Insert application and data processing layer diagram here

Description of application and data processing:

Enter description here...

Data space layer

Insert data space layer diagram here

Description of data space layer:

Enter description here...

Technologies layer

Insert technologies layer diagram here

Description of technologies layer:

Enter description here...

Physical infrastructures layer

Insert physical infrastructures layer diagram here

Description of physical infrastructures layer:

Enter description here...

API specification for "*enter case name here*"

The details of example of API specification are described in D1.3.

API specification				
API number in catalogue	**API name**	**API owner** *(State the name of the component that provides the API)*	**API consumer** *(State the name of the component that uses the API)*	**API description** *(Provide brief description of API)*

IT/ business component names and types (business actors and system actors)

The IT/business components are similar to actors which can cover people (their roles or jobs), systems, databases, organizations, and devices. Thus, IT/business components can be of type devices, applications, persons and organizations, these can be associated to domains relevant for the underlying use case.

- "Component type" may include *business, application, data, system, devices, etc.*

IT/business component for *"enter use case name here"*			
Component Name	**Component Type**	**Component Description**	**Further information specific to this use case (if any)**

Use case steps of data exchanged among services

Step #	**Data Types** *(What type of data is involved?)*	**Component** *(What component, either primary or secondary is responsible for the activity in this step?)*	**Description of the activity** *(Describe the actions that take place in this step including the information to be exchanged.)*	**Data producer**	**Data receiver**	**Data exchanged**	**Additional Notes** *(Elaborate on any additional description or value of the step to help support the descriptions.)*
Insert service 1 name here *(Use enter in keyboard to add more steps for each service)*							
Insert service 2 name here *(Use enter in keyboard to add more steps for each service)*							

Insert service 3 name here *(Use enter in keyboard to add more steps for each service)*							
Insert service 4 name here *(Use enter in keyboard to add more steps for each service)*							

Appendix C – Feedback Collection for Final Model Validation

This section of the report presents direct feedback received from the project partners for some use case.

C1. Seamless eMobility System Including User Interface Use case

Feedback Collection and Final Validation

During the course of development of the use case for the seamless eMobility system, several discussion meetings were carried out from 2019 to 2020 by researchers in T1.1 with partners in FourC to model the first version of the use case for seamless eMobility system. The discussion took place at FourC premise. Also, feedback was collected from FourC and TK to get more insights on eMobility related services needed in Trondheim. Additional feedbacks were received from subsequent meetings with FourC and TK that helped to refine and update the use case. Lastly, more feedback was retrieved from D2.5 deliverable [43] and IOTA to finally validate the use case as shown in Figure A.2.

C2. IOTA eMaaS Payments Trail and Tech Specs and Requirements Use case

Feedback Collection and Final Validation

To identify the case, the technology specification and requirement document was requested from the partner (IOTA) and T1.1 regarding discussion on the role of IOTA in ensuring micro payment for the eMaaS. Data was also collected during another meeting with partners from IOTA, D1.2, and D1.3. regarding the technical requirements and specifications for the IOTA payment module. After the use case was modelled in the developed EAF. The model was sent to partners at IOTA and feedback was provided. The feedback highlights few corrections which were made to refine the developed use case as shown in Figure A.3.

C3. Limerick DST (Integrated Modelling and Decision Support Tool) Use case

Feedback Collection and Final Validation

After the use case was modelled in the developed EAF. The modelled use case was sent to partners at IESRD to get feedback and meeting was scheduled. During the online meeting feedback was provided from two partners in IES and Lero. The suggestions helped to improve the developed use case as shown in Figure A.4. The discussion also provided more insights on the functionality of the DST to partners at IES, Lero, and NTNU.

C4. Delivery of the Citizen Participation Playbook Use case

Feedback Collection and Final Validation

After the delivery of the citizen participation playbook use case was modelled in the developed EAF. The modelled use case was sent to partners involved in D3.2 deliverable (LCCC, TK, Colaborativa) to get feedback and meeting was scheduled. During the meeting feedback was provided from Participants LCCC, TK, and Lero. Furthermore, another meeting was held with a partner from Colaborativa. In this meeting more data was gathered that helped to further refine the developed use case for delivery of the citizen participation playbook. The feedback helped to improve the developed use case as shown in Figure A.5.

C5. Framework for an Innovation Playground Use case

Feedback Collection and Final Validation

After the delivery of the citizen participation playbook use case was modelled in the developed EAF. The developed model was showed and described to a partner involved in D3.6 in UL and the initial feedback suggest that the use case is easy to be understand and aligns to D3.3 report. Additionally, the modelled use case was sent to partners involved in D3.3 deliverable (Space Engagers, NTNU, Officinae Verdi Group) to get feedback. Feedbacks were also provided which helped to improve the modelled delivery of the citizen participation playbook use case as shown in Figure A.6.

C6. Monitoring and Evaluation Dashboard Use case

Feedback Collection and Final Validation

After the monitoring and evaluation dashboard use case was modelled in the developed EAF. The modelled use case was sent to partners involved in D4.1 deliverable (FAC and ISOCARP) to get feedback. A brief feedback was received from one of the partners involved in D7.4 to include a data source showing that data comes from other DPs (1-11) into the MERT. Another meeting was held between partners from D7.4 and D1.2.
During the meeting which comprises 3 partners from FAC and I partner from D1.2, the role of D1.2 and the developed EFA was presented. Then, one of the partners in FAC explained the role of the Monitoring and Evaluation Dashboard as regards to the +CityxChange project.
Next, one of the partners in D1.2 proceeded to discuss why it was important to model the monitoring and evaluation dashboard case and how it will help the project. During the discussion a workshop approach was employed whereby feedbacks from the partners (FAC) on each of the EAF layers, components, and relations. Recommendations based on what FAC was developing was directly modelled in ArchiMate by the partner in D1.2 to get immediate feedback. After several iterations a final model was approved by all participants in the meeting. The refined monitoring and evaluation dashboard use case modelled in the EAF is shown in Figure 7.1.

C7. MPower Tool Use case

Feedback Collection and Final Validation

The first version of the modelled MPower tool use case represented in the developed EAF was sent to partners at MPower involved in D2.2 deliverable to get feedback to improve the use case. A meeting was scheduled and during the meetings feedbacks were gotten which helped to verify the developed use case components and relationships. The final MPower tool use case modelled in the EAF is shown in Figure A.7.

C8. IES Tool (Intelligent Virtual Network (iVN)) Network Modelling Tool Use case

Feedback Collection and Final Validation

The first version of the modelled IES tool in the developed EAF was sent to partners at IES involved in D2.2 deliverable to get feedback to enhance the use case. During scheduled meetings feedbacks were gotten which helped to verify the developed use case components and relationships. The final IES tool use case modelled in the EAF is shown in Figure A.8.

C9. Powel Tool – (Grid Operation Tool) Design and Operation of Local Energy System Use case

Feedback Collection and Final Validation

The first version of the modelled Powel tool in the developed EAF was sent to partners at Powel involved in D2.2 deliverable to get feedback to enhance the use case. A meeting was setup. During the meetings feedbacks was provided which improved the developed use case. The updated Powel tool use case modelled in the EAF is shown in Figure A.9.

Appendix D – Prior Smart City Architectures

This section describes a Smart City Reference Architecture from standardization bodies (ISO) and relevant Smart City architectures from the literature.

D.1 SC Reference Architecture Concepts

The ISO JTC1 (Joint Technical Committee) WG 11 on Smart Cities [51] have proposed a Reference Architecture and a Solution Concept; see Figure D.1.1. This high-level engineering view of a Smart City is organized in layers, which is aligned with several other EAF and Reference Architectures for Enterprises and Smart Cities that reported in the literature [52].

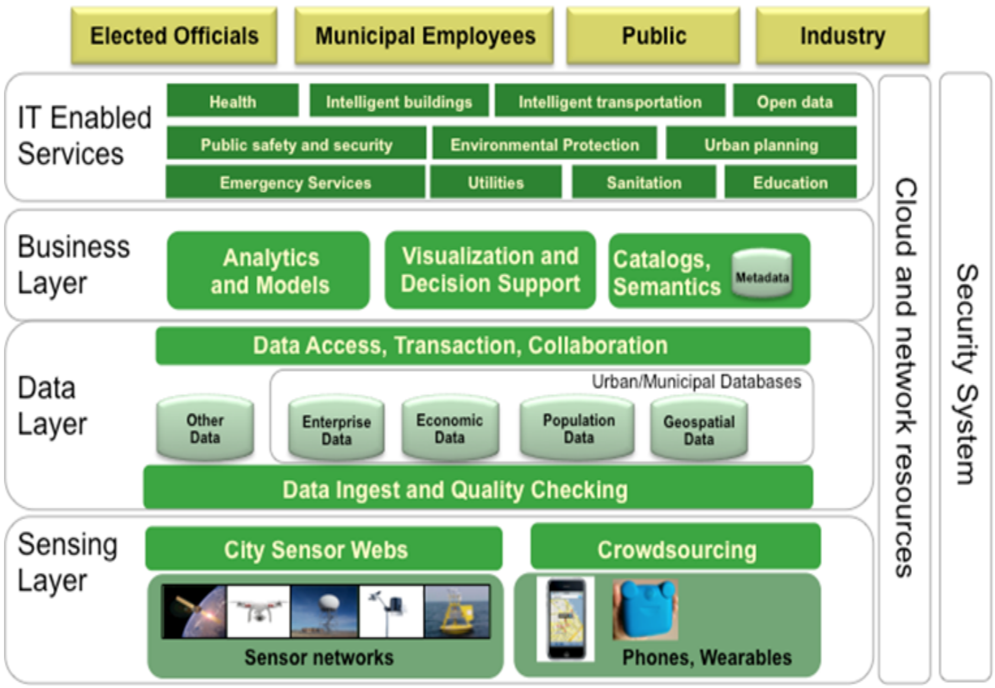

Fig. D1.1: Proposed smart city reference architecture concepts [51]

Four main layers are identified:

1. IT enables services - which identify the different thematic or application areas for the services, such as Heath, Intelligent Buildings and Open Data.
2. Business Layer to describe the applications that are used to provide the services, such as data analytics.
3. Data Layer to describe the data, data sources and services to access data and to support collaboration, etc.

4. Sensing Layer to link to devices such as sensors or mobile and other (Edge) devices.

Services common to the four layers are identified, such as storage and security. It also identifies stakeholders such as public authorities and industry.

D.2 Smart City Architectures from Literature

Different smart city frameworks/architectures which have various abilities and approaches to overcome different challenges. A summary of these frameworks presented in Table 2.2 is discussed in this section. The following section will discuss specific architectures from related H2020 SCC1 smart city projects.
Among the reviewed studies [10] described an open service architecture to enable flexible interaction, collaboration, integration, and participation, while incorporating advanced information navigation, trust, and access control. [11] believed that there was no common agreement on which architecture layers, which artefact types and which dependencies constitute the essence of enterprise architecture. Therefore, they identified essential elements of enterprise architecture by specifying it as a hierarchical, multilevel system comprising aggregation hierarchies, architecture layers and views. Moreover, [11] proposed interfacing requirements of enterprise architecture with other architecture models. In conclusion, they emphasized on the necessity of identifying and validating a reference meta architecture that specifies architecture components and interfaces between those components.

[16] presented the development methodology of a sample digital city. They believed that the methodology can be considered as a general implementation model for developing similar municipal-area environments for e-Government. Their development methodology consisted of multiple considerations and the investigation of all possible parameters influencing the digital environment. [13] attempted to modularize the structure of utilities and develop a system for following up the activities electronically on the city scale. They explained that the smart city has four principle unites that cover the majority of networks, processes, applications and several associated activities in different trends, containing: 1) applications; 2) business units in order to realize the function of using the mentioned applications, 3) process management to define the relationship, rules, strategies and policies between the city applications and related business unites; and 4) communication protocols as the closer of this activity city cycle. [13] stated that the main goal of this research has been provide the initial necessary guidelines to improve operations and maintenance, reduce the cost of operation,

provide enhanced energy management capabilities and provide scalability and freedom for future.

[13] debated smart city infrastructure architecture development framework and surveyed positional accuracy of locating the assets as a base of the smart city development architecture integrated with all the facilities and systems related to the smart city framework. [12] concluded to a common enterprise architecture for digital city. This common architecture identified the blueprints for urban information-based development. They proposed future research on the transaction of these architectures with social networks, either existing or others installed in city areas. [14] presented an event driven architecture that allows the management and cooperation of heterogeneous sensors for monitoring public spaces as a solution architecture. They implemented the main components of this architecture in a testbed on a subway scenario to demonstrate that their proposed solution can enhance the detection of anomalous events and simplify both the operators' tasks and the communications to passengers in case of emergency.

[15] described a framework which described foundation and principles for Information Technology (IT) in smarter cities containing: 1) instrumented (data from sensors); 2) interconnected (Integration of data) and intelligent (inclusion of complex analytics, modelling, optimization); and 3) visualization in operational business processes). The layered structure of interconnection is the Smarter Planet Command Systems. The explained that primary flows of information are upward and downward within individual city services within three Level.

[15] presented the Urban Information Model (UIM) by depicting a layered view on the resources of the city. In this way, they classified different types of information that can be generated, produced, and consumed by any of these resources. [17] developed an integrative framework to explain the relationships and influences between 8 critical factors of smart city initiatives. They emphasized that each of these factors is important to be considered in assessing the extent of smart city and when examining smart city initiatives.

[18] conducted a survey on 18 people involved in a Smart City projects. Main findings included SC initiatives being government driven and most of them having no defined business case. As a result, they described a conceptual architecture for Smart City sensors interconnection with the organization, and interconnection between organisations. [19] proposed a smart city architecture from the perspective of the data

that underpins all the functionality of smart cities. The proposed architecture discussed, outlining design challenges and offered insight into the development of smart cities. This framework explained data sources, required applications and technologies. Moreover, it elaborated critical success factors in a smart city including, administration requirements, security (sensor security, transmission security, data vitalization security and application security), and standards (standard framework, basic standards, application Standards, security standards).

In conclusion, many researchers attempted to inspected smart city challenges from different perspectives. Consequently, they have proposed various types of architecture containing high layered architecture, solution architecture, units of smart city, smart city factors and so on. However, none of the investigated frameworks had a view from an interoperability perspective with other initiatives. Moreover, although some frameworks explained about standards and security for smart cities (e.g. [19]), more details have not been issued for this purpose.

By inspecting these frameworks/architectures and their abilities and areas, a comprehensive reference architecture for services in a smart city was presented by [7], which is described in the following subsection.

According the presented architecture, two new layers, i.e. context layer and service layer have been introduced to design services in smart cities. The presented architecture has been created by going through the process, including: 1) development of the context layer; 2) development of the service layer; 3) defining relationships between service layer, and information layer.

The context layer consists of some components to specify the stakeholders, their concerns, quality factors, and their enablers/drivers. The service layer describes the “operant” resources of the service system, specifically the service actors and their interactions. The third activity in the introduced methodology defines a process for the alignment of the service and information layers, by defining the key activities regarding the identification of the relationships between the service and the information layers.

Appendix E - Relevant EU Smart City Projects

This section describes relevant EU H2020 Smart City projects and their Reference Architectures for the Smart City. One of such EU H2020 Smart City projects is ESPRESSO which is a standardisation project for smart city standardisation running 2016-2017 and is the basis for many following projects. Also, there are previous relevant H2020 SCC1 (Smart Cities and Communities) smart city Lighthouse projects running in the same EU call topics as +CityxChange, which are therefore of specific interest to map our experiences and approaches. In the following, relevant ones have been selected that also make sufficient information about their architecture approaches available. They share commonalities in that all place a priority on open data, city platforms, interoperability, and integration.

There are many other EU projects that include components that are relevant to the +CityxChange project and these are referred to where relevant throughout this document.

E.1 ESPRESSO

One of the EU H2020 projects, ESPRESSO's key objectives is to identify a collection of open conceptual standards that work well together to support smart cities [8]. It is a cross-cutting project for broad and general framework development, not like +CityxChange or the above SCC1 projects focused on specific deployment scenarios in specific cities. The focus is on conceptual standards and not technical standards; thus, to develop a "conceptual standards framework".

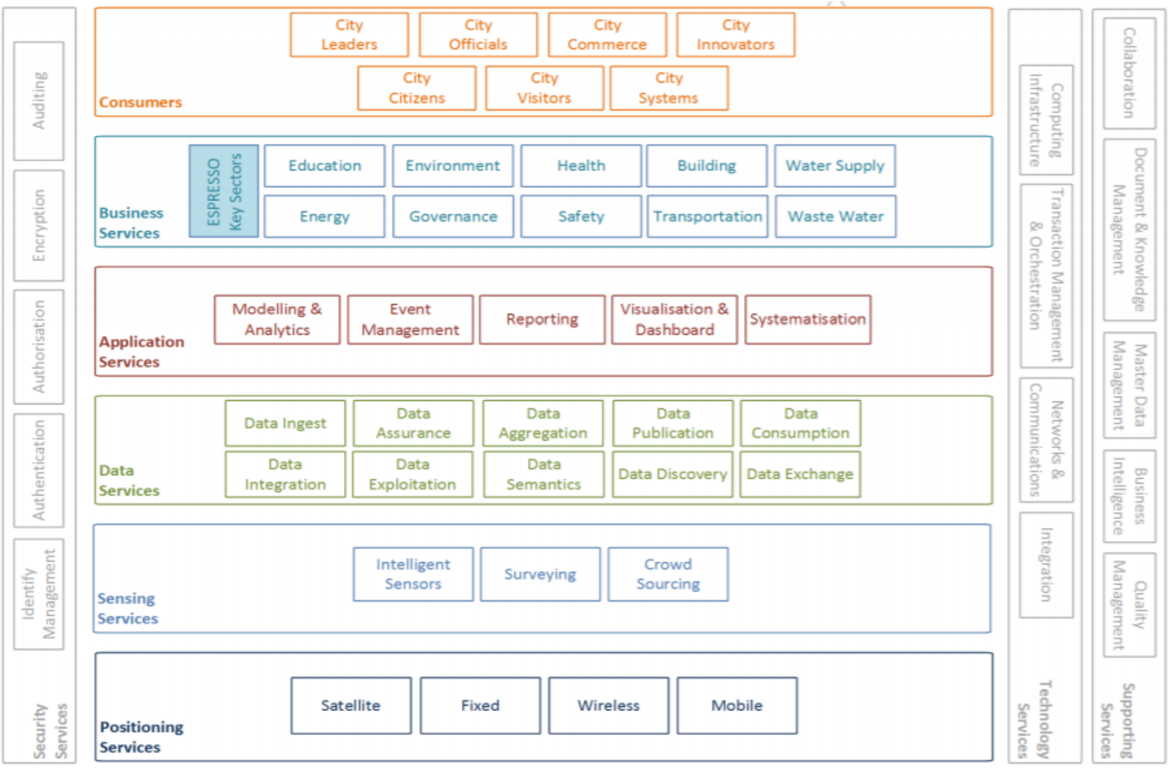

Fig. E1.1: The ESPRESSO Reference Architecture [8]

Based on the Reference Architecture proposed by ISO JTC1 WG11 described in Section E.1, ESPRESSO proposed a layered Reference Architecture as shown in Figure E.1.1 [8]. The ESPRESSO Reference Architecture extended the concept of services to all layers. In addition to the business, data and sensing layers, it includes two horizontal layers; one at the top to indicate the consumers of services, and one at the bottom to describe positioning services. Positioning services include geodetic, coordinate reference and global positioning related capabilities. This links the sensing layer to the physical space, which may be relevant for scaling and some decision-making processes. In addition, the ESPRESSO Reference Architecture includes four “vertical” or cross cutting layers: security services, technology services and supporting services, which are not bound to or specific to a given “horizontal” layer. They include various capabilities that could be required for any of the horizontal layers.

E.2 SmartEnCity

SmartEnCity [22] is an EU H2020 project and its main objective is to develop a highly adaptable and replicable systemic approach towards urban transition into sustainable, smart and resource-efficient cities in Europe; e.g. through maximizing renewable energy or reducing energy demand. The SmartEnCity Reference Architecture is a layered model based on UNE 178104:2015 (AENOR CTN-178 group standard).

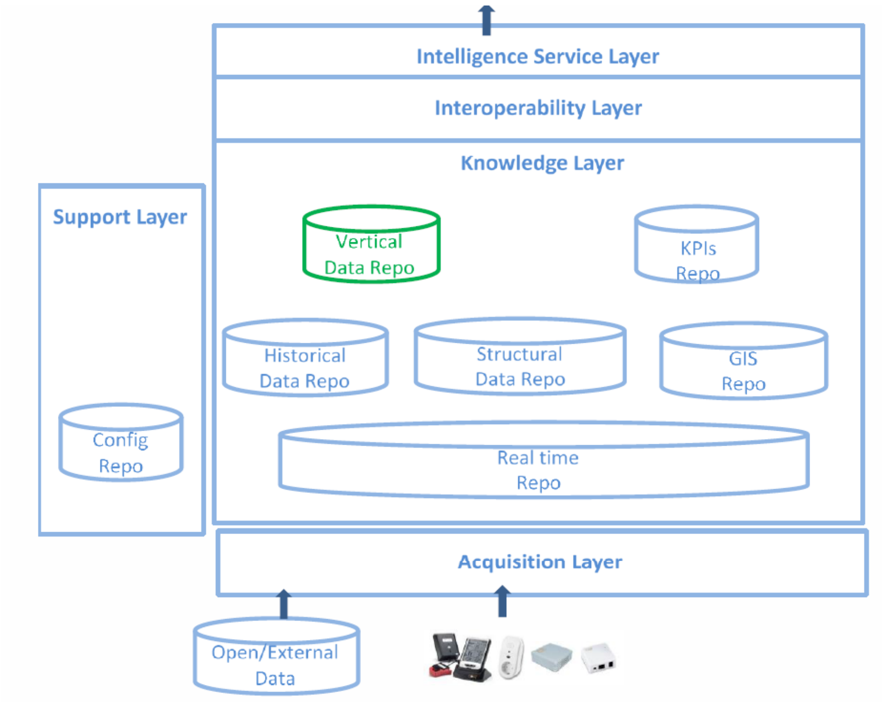

Fig. E.1.2: SmartEnCity architecture [22]

The SmartEnCity Reference Architecture aims to address replication in smart cities as shown by the interoperability layer and several data sources positioned in the knowledge layer as seen in Figure E1.2. This is similar to the work discussed in D1.3 which aims to support data interoperability and integration. Also, D1.3 presents APIs used by +CityxChange partners to provide services.

The SmartEnCity Reference Architecture is a layered platform, and the core of it is an IoT platform. The horizontal layers and modules composing the reference architecture are shown in Figure E.1.2. The architecture implementation gathers different types of data through the acquisition layer; e.g real time data (sensor data), open data (weather forecast), district heating, mobility, social networks, etc. Those data are stored and treated in the knowledge layer. The interoperability layer enables the consumption of those data through APIs. At the top, the intelligent service layer offers services and applications for the different vertical domains (energy, environment, mobility, etc.). A support layer relates to all the horizontal layers and provides support such as monitoring, audit, security, etc.

The repositories necessary to build a Smart City platform are also outlined in the Reference Architecture as data models. Different data repositories and data models have been identified in the knowledge layer as follows:

- Vertical repository/data models which are closely related to the different applications and data that will be used in the specific (lighthouse) cities in the project.
- KPI repository/data model.
- Historical data repository stores the historical data collected in the platform. Historical data is gathered from other repositories and stored permanently in a common space.
- Structural data repository stores the structural data collected in the platform and the relations among them. This information is then used to store data related to the structural elements (such as consumption per household).
- Geographical Information System (GIS) repository stores the information to describe the city area geographically; the 2D geometry of the common city elements as well as the alphanumerical info associated to them.
- Real Time Repository contains data received from the different sensors and external systems that act as external information sources for the different components of the platform.
- A configuration repository is the database of the needed information to manage the different users, profiles and security permissions. The configuration repository acts in a transversal way to the rest of the layers and components of the platform by offering services such as users' management, security, access monitoring.

E.3 Sharing Cities

Sharing Cities [http://www.sharingcities.eu] has developed the concept of an Urban sharing platform to manage the number and range of data sources and sensors that cities are working with, in a common platform including database, analytics, and sharing.

It is a common reference architectural model developed by the three cities in the project with a focus on a federated open API approach and the use and analysis of open city data through a marketplace approach.

Its aim was to develop a common support for the design and architecture in the individual cities, while providing common templates and terminology. It follows themes of sensing, sharing, interoperability, open APIs, data, and support services.

The reference model contains the overall model, and also its instantiation in the three cities with different priority areas and connections to local demos and data services [53]. This makes it useful to understand possible adaptations and the commonalities between the cities. Following reports discuss implementation details, including deployment diagrams of local components, further adaptation after local development, and actual use of the data and analytics functionalities [54](D4.3, D4.4, D4.5). Figure E1.3 depicts the sharing cities architecture.

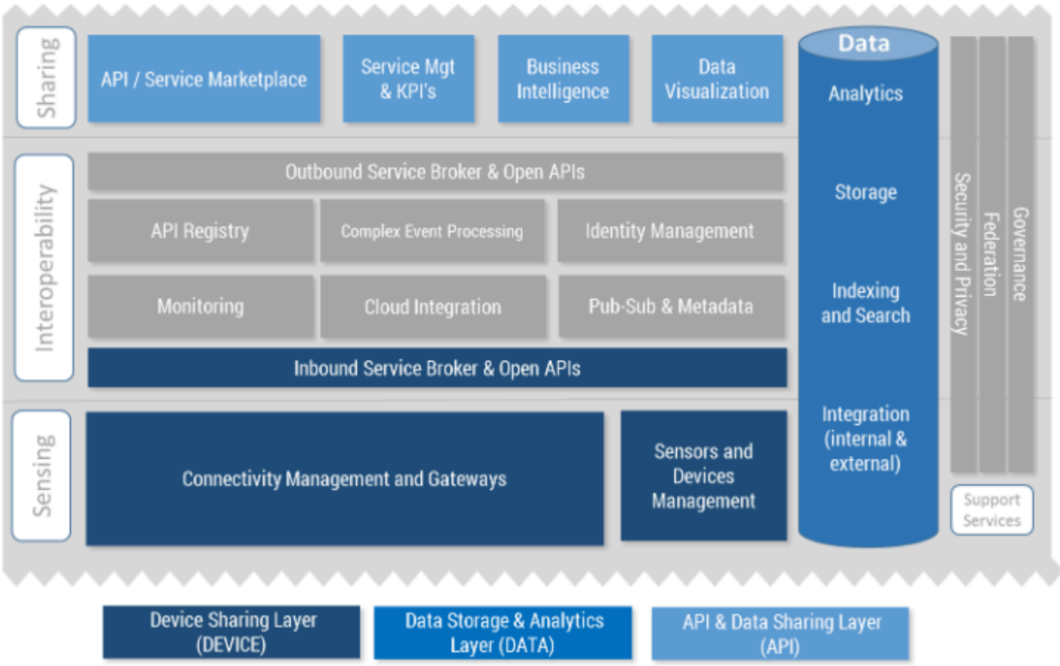

Fig. E.1.3: Sharing Cities architecture [53], [54]

E.4 RUGGEDISED

RUGGEDISED [https://ruggedised.eu/] has developed a layered architecture model for its smart city solutions and components. It consists of 11 layers in an innovation and business value chain from an infrastructure layer up to a user layer including citizens and businesses. It specifically highlights a data marketplace layer, described as the core platform and infrastructure with protocols, APIs, and a data catalog, built on top of an integration layer that enables open integration through open APIs, semantic Web services, and ontologies.

It includes governance, ownership, and security as cross cutting concerns.

The report includes multiple views, including a high-level architecture view of the layers and cross-demonstrations, and a detailed one that is covering more detailed functional components and entities within the layers. Figure E1.4 and E1.5 depicts the RUGGEDISED architecture.

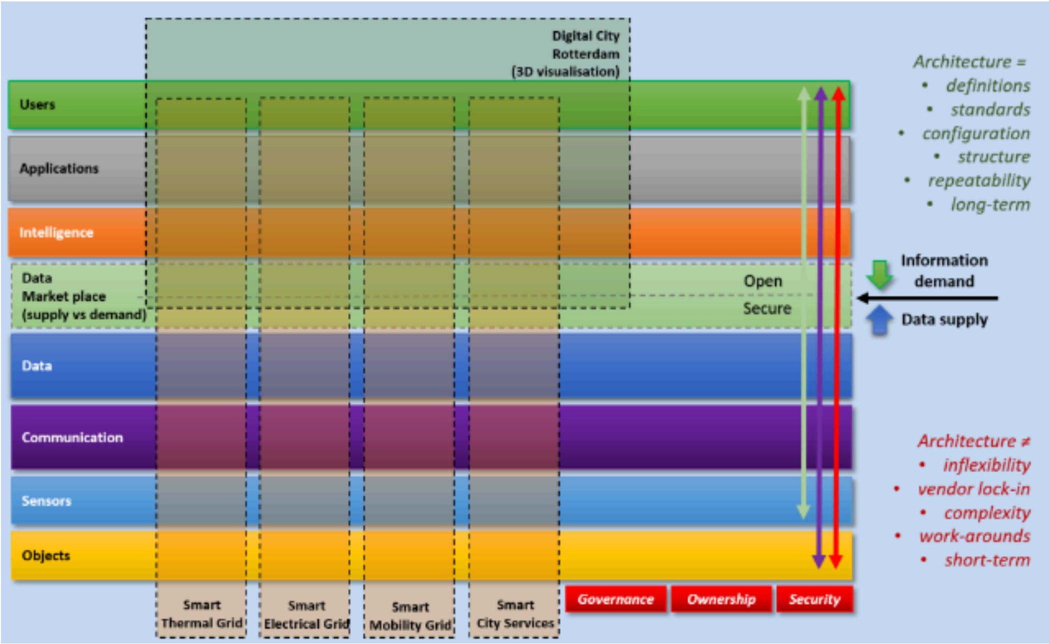

Fig. E.1.4: RUGGEDISED architecture 1 [55]

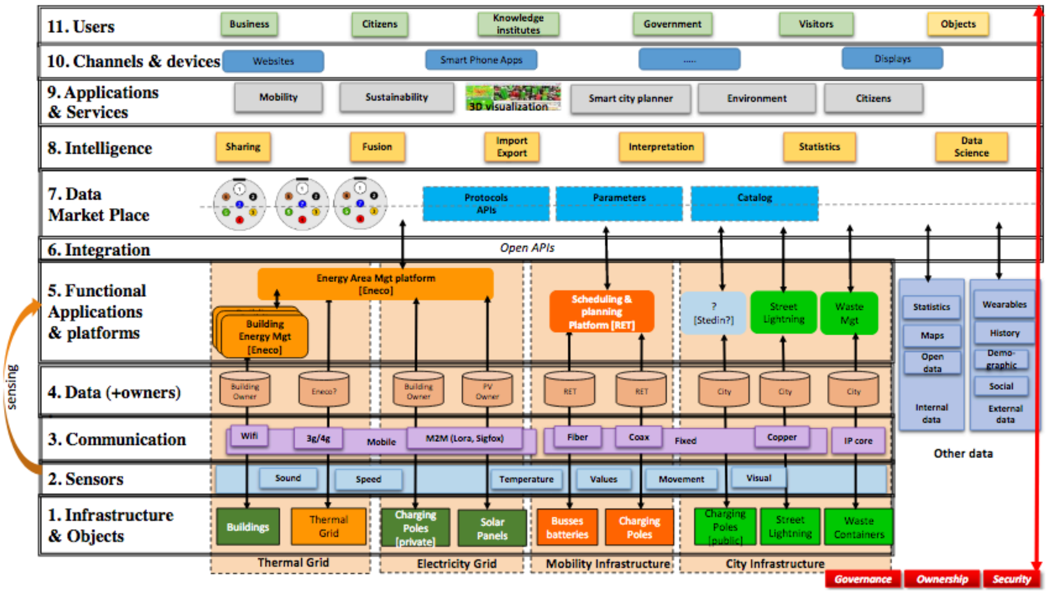

Fig. E.1.5: RUGGEDISED architecture 2 [55]

E.5 REPLICATE

REPLICATE [https://replicate-project.eu/] has developed a platform architecture around the use of a common data hub as an open data platform, a common data model, and the use of FIWARE core components. It is an example of a pragmatic technical architecture and its reports follow the evolution of the architecture developments, making them relevant in the development of other project's architectures. The following

figure shows their integration of different apps and infrastructure connected to their central smart city platform.
Figure E1.6 depicts the REPLICATE architecture.

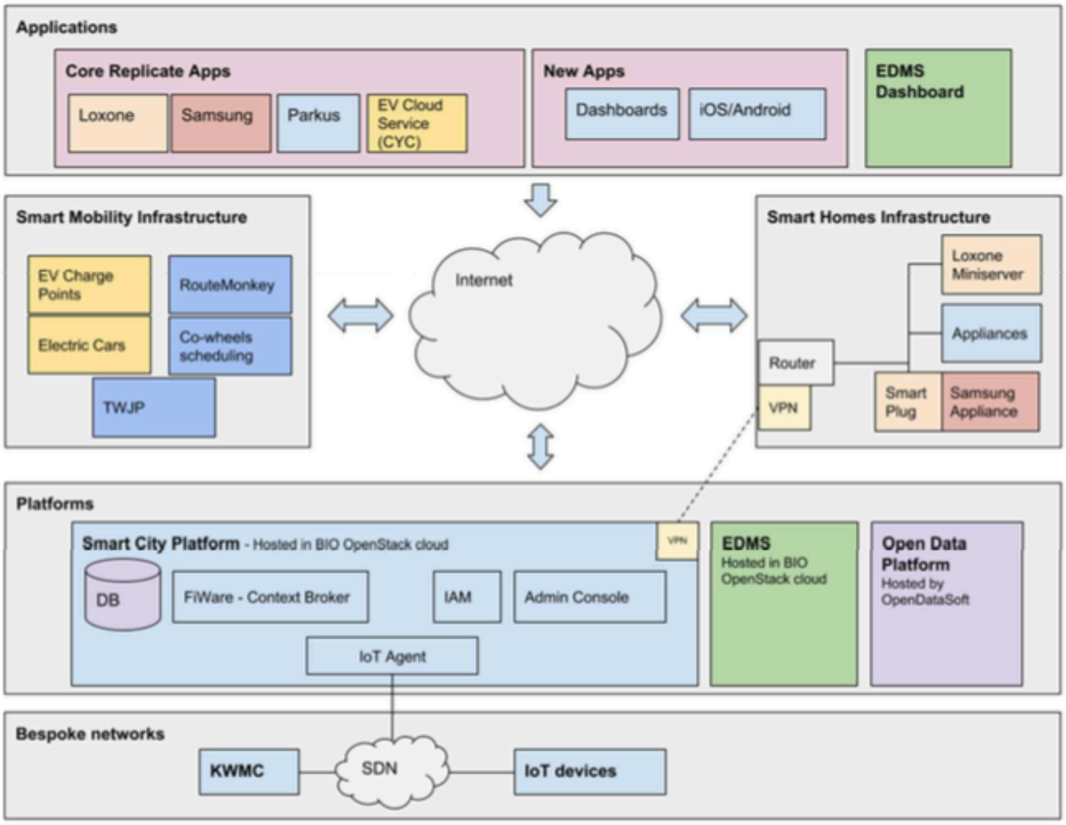

Fig. E.1.6: REPLICATE architecture [56]

E.6 mySMARTLife

mySMARTLife [https://www.mysmartlife.eu/] built a framework for interoperability and to easily build standardised urban data platforms in its participating cities. It is defined as an Open Specifications Framework and not a reference architecture, but it shares similar ambitions and approaches. The motivation is the integration of different city domains and implementation of services around them, from the project topics of “infrastructures, mobility, energy, buildings ... smart management and big-data analytics”. Their framework is structured similar others discussed here and addresses 4 challenges of “(1) data interoperability; (2) services or verticals interoperability; (3) openness; and (4) replicability” within a 6-layer framework of sensing, drivers, surveillance, data, interoperability, and intelligent services layers (see also +CityxChange D1.3, Section 2, for a discussion on the interoperability). The approach is described together with a review of relevant related approaches [57]. Figure E1.7 depicts the mySMARTLife architecture.

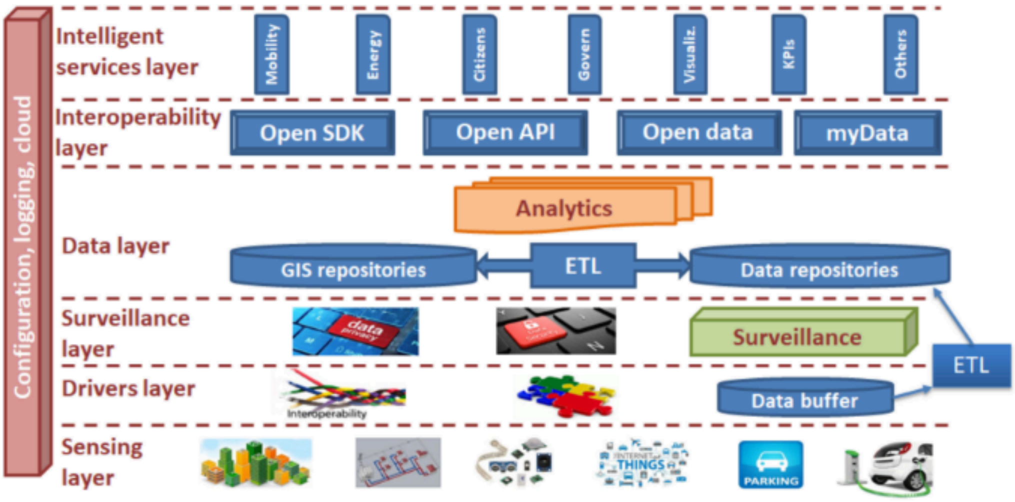

Fig. E.1.7: mySMARTLife architecture [57]

E.7 IRIS

IRIS [https://irissmartcities.eu/] is building their ICT systems strongly based on their demonstration projects and an overall concept of a City Innovation Platform (CIP), which is built to collect, manage, and exchange data to enable sharing of data and development of new services. In this view, ICT is an enabler. They describe a reference architecture targeted to the project and based on a number of previous references, their own requirements and stakeholder mapping, and a baseline analysis of city ICT systems. Key impacts are described as “common language for all stakeholders”, “consistency of functional and technical requirements”, “support for common standards, specifications and patterns”, and support for IRIS business models.

The architecture is also used to map out individual demonstrations and their requirements on top of it, and to map commonalities with other frameworks. Figure E1.8 depicts an example of IRIS CIP reference architecture mapping to platform capabilities.

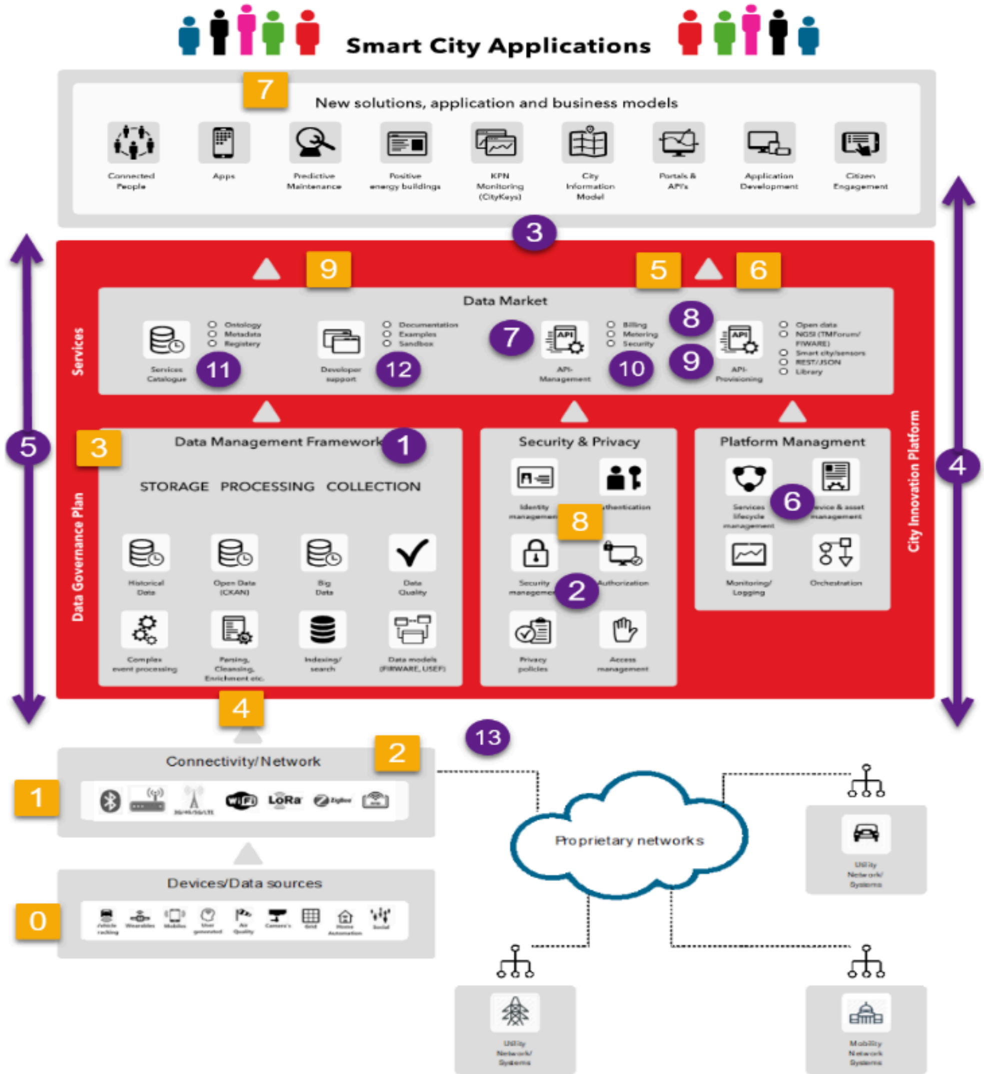

Fig. E.1.8: IRIS architecture [58]

E.8 MAtchUP

MAtchUP [https://www.matchup-project.eu/] has main objectives of integration and interoperability within an urban data platform that can connect different modules for the demonstrations. Their work includes specific interoperability standards and the detailed definition of data flows and data brokers within their integrated platform for the city. As an example, the authors showed the building blocks for the data platform for the city of Valencia. Figure E.19 shows an example of the MAtchUP Valencia urban platform

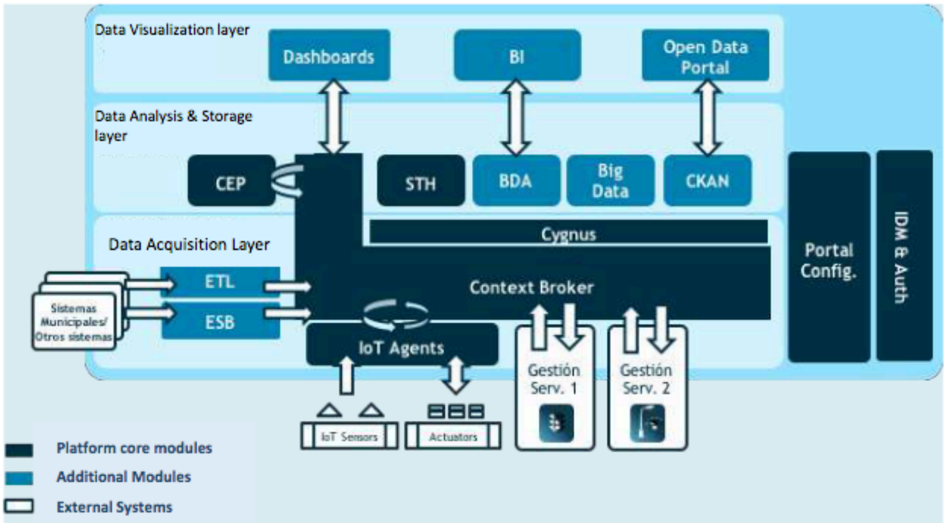

Fig. E.1.9: MAtchUP architecture [59]

Appendix F – Questionnaire

This section presents the online questionnaire designed to collect feedback as stated in section 8.4. The online questionnaire is created in order to obtain a more systematic feedback from the partners as regards to the developed +CityxChange EAF.

Enterprise architecture: its role in + CityxChange

Request for participation to provide feedback on the + CityxChange Enterprise Architecture Framework

This is a question to you about participation in a research project. Here we give you information about the aim of the project and what participation means for you.

Aim
The aim of this questionnaire is to obtain feedback on the Enterprise Architecture Framework (EAF) used in + CityxChange (+ CxC). The questionnaire has three main parts: (i) Demographic information on respondents; (ii) feedback on the usefulness of the EAF and use case models; and (iii) how the EAF could be enhanced to support knowledge transfer within and across cities.

This work is conducted as part of a Master's project at the Department of Computer Science, at NTNU. The feedback on the + CxC EAF may be included as part of the deliverable D1.2 Report on the Architecture for the ICT Ecosystem for the + CxC project.

The respondents to this questionnaire should have seen a presentation or used the + CxC EAF for modeling use cases.

Who is responsible for the research project?
NTNU IDI is responsible for the data processing in this project.

Why are you being asked to participate?
You are associated with the + CityxChange project and have been exposed to the + CxC EAF

Prospective respondents were purposely selected and invited to partake in the survey since they have prior knowledge on enterprise architecture or / and are familiar with the developed EAF used in + CxC project. Accordingly, the email address of the selected respondents were gotten either from the + CxC project master list or from the respondents organizational website.

What does it mean for you to participate?
Participation is through an electronic questionnaire. The questions are primarily about your opinion of how Enterprise Architecture relates to your work and the usefulness of the + CxC EAF. The questions are a combination of multiple choice, likert-scale and free-text.

Participation is optional
It is optional to participate in the project. If you decide to participate, then you can opt out at any point and withdraw your consent without giving any reason. All your personal data will then be deleted. There are no negative consequences for you if you do not wish to participate or opt out later.

Your privacy - How we use or process your data

We will only use the data for purposes explained here. We process your data confidentially and in line with regulations.

- Those that will have access to the data are: The student working on the thesis, the supervisor and the co-supervisor.
- The data will only be accessible to those mentioned above, deleted once the project completes and any published research will anonymize the data.
- The questionnaire is conducted with web form. You can get more information on that here: https://www.uio.no/tjenester/it/adm-app/nettskjema/mer-om/

Any research publication will not provide personally identifiable information

Your rights
As long as you can be identified by the data, you will have the right to:

- Insight into what data we collect about you and retrieve said data.
- Correct the data about you.
- Delete the data about you
- Complain about the use of data to "Datatilsynet"

What gives us the right to process personal data about you?
We process data based on your consent.

How can i learn more?
If you have questions in regards to the studies, or wish to exercise your rights, contact:

- NTNU IDI sobah.a.petersen@ntnu.no.
- Data protection office at NTNU: Thomas Helgesen, thomas.helgesen@ntnu.no

If you have questions about NSD's evaluation of the project; contact:

- NSD - Norwegian Center for Research Data AS via email (personverntjenester@nsd.no) or phone: 55 58 21 17.

Regards,

Sobah Abbas Petersen, PhD
Associate Professor
Dept. of Computer Science
Norwegian University of Science and Technology
Trondheim, Norway.
Mobile: +47 92846595
Skype: Sobah1

Consent for participation in the study: I have received and understood information about the project to provide feedback on the + CityxChange Enterprise Architecture Framework. *

☐ I give consent

Demographic Information

To understand where the feedback is coming from, we need to understand your position in your organization and your familiarity with the Enterprise Architecture approach.

Gender? *

- ◯ Measure
- ◯ Female
- ◯ Other gender identity
- ◯ Prefer not to answer

Age? *

- ◯ <20 years
- ◯ 20 - 30 years
- ◯ 31 - 40 years
- ◯ 41 - 50 years
- ◯ 51 - 60 years
- ◯ Over 61

What type of organization do you represent? *

- ◯ University
- ◯ Research organization
- ◯ City council or municipality
- ◯ Private organization
- ◯ Public organization
- ◯ Other

If you answered other in the question above, please specify here.

What type of services does your organization primarily provide? *

- Energy related
- Data related
- Innovation related
- ICT Infrastructure related
- Transport / mobility related
- Other

If your answer to the question above was "Other", please indicate the type (s) of service (s) provided by your organization.

What is your primary role within your organization? *

How much experience do you have with Enterprise Architecture *

- No experience
- Less than 1 year
- 1 - 3 years
- 4 - 5 years
- 6 or more years

How much experience do you have with Smart City related projects? *

- No experience
- Less than 1 year
- 1 - 3 years
- 4 - 5 years
- 6 or more years

Enterprise Architecture Approach

Indicate your level of agreement with the following statements about EA in general

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not applicable
Enterprise architecture is relevant to my work. *	○	○	○	○	○	○
Enterprise architecture is relevant for the + CxC project. *	○	○	○	○	○	○

Are you familiar with the + CxC Enterprise Architecture Framework (+ CxC EAF)? *

- ○ I have seen a presenation of it
- ○ I have used it
- ○ I have provided feedback on the EAF
- ○ I have provided input and / or feedback to one or more models based on the EAF
- ○ I am not familiar with it
- ○ Other

Indicate your level of agreement with the following statements about the + CxC EAF

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not applicable
The framework is useful for my work. *	○	○	○	○	○	○
The framework is useful for CxC. *	○	○	○	○	○	○
The framework is easy to understand. *	○	○	○	○	○	○
The framework is easy to use. *	○	○	○	○	○	○
I will recommend the framework to colleagues in my organization. *	○	○	○	○	○	○
I will use the framework for my work in the future. *	○	○	○	○	○	○

Use Case Scenarios described using the + CxC EAF

Indicate your level of agreement with the following statements about the use case scenario models described using the + CxC EAF

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not applicable
The use case models are useful for my work. *	○	○	○	○	○	○
The use case models are useful for the + CxC project. *	○	○	○	○	○	○
The use case models are easy to understand. *	○	○	○	○	○	○
I find it easy to describe a scenario using the use case models. *	○	○	○	○	○	○
The use case models have helped me clarify details about our use case. *	○	○	○	○	○	○
I will use the use case models for my work in the future. *	○	○	○	○	○	○
I will recommend the use case models to colleagues in my organization. *	○	○	○	○	○	○

Enterprise architecture and knowledge transfer

Indicate your level of agreement with the following statements about how the + CxC EAF could help

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not applicable
It could help in discussions with colleagues and / or collaboration partners within my organization. *	○	○	○	○	○	○
It could help when explaining use cases and solution architectures to colleagues. *	○	○	○	○	○	○
It could help with capturing knowledge. *	○	○	○	○	○	○
It could help with sharing knowledge within my organization and / or project partners. *	○	○	○	○	○	○
It could help when sharing knowledge across cities. *	○	○	○	○	○	○
It could help with reusing knowledge. *	○	○	○	○	○	○

Indicate your level of agreement on if + CxC EAF could support various types of activities

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Not applicable
It could support participatory design activities. *	○	○	○	○	○	○
It could support collaborative activities. *	○	○	○	○	○	○
It could support reflection on use cases. *	○	○	○	○	○	○
It could support identifying potential value added services. *	○	○	○	○	○	○
It could support creative activities such as brainstorming. *	○	○	○	○	○	○
It could support shared understanding to support decision making. *	○	○	○	○	○	○

Are there additional information that you would like to capture using the + CxC EAF?

What techniques does your organization use to document knowledge that individuals have learned during a project? eg interviews, observations or writing documentation.

What techniques does your organization use to share knowledge? eg collaboration, training or meetings.

Apart from the + CxC EAF, does your organization use Enterprise Architecture for other means? If so, how does it relate to this framework and can they be combined?

Which problems do you think enterprise architecture can or should attempt to solve?

If you have any other feedback or comments, please add them here.