HORIZON – CL5-2021-D4-02-01

Innovation Action

CBDC powered Smart PerFORrmance contracTs for Efficiency, Sustainable, Inclusive, Energy use

D2.3 Reference architecture and components functionality

Report Identifier:	D2.3		
Work-package:	WP2	**Task:**	T2.3
Responsible Partner:	European Dynamics (ED)	**Version Number:**	1.0
Due Date	M9	**Document Date**	28/08/2023
Distribution Security:	PU	**Deliverable Type:**	R
Keywords:	Reference architecture, software components, interfaces		
Project website: http://www.fortesie.eu/			

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101080029.

Quality Control

	Name	Organisation	Date
Editor	Kostas Panagopoulos	European Dynamics	24/07/2023
Peer review 1	Marta Vírseda	ENE	04/08/2023
Peer review 2	Ilvija Asmane	MESH	14/08/2023
Authorised by (Technical Coordinator)	Alkiviadis Giannakoulias	European Dynamics	28/08/2023
Authorised by (Quality Manager)	Kostas Panagopoulos	European Dynamics	28/08/2023
Submitted by (Project Coordinator)	Anastasia Garbi	European Dynamics	28/08/2023

Legal Disclaimer

FORTESIE is an EU project funded by the Horizon Europe (HORIZON) research and innovation programme under grant agreement No. 101080029. The information and views set out in this deliverable are those of the author(s) and do not necessarily reflect the official opinion of the European Union. The information in this document is provided “as is”, and no guarantee or warranty is given that the information is fit for any specific purpose. Neither the European Union institutions and bodies nor any person acting on their behalf may be held responsible for the use which may be made of the information contained therein. The FORTESIE Consortium members shall have no liability for damages of any kind including without limitation direct, special, indirect, or consequential damages that may result from the use of these materials subject to any liability which is mandatory due to applicable law.

Table of Contents

List of Figures

List of Tables

Abbreviations

FORTESIE	CBDC powered Smart PerFORrmance contracTs for Efficiency, Sustainable, Inclusive, Energy use
ESIE	Efficient Sustainable Inclusive Energy use
BIPV	Building Integrated Photovoltaics
EPC	Energy Performance Contract
SSH	Social Sciences and Humanities
€G	Green-euro
CBDC	Central Bank Digital Currency
LEED	Leadership in Energy and Environmental Design
GHG	Green-house Gas
ESCO	Energy Service Company
NGO	Non-Governmental Organisation
M&V	Measuring and Verification
OSS	One Stop Shop
UX	User Experience
UI	User Interface
HVAC	Heating Ventilation and Air Conditioning
GDPR	General Data Protection Regulation

Executive Summary

The purpose of this Deliverable is to design and define the FORTESIE architecture, to present the architectural framework for all the different subsystems that constitute the FORTESIE Platform and provide a functional description of each one of the subsystems.

In this deliverable, each respective component will be responsible to realise specific requirements as mentioned in the Deliverable D2.1: End-user and pilot requirements and use cases description. These components are associated to the digital services defined in D2.2.

1 Introduction

1.1 Project Introduction

The overall vision of FORTESIE is to design, demonstrate, validate and replicate innovative renovation packages in the building industry with Smart Performance-Based guarantees and financing, aiming at Efficient, Sustainable and Inclusive Energy (ESIE) use to accelerate the Renovation Wave in Europe. The renovation packages will combine state-of-theart construction materials and technologies components (prefabricated facades, BIPV, heat pumps, etc.), innovative digital technologies for measurement and verification, and attractive financing (e.g. contractual frameworks for smart performance guarantees, financing mechanisms, engagement techniques, green-euros, etc.), to raise the overall EPC value proposition. The renovation packages will be tailored to specific target groups needs and optimised to improve the ESIE performance considering energy, CO2 and comfort. Each package will be demonstrated and validated in real life use cases and customised for replication in all other partner countries for immediate market take-up.
Methodologies from Social Sciences and Humanities (SSH) will be adopted for:

a. the creation of collaborative business models that boost the Renovation Wave by considering all stakeholders' value and revenue streams,
b. novel incentivisation and behavioural change models that aim to stimulate long term engagement with focused interactions to adopt green behaviour
c. the incorporation of a digital currency, green-euro, (€G) for financing, rewarding and creating an inclusive / collective narrative in the fight against climate change
d. the collection of feedback for recommendations to policy and business stakeholders,
e. Mapping and understanding the complex interplay between the different stakeholders to deliver an engagement strategy across the value chain.

These demonstrations could potentially constitute the green-euro as a retail Central Bank Digital Currency (CBDC), hence revolutionising the financing of renovation approaches. An online marketplace, will be offering first level advice, directing consumers through the value chain of stakeholders and facilitating access to these "packaged" renovation services.

1.2 Deliverable Purpose

This report corresponds to Task 2.3 (Reference architecture tailored to renovation technologies for increased performance), the development of a reference architecture together with the functional specifications for all the subsystems of the FORTESIE Platform. Besides the Reference Architecture, this task will describe and specify the high-level architecture design, including dependencies, interactions between the FORTESIE subsystems and applications. Interfaces between the sub-systems will also be defined. The architectural design will be developed in line with the users' needs, and the use cases and scenarios as well as the behavioural model and the designed recommendation approach.
The main goal of Task 2.3 is to design a modular architecture, with truly extensible and independent elements, making use of as much as possible already-proven solutions, in order to enhance the interoperability with existing systems and maximize the final impact. The Reference Architecture encompasses the determination of the Software components that constitute the overall platform and the interfaces where necessary with the renovation components, covering requirements for privacy, legal/ethical issues and data protection.

1.3 ESIE measurements

The packaged renovation services of this project aim at Efficient, Sustainable and Inclusive Energy (ESIE) use. The improvement of ESIE performance considers energy, air quality (temperature, humidity, CO2) and comfort. The collection of these measurements is needed for recommendations to policy and business stakeholders to deliver an engagement strategy across the value chain.

1.3.1 LEED standard information

For the needs of FORTESIE project, we can use and adapt to principles or approach of LEED standard. LEED (Leadership in Energy and Environmental Design) is a green building rating system. This standard has applications for all building types, from new construction to existing buildings, and all building sectors (e.g. schools), from homes to hospitals and corporate headquarters. LEED provides a framework for identifying and implementing practical and measurable green building design, construction, operation, maintenance strategies and solutions (healthy, highly efficient, and cost-saving green buildings). LEED certificates sustainability achievement and leadership. Millions of people are living, working and learning in LEED-certified buildings around the world.

LEED is a holistic system that doesn't simply focus on one element of a building such as energy, water or health, rather it looks at the big picture factoring in all of the critical elements that work together to create the best building possible. The goal of LEED is to create better buildings that:

- Reduce contribution to global climate change
- Enhance individual human health
- Protect and restore water resources
- Protect and enhance biodiversity and ecosystem services
- Promote sustainable and regenerative material cycles
- Enhance community quality of life

Of all LEED credits, 35% of the credits in LEED are related to climate change, 20% of the credits directly impact human health, 15% of the credits impact water resources, 10% of the credits affect biodiversity, 10% of the credits relate to the green economy, 5% of the credits impact community and 5% of the credits impact natural resources. In LEED v4.1, a majority of the LEED credits are related to operational and embodied carbon.

LEED certified buildings save money, improve efficiency, lower carbon emissions and create healthier places for people. They are a critical part of addressing climate change and meeting ESG goals, enhancing resilience, and supporting more equitable communities. To achieve LEED certification, a project earns points by adhering to prerequisites and credits that address carbon, energy, water, waste, transportation, materials, health and indoor environmental quality. Projects go through a verification and review process by GBCI (Green Business Certification Inc.) and are awarded points that correspond to a level of LEED certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

LEED metrics (credit categories) are categorized with nine key areas of human and environmental health. These areas include sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, locations & linkages, awareness & education, innovation in design, and regional priority. They are contained in the LEED certification.

Figure 1 LEED certification

LEED Certification applies to all buildings everywhere, regardless of where they are in their life cycle. Rating Systems categorize your building project. Credit Categories target systems in the building. Credits are the actual strategies to improve your building. Points are earned when you correctly implement a strategy. When you work on a LEED certification project, you'll choose relevant credits that help you optimize building performance. Some credits offer a point range, giving you additional flexibility in terms of how sustainable you want to be. The more points earned, the more sustainable the building is.

RATING SYSTEMS	CREDIT CATEGORIES	CREDITS	POINTS
New Construction	Integrative Process	Integrative Process	1
Existing Buildings	Location & Transportation	Site Assessment	1
Interior Design	Sustainable Sites	Open Space	1
Homes	Water Efficiency	Water Metering	2
Neighborhoods	Energy & Atmosphere	High Priority Site	1
	Material & Resources	Bicycle Faciltiies	1
	Indoor Environmental Quality	Green Vehicles	2
	Innovation	Demand Response	1
	Regional Priority	Low Emitting Materials	2
		Interior Lighting	3
		Daylight	1
		Quality Views	1

Figure 2 LEED credits

Valuable measurements to be collected are summarized in the following table. According to LEED standard prerequisites, carbon, energy, water, waste, transportation, materials, health and indoor environmental quality should be measured.

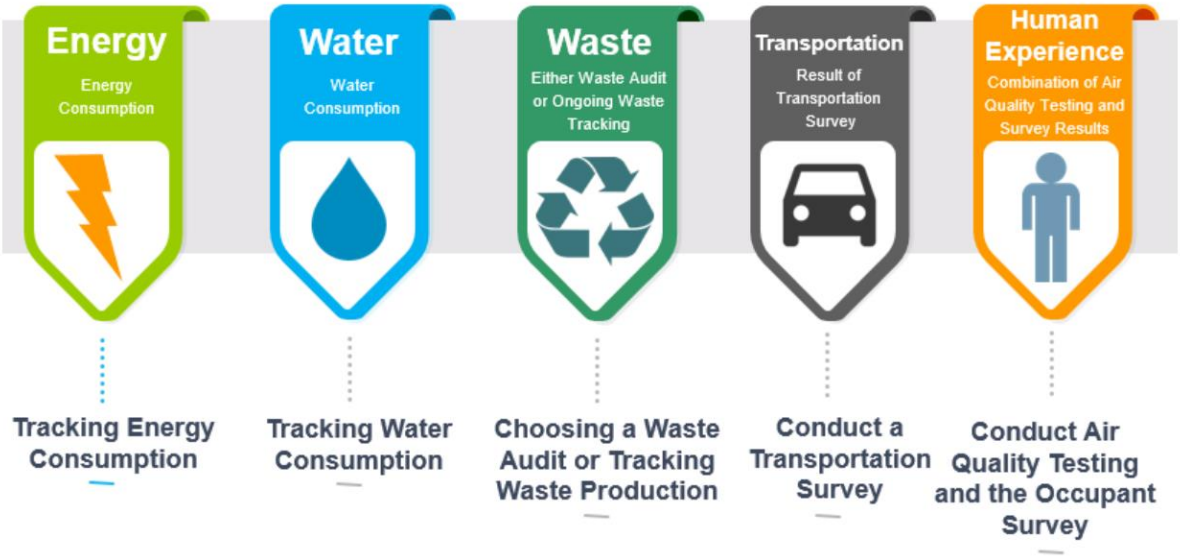

Figure 3 LEED measurements

1.3.2 LEED standard for FORTESIE Project

Relevance for FORTESIE

Out of these categories of measurement in the previous figure, for FORTESIE project we are interested in the energy consumption and air quality (the first and the last one) which are analysed below in more detail.

Building-level energy metering: For LEED certification, through building-level energy metering, energy management is supported and the energy wastages are targeted in order to achieve energy savings by tracking building-level energy use by using existing or newly installed building-level energy meters or sub-meters including electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc. For this are used utility-owned meters or other proprietary meters. The monitoring is committed for a five-year period beginning on the date the project accepts LEED certification. At a minimum, energy consumption must be tracked at one-month intervals. The calibration of meters is needed within the manufacturer's recommended interval if the project owner, management organization, or tenant owns the meter. Meters owned by third parties (e.g., utilities or governments) are exempt. LEED points are based on project **energy performance** across **two metrics**: **greenhouse gas emissions and source energy**.

These meters result in calculation of GHG emissions score rates of the building's total greenhouse gas emissions against the total greenhouse gas emissions of comparable high-performing buildings. The score is a value from 1-100 based on the project's GHG emissions per occupant and GHG emissions per floor area. To calculate a GHG emissions score, the following data is required:

- Annual Energy consumption (kBtu), with monthly or daily totals and distinguished by fuel type

-Gross floor area (sq. ft. or sq. m.)

-Weighted occupancy

-Weighted operating hours

-Outside air temperature

-Location

GHG emissions are adjusted for weighted operating hours and outside temperature and converted into daily GHG emissions using Equation 1.

Equation 1: adjusted GHG emissions = (GHG emissions * outside temperature adjustment factor *

Operating hours adjustment factor) / 365 days.

The operating hours adjustment factor is determined using the following figure. The adjustment factor accounts for typical LEED buildings operations of 50 hours a week.

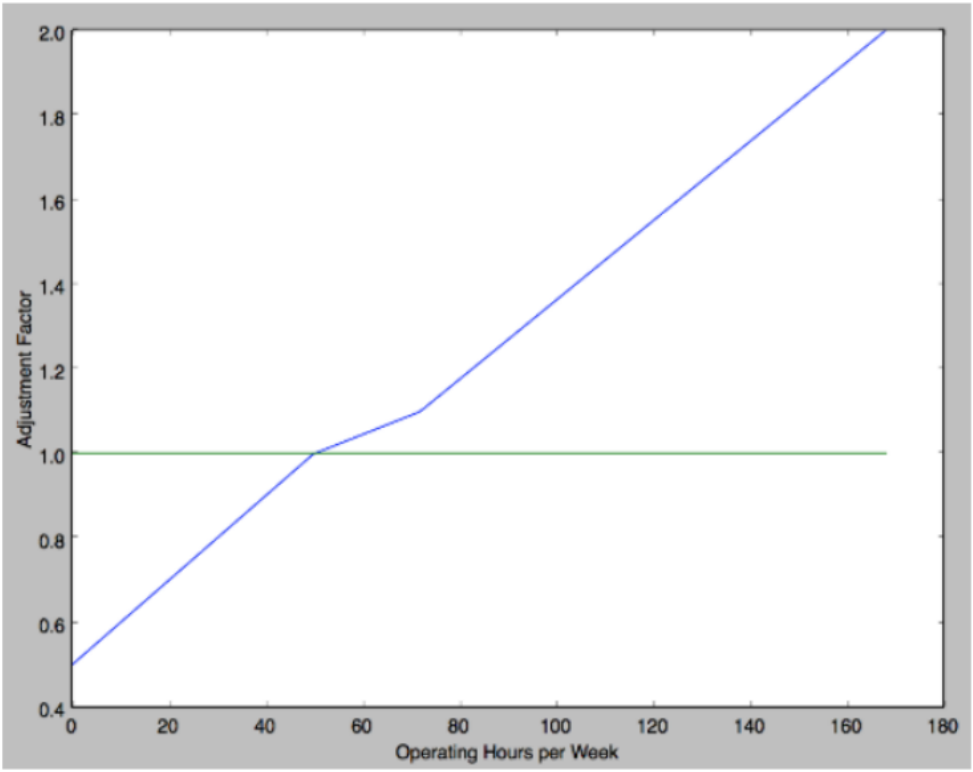

Figure 4 Adjustment Factor for Operating hours

GHG emissions per occupant is calculated by dividing the adjusted GHG emissions by the weighted occupancy.

Equation 2: GHG emissions per occupant = adjusted GHG emissions / weighted occupancy

GHG emissions per floor area is calculated by dividing the adjusted GHG emissions by the gross floor area.

Equation 3: GHG emissions per floor area = adjusted GHG emissions / gross floor area

The project's calculated GHG emissions per occupant and GHG emissions per floor area are input into the energy scoring function for the specific project type.

The source energy score rates the building's total energy consumption against the total energy consumption of comparable high-performing buildings. The measurement of the project's energy use is on a monthly basis for twelve consecutive months (one full year). Twelve months of energy use data is used to obtain an energy performance score. The score is a value from 1-100 based on the project's source energy consumption per occupant and per floor area. For Source Energy Score calculation, the following data is required:

-Annual Energy consumption, with monthly or daily totals and distinguished by fuel type

-Gross floor area (sq. ft. or sq. m.)

-Weighted occupancy

-Weighted operating hours

-Outside temperature

-Location

The step, after the collection of energy use, by fuel type for 12 consecutive months (one full year), is to provide as input building's energy use to LEED online platform. It is recommended to provide data formatted with each energy meter listed separately. If providing combined data include a calculation or summary table showing how the values were determined. Only combination of data from meters with identical service dates is accepted. After these steps, an energy performance score will automatically generate for your project once data is entered. The energy score will be calculated using the floor area, occupancy, weekly operating hours, project location, and emission factor information provided for the project.

Indoor Environmental Quality Performance: An assessment is conducted on how well the building is performing for the occupants, in particular with regards to indoor air quality and comfort. For this assessment, it is needed to conduct an **occupant satisfaction survey** and/or an **indoor air quality evaluation**.

For the **occupant satisfaction survey**, regular building occupants must be surveyed. The required number of responses that must be received is outlined in the equation and figure below.

Equation 4: Response rate= 100 * (0.25 / square root (occupancy / 500))

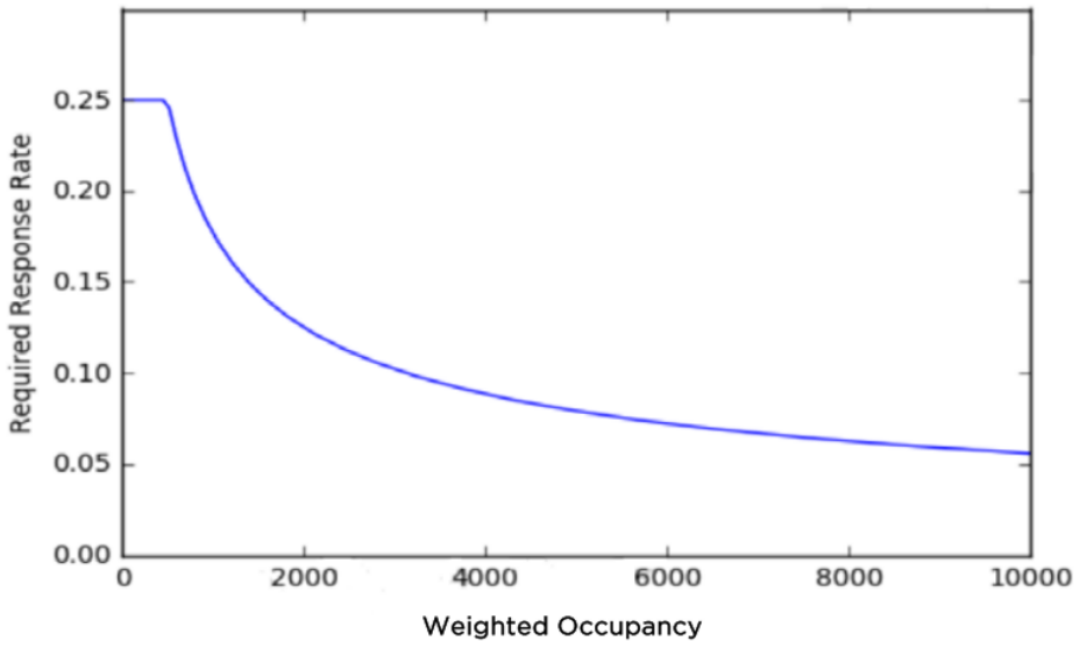

Figure 5 Required Response Rate for Occupant satisfaction survey

The occupant satisfaction score rates the satisfaction occupants have with the building against satisfaction of occupants of comparable LEED certified buildings. The score is a value from 1-100 based on the project's average occupant satisfaction level taking and the variance in the occupant responses. To calculate an occupant satisfaction score, via the occupant satisfaction survey, the following data is required:

-Number of regular building occupants and visitors

-For Hospitality projects, number of hotel or lodging guests (these occupants may be excluded from the survey)

-Occupant satisfaction level (for each survey response)

The survey should be conducted at least once per year and an occupant satisfaction score be calculated for the project. The projects occupant satisfaction score is calculated by taking the average of the satisfaction levels for each building occupant that completes the survey, and considering the variance in the responses, using the following equation.

Equation: Occupant satisfaction score = (Average occupant satisfaction level x 10) - variance in occupant satisfaction level

The indoor air quality evaluation should be conducted at least once per year. Measured contaminant levels should be provided as input and calculate a CO2 score and TVOC score for the project. Testing for any of the following contaminants is needed:

For Inorganic Contaminants:

-Carbon Monoxide (CO)

-Carbon Dioxide (CO2)

-Ozone (O3)

-PM2.5

For Volatile Organic Compounds:

-Acetaldehyde (75-07-0)

-Benzene (71-43-2)

-Styrene (100-42-5)

-Toluene (108-88-3)

-Naphthalene (91-20-3)

-Dichlorobenzene (1,4-) (106-46-7)

-Xylenes-total (108-38-3, 95-47-6, and 106-42-3)

-Formaldehyde (50-00-0)

-Total volatile organic compounds (TVOC) (as defined in ISO 16000-6)

Points are awarded based on the results from the CO2 and TVOC measurements.

The indoor air measurements are taken in locations representative of all occupied spaces, within the breathing zone (between 3 and 6 feet (900 and 1800 millimeters above the floor), during normal occupied hours, under typical minimum ventilation conditions.

For the indoor air quality evaluation CO2 and TVOC score are needed.

The **CO2 score** rates the building's CO2 levels against the industry benchmark level of 1000 ppm. The score is a value from 1-100 based on the project's average 95th percentile CO2 value. To calculate a CO2 score, the following data is required:

1. Measurement location

2. Date and time for each measurement

3. Measured CO2 concentration (ppm)

The 95th percentile value for each location (CO295th) is calculated. The 95th percentile is the CO2 value where 95% of the data falls below. An average CO295th value is calculated for the indoor environmental quality evaluation. The project's average CO295th value is then input into the CO2 scoring function (see following figure) to produce a CO2 score for the project. The CO2 scoring function was developed based on the industry benchmark level of 1000 ppm.

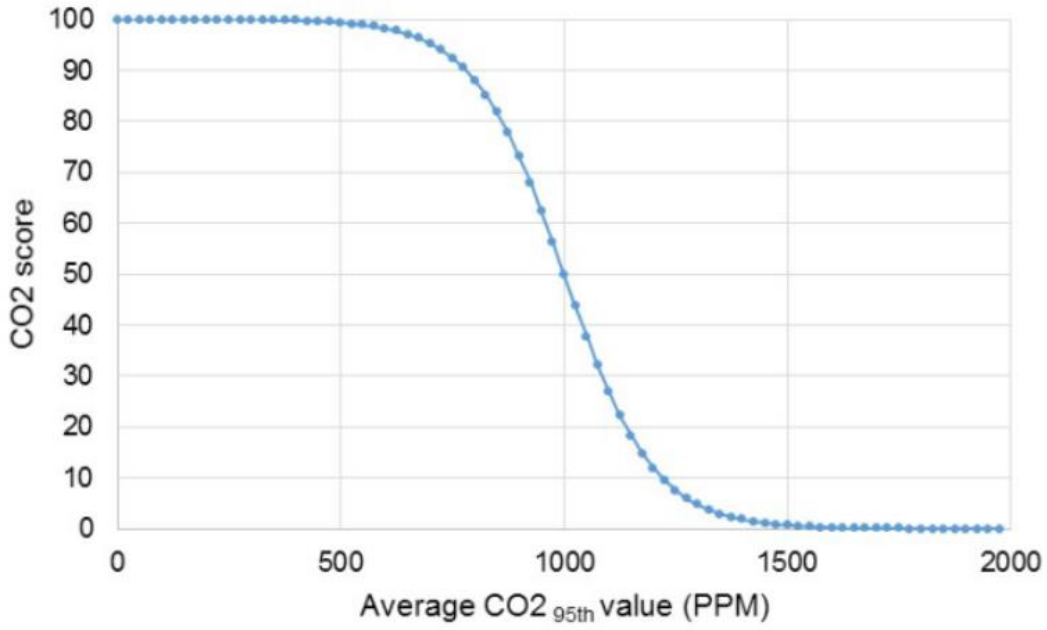

Figure 6 CO2 scoring function

The **TVOC score** rates the building's TVOC levels against the industry benchmark level of 500 µg/m3. The score is a value from 1-100 based on the project's maximum TVOC value. To calculate a TVOC score, the following data is required:

-Measurement location

-Measurement date(s)

-Start and end time(s) for each measurement

-Measured TVOC concentration (µg/m3)

An average TVOC level (TVOCavg) is calculated for each location by averaging all of the TVOC measurements taken at that location during the indoor air quality evaluation. A maximum TVOC level (TVOCmax) is determined by taking the highest TVOCavg value for the indoor environmental quality evaluation. The project's maximum TVOC level (TVOCmax) is then input into the TVOC scoring function to produce a TVOC score for the project. The TVOC scoring function was developed based on the LEED TVOC limit of 500 µg/m3.

Concerning indoor environmental quality performance, the human experience score is based on the three previously described components which are weighted differently:

1. Occupant satisfaction score (50% weighting)

2. CO2 score (25% weighing)

3. TVOC score (25% weighting)

The project's satisfaction, CO2 measurements, and TVOC measurements are translated into a human experience score, comprised of three sub-scores: an occupant satisfaction score, a CO2 score, and a TVOC score. At this time the additional inorganic contaminants and volatile organic compounds are not included in the human experience score. For a more comprehensive indoor air quality evaluation, projects are encouraged to include all or some of these additional contaminants in their measurements.

LEED certification for Homes/Commercial Buildings involves the following steps:

Registration of a project by providing basic information and submitting payment, and ensure that the minimum requirements that make a project appropriate for pursuing LEED are covered. These include: measurements should affect all contiguous land that is associated with the project and supports its typical operations, for example parking and sidewalks, septic or stormwater treatment equipment and landscaping. The LEED boundary may not unreasonably exclude portions of the building, space, or site to give the project an advantage in complying with credit requirements. The LEED project must accurately communicate the scope of the certifying project in all promotional and descriptive materials and distinguish it from any non-certifying space.

A building cannot be partially certified, but must be a complete, permanent building. Single units in multi-family buildings cannot participate in LEED unless the entire building is registered to participate. Stacked attached homes, such as condominium flats, are considered to be multi-family buildings. Every unit within a multi-family building must earn the same certification level (e.g. Silver, Gold). Single-family side-by-side attached homes, such as row houses, are considered to be separate buildings

Requirements for commercial buildings: For LEED certification, commercial buildings must:

-Be in a permanent location on existing land

-Use reasonable LEED boundaries

-Comply with project size requirements (e.g. minimum floor area or occupancy requirements) or comply with environmental laws.

The process starts with on-site verification that includes necessary information, calculations and documentation to a locally appointed LEED Green Rater. To verify that the project is on track and properly achieving certain milestones and steps in the LEED certification process, on-site verification is needed to be coordinated throughout the design and construction process.

Following the information and data collection, the LEED application is submitted to the Green Business Certification Inc. (GBCI) for review. To submit for certification review, LEED v4.1 O+M projects must be fully operating for at least one year.

Final step is the certification from GBCI and promotion of the achieved accomplishments.

1.3.3 FORTESIE measurements

The improvement of ESIE performance includes energy, CO2 and comfort. Therefore, adapting to the prerequisites of relevant standards (e.g. LEED) that are essential for FORTESIE project, there is need for the collection of data i.e. energy consumption, CO2 measurements around the area, average indoor/outdoor conditions (temperature, humidity, human comfort).

2 System components specification (ED, ALL)

Any system has a set of prerequisites, in either hardware components or software resources, which support a smooth operation process. The requirements of any system should be built on the users' requirements, in a way that users will have the best possible experience. As such, each of the users' requirements should be addressed by the FORTESIE system components.

2.1 Components Functional Specifications

The Functional Requirements for FORTESIE project summarized below (based on the requirements and user stories that have been concluded in D2.1, presenting an identifier, each title) are associated with the relative FORTESIE services (D2.2) and components specifications (with the relevant component specifications identifier). These requirements given by all pilots are allocated to the relevant components and services that will address and demonstrate them. This table is presented below:

Table 1 Components Functional Specifications

UR#	Description of Functional User Requirement	Related Service	CS#	Component Specifications
F1	The FORTESIE solution shall be able to allow the definition of a smart Energy Performance Contract based on ESIE measures.	Improvements achieved calculation service and Green Euro Rewarding Service (Smart EPC Component)	1	The contract Rules of the EPC will be translated to Smart Contract Rules (Smart EPC) to put the ESCO's EPC business logic in code suitable for the blockchain. These smart contracts will have to be parameterized with the specific conditions of each client. These data will be saved in the blockchain so that the process can be trusted.
F2	The FORTESIE solution shall be able to store the relevant data needed for the Energy Performance Contract.	Data Sovereignty Service/ User profile Service	2	The measurements of sensing components and External Systems should be received by the FORTESIE Data sovereignty layer (e.g. through Gateway devices, or through established interfaces with other systems or databases). The data sovereignty should store the data measurements and should establish the relevant interfaces to be shared to other data consuming services, but first they should be homogenised, and anonymised. Also the data should be open and accessible following the FAIR principles.
			3	Data visualization for facility managers or building managers of governmental buildings should ensure the monitoring of the building performance. The monitoring of building performance should ensure security for companies.
		Improvements achieved calculation service and Green Euro Rewarding Service (EPC Component)	1	For a given period, EPC calculates the bonuses / malus of a given customer through consumption, variables defined and smart contract. These calculations are presented to ESCOs who request it through a relevant web front-end. An end-point API in the EPC component will serve the data to the mobile app (for end-users). The definition of EPC is extended in FORTESIE so that there is direct connection with Green-euro app, to execute automatic execution (smart EPC) of a payment is done if real energy consumption is below the baseline or as agreed in the contract.
F3	The FORTESIE solution shall be able to provide a trusted method for guaranteeing that the information stored (which is needed for the calculation of the Energy	Improvements achieved calculation service and Green Euro Rewarding	4	For M&V Component, blockchain infrastructure will be created to transparently store all the data that needs to be verified. Since the blockchain may share a public record, sensitive information must be stored in anonymized form, possibly using hashing mechanisms. EPC, Green Euro and mobile application will rely their fact-checking

	Performance Contract) is not altered.	service (M&V Component)		mechanisms on the trusted registry of hashes managed by the M&V.
F4	The FORTESIE solution shall be able to provide a means for the final user to consult the information related to the Energy Performance Contract stored and calculated in it (only the relevant information for that user).	OSS – Marketplace services (Knowledge base service/Info & funding service)	5a/ 5b	The marketplace is One Stop Shop that is accessible online, and refers also to the local physical One Stop Shops to be established. In the online platform it presents information about what is the Renovation wave, why it is important for Europe and its policies, what it means for the consumer and the household. In addition, it presents innovative financial schemes, investments and smart contracts should be accessible and transparent to end-users. Also the success stories that are being developed in FORTESIE will be presented, to understand the contribution of building renovation technologies to the building and personal life comfort and wellbeing, but also to demonstrate what is the overall costs and benefits. The marketplace will be a way to present the renovation packages that are being built for each target group. It also acts as a matchmaking service for connecting local suppliers with interesting consumers of any kind.
		User Profile Service (Mobile Application)/ Data Sovereignty Service	3/2	The mobile application should allow end users to access to EPC and M&V so that e.g. any household can view the periodic building performance improvements for various periods and the information about the Smart contract status (e.g. current payment, current and past performance, etc. to be defined with the respective pilots) and the real results of the building. For public buildings the real profits visualization of the implementation of the green solutions is important for the contribution of users. The data sovereignty layer provides to the mobile app the stored savings and performance improvements that have occurred for a period of time requested by the user.
		Improvements achieved calculation service and Green Euro Rewarding service (EPC component) / Data Sovereignty Service	1/2	The EPC should inform end-users about the performance improvements of their building/apartment achieved in a predefined period. The EPC should inform users at any time about the contract details with the ESCO, the guaranteed performance and the investment plan. For a given period, it calculates the bonuses / malus of a given customer through consumption, variables defined and smart contract. These calculations are presented to end-users through the mobile app, so there will be an endpoint to serve this data to the mobile application.

				The Data sovereignty should be able to provide the EPC module with the actual data for any requested period for a specific building / home /user.
		Improvements achieved calculation service and Green Euro Rewarding service (M&V component)	4	The data sovereignty needs to present to the M&V module the energy consumption results from ESIE measures.
		Improvements achieved calculation service and Green Euro Rewarding service (Green Euro rewarding Component)	6	FORTESIE Application should motivate the visitors (Pilot 1 and Pilot 6) and employees (Pilot 1) to contribute to green operations and notify them about the relevant results. Links between the FORTESIE app and the CCO2 app should allow for a simple and attractive UX for all pilots users. Some data should be redundant on both apps (automated rewards gains credited in €Gs credited on the user CCO2 account, as defined in the smart EPC) and some data should not (energy consumption, answer to quiz and incentive programs).
F5	The FORTESIE solution shall be able to provide means for the relevant stakeholders (e.g. ESCOs, renovation companies, potential investors) to consult the information related to the Energy Performance Contract stored and calculated in it.	OSS – Marketplace services (Knowledge base service)	5a	The OSS Marketplace component serves as a repository of information about building renovation projects. It provides stakeholders with access to relevant data, reports, case studies, and best practices, financing schemes, helping them to make informed decisions about their projects. (Online documentation could also exist describing the system in detail. Online FAQ easily accessible, responding to most of questions and describing the system and its rational could be also added.) Evidence for the implementation of ESIE measures (e.g. energy savings, indoor climate improvements) in different building facilities should be accessible to customers, service providers, policy makers or other interested target group. The marketplace should provide information about ESIE measures (with trustful evidence) and financial options (e.g. costs of the interventions, details for Energy Performance Contracts) to end-users (e.g. homeowners, prosumers, labor syndicate members). Also, it should provide information about start-of-the-art technologies and systems (e.g. façade renovations, PV system performance improvement). Marketplace should provide access to information (e.g. economic and environmental

				impact, how to get return on investments) concerning investments on energy efficiency measures (e.g. benefits, savings in HVAC investments, minimization of maintenance costs for buildings of schools) for banks/ investors/ companies. Marketplace should provide a place for policy makers to be informed trustfully about innovative financing schemes of renovation processes that can be applied for Public Administration. Marketplace (Knowledge base component) should provide solid information concerning state-of-the-art renovation systems (e.g. materials for the façades, ventilation systems) for companies (project designers, renovation companies, facility managers): Marketplace should provide information about the operation of energy performance contracting (EPC) and the benefits of the new technologies implementation in a comprehensive way. Marketplace should provide Energy Performance Contracts offerings describing the benefits that FORTESIE solution offers to both the owners and the ESCOs. Marketplace should provide information about ventilation system renovation projects (e.g. ESIE measurements) and about funding (e.g. payback period for relevant investments).
		Data Sovereignty Service/OSS Marketplace Services	2/5	Through Marketplace, the FORTESIE professional stakeholders of pilots should be able to access to EPC and M&V, to view the periodic building performance improvements for various periods and the information about the Smart contract status (e.g. terms, current payment, current and past performance, etc. to be defined with the respective pilots). In addition the marketplace should visualise and notify the FORTESIE internal stakeholders about the real results (e.g. benefits) of ESIE measures and renovation technologies (e.g. emissions reduction) for all buildings (facilities) owners or managers, or relevant ESCOs.
F6	The FORTESIE solution shall be able to compare the before and after energy consumption or demand of the building.	Data Analysis Service	7	The data analysis service is responsible for performing pre-defined analyses over the stored data. In particular, the data analysis service requests and receives data from the Data Sovereignty Service. The requested data contains the before and/or current energy consumption for the building and, information about comfort and personal preferences. Then, the data analysis service performs a number of pre-defined

				analyses, which include comparing before and after energy consumption, investigating seasonal trends and correlations as well as running personalised analyses. The output of the data analysis service will be presented in the gamified mobile app. The core objective of this service is to extract insights and knowledge from the data to facilitate the stakeholders to make informed decisions.
		Data Sovereignty Service	2	The data sovereignty stores and provides the comparison (before and after) of measurements of ESIE including efficiency of the facilities, costs and GHG emissions monitoring, etc. as they are specified for each pilot. The provision of accurate information about the facility's behaviour before and after intervention is the basis for the calculation of the results provided by ESIE measures.
		User Profile Service (Gamified mobile Application)	3	Data visualization component generates visualisations, charts, and reports that help to communicate the insights and findings (e.g. energy savings, bills cost decrease, CO_2 emissions decrease, comfort increase) from the data analysis concerning the implementation of ESIE measures in a building for the end-users (owners, citizens/users of pool/employees) and stakeholders (NGO/ESCOs/Companies).
		Improvements Achieved calculation service and Green Euro Rewarding service (EPC component)	1	Users will be able to check the details of the contract as well as the difference in consumption between previous and current data through the mobile app, which will connect to the EPC module via an endpoint. Automatic payment of green-euros is done as a rewards when energy consumption targets defined in the Efficiency contract are met.
F7	The FORTESIE solution shall be able to provide a comparative of performance of buildings from an energy and sustainability perspective.	Data Analysis service	7	The data analysis service is responsible for performing pre-defined analyses over the stored data. In particular, the data analysis service requests and receives data from the Data Sovereignty. The requested data contains the before and/or current energy consumption for the building, information about comfort and personal preferences. Then, the data analysis service performs a number of pre-defined analyses, which include comparing before and after energy consumption, investigating seasonal trends and correlations as well as running personalised analyses. The output of the data analysis service will be presented in the gamified mobile application.

		User Profile Service (Gamified Mobile Application)	3	Data visualization component generates visualisations, charts, and reports that help to communicate the insights and findings from the data analysis (e.g. energy savings, bills cost decrease, CO_2 emissions decrease, comfort increase,) concerning the implementation of ESIE measures in a building so that end-users (owners, citizens or pool operators/employees) and stakeholders (NGO, provider of digital solutions, renovation company) are convinced/satisfied.
F8	The FORTESIE solution shall be able to provide personalised feedback to consumers regarding their progress in achieving energy savings.	User Engagement Service/ Behavior & Recommendation Service	8/9	Notification-automation component sends notifications and messages to users, such as push notifications (e.g. when they have managed to achieve high energy savings or when meter data is showing abnormal energy use): a. Mobile notifications b. In-app notifications This personalised feedback is addressed to the households, the museum and office visitors or pool operators who need to be engaged in the ESIE performance improvements along with the building itself in the case of EEF and GSIS and the citizens who visit the municipal swimming pool (GK). The mobile application will display the performance of the user in line with the role the user can play in the building. Important information about the current building performance will be displayed to support users' actions in accordance with recommendations for performance increase and motivating users to accept challenges tailored to their role. Each type of end user will be provided with different kind of data visualisation that can be of interest (for example the museum visitor is interested about the indoor current temperature and humidity and the one that is recommended to ensure the maintenance of the artwork, while the pool visitor will be informed about the pool water temperature and the potential benefit economic and social of reducing the temperature by 1°C). This will be enabled through an in-app profiling that is filled out at the first download of the app.
		User Profile Service	3	UI **component** for register, sign up, login, gathering user info. This profile setup addresses the households, the museum and office visitors who need to be engaged in the ESIE performance improvements along with the building itself in the case of EEF and GSIS and the citizens who go to swim in the municipal swimming pool.

				The users will be asked as a first task to register and provide the minimum necessary information to be able to tailor recommendations and progress to them. Each group of users will need to provide tailored information to their potential role in the building performance improvements, and always in full compliance with GDPR and all legal and ethical standards. All input necessary for all interaction with the system will be gathered here.
			Data analysis service	7	The data analysis service is responsible for performing pre-defined analyses over the stored data. In particular, the data analysis service requests and receives data from the Data Sovereignty. The requested data contains the before and/or current energy consumption for the building, information about comfort and personal preferences. Then, the data analysis service performs a number of pre-defined analyses, which include comparing before and after energy consumption, investigating seasonal trends and correlations as well as running personalised analyses. The output of the data analysis service will be presented in the gamified mobile application.
			Improvements achieved calculation service and Green Euro Rewarding Service (Green Euro component)	6	Notifications about the results of ESIE measures in a building (e.g. bills cost decrease, comfort increase, building sustainability) and the relevant rewardings for green operations should be provided to the visitor (Pilot 1 and 6) and employee (Pilot 1). Green Euro Rewarding Component should inform the visitor (Pilot 1 and 6) and employees (Pilot 1) about the results of their green operations so that can be rewarded. Links between the FORTESIE app and the CCO2 app should allow for a simple and attractive UX for all pilots users. Some data should be redundant on both apps (automated rewards gains credited in €G credited on the user CCO2 account, as defined in the smart EPC) and some data should not (energy consumption, answer to quiz and incentive programs).
					Automatic payment of green-euros as a rewards should be done when energy consumption targets defined in the Efficiency contract are met. Green Euro Wallet component should allow the spending of green-euros in all shops or on specific proposition from ESCO or commercial partners of the ESCO or FORTESIE Consortium.

F9	The FORTESIE solution shall be able to offer personalised challenges to the consumers related to their energy consumption.	Behaviour & Recommendation Service	9	The solution includes a library of challenges that are targeted to different types of users based on the user's energy use contexts, motivation and behaviour. The component will be specified based on analysis of the user's profile and other self-report data (e.g. survey responses) and building's performance data analysis. User's engagement with the digital components triggers the challenges.
		Data Analysis service	7	The data analysis service is responsible for performing pre-defined analyses over the stored data. In particular, the data analysis service requests and receives data from the Data Sovereignty. The requested data contains the before and/or current energy consumption for the building, information about comfort and personal preferences. Then, the data analysis service performs a number of pre-defined analyses, which include comparing before and after energy consumption, investigating seasonal trends and correlations as well as running personalised analyses. These analyses will facilitate the Behaviour & Recommendation service to generate and provide personalised challenges to the consumers related to their energy consumption.
		User Engagement Service/ User Profile Service	8/3	Notification-automation component sends notifications and messages to users, such as push notifications and emails (e.g. when they have managed to achieve high energy savings). a. Mobile notifications b. Email (for more broad information) c. In-app notification Especially the in-app notifications will be directly linked to the KPIs relevant for the pilot, and link directly to the meter data. Personalised Challenges will be provided to the mobile application of the user similar to those known from sports' motivation apps. The challenges will be generated from the recommendation engine and will be communicated to the user through the mobile application. The user will be able to accept /activate challenges or reject challenges. The mobile app will visualise the active challenges, the rejected challenges, and the completed challenges. It will also keep a challenges record, to monitor the achieved challenges and gained batches and/or rewards as defined by the recommendation engine.

				Access and control of the building performance parameters should be provided to employees (Pilot 1) so that they can take and promote relevant actions (for example to issue a poll for visitors to reduce the temperature when energy consumption increases, or to switch on the ventilation when the air quality drops). The employees will be involved in the decision about the environmental conditions of their workspace, so that their well-being and comfort at work is ensured. Information will be provided to prosumers about ESIE measures and training on how they should manage the energy consumption of their building.
F10	The FORTESIE solution shall be able to generate personalised recommendations and rewards to guide the consumers towards a more energy efficient behaviour.	Behaviour & Recommendation service	9	The solution includes a library of recommendations and rewards that are targeted to different types of users based on the user's energy use contexts, motivation, and behaviour. Analysis of the user's profile and other self-report data (e.g. survey responses), building's performance data analysis, and user's engagement with the digital components triggers the recommendations and rewards.
		User Engagement Service	8	Notification -automation component sends notifications and messages to users, such as push notifications, and emails (e.g. when they have managed to achieve high energy savings). a. Mobile notifications b. Email c. In-app notifications This component will be displaying the performance of the user in line with the role he can play, in the building, and important information about the current building performance, to support taking action from his part. The personalised recommendations/tips will be selected/generated by the Recommendation Engine – Component (based on the behavioural analysis outcomes of the Behavioural Model) and will be offered to the user by the mobile application. Recommendations/tips will be provided to the end-users for acceptance to increase performance and motivate users tailored to their role to improve energy behaviour. Each type of end user will be provided with different kinds of data visualisation that can be of interest.
		Improvements Achieved	6	Notifications about environmentally friendly or energy saving operations (e.g. results and

		calculation service and Green Euro Rewarding service (Green Euro Component)		relevant rewardings) will be provided to the visitor (Pilot 1 and 6) and employee (Pilot 1) or pool operator (pilot 7). Links between the FORTESIE app and the CCO2 app should allow for a simple and attractive UX for all pilots users. Some data should be redundant on both apps (automated rewards gains credited in €G credited on the user CCO2 account, as defined in the smart EPC) and some data should not (energy consumption, answer to quiz and incentive programs).
F11	The FORTESIE solution may be able to integrate non-economical rewards (e.g., badges) and/or economical rewards (e.g. Green euro).	Behaviour model& recommendation service / User Engagement Service	9/8	When the user has successfully completed a challenge as defined in F9, they will receive a non-economical (e.g. badge) or economical (Green euro) reward and are notified of this reward in the app. The notification-automation component sends notifications and messages to users, such as push notifications (e.g. when they have managed to achieve high energy savings) and receives rewards through: a. Mobile notifications b. Email c. In-app notification For group level, public buildings, possible rewards can be organized through group organisations in the app (clustering users from same geographic area). For live user engagement, tailor made activities can engage the end users (target group level) for each demo through engagement activities outside the app (so far the pool, school and museum are the demos identified, but live engagement can also be optional for the poverty households). These engagement could be live poll stations, quizzes, competitions between floors or classrooms or visitor surveys (all live engagement will be demo leader driven).
		Improvements Achieved calculation service and Green Euro Rewarding service (Green Euro Component)	6	FORTESIE mobile application will be displaying recommendations for performance increase and allowing users to engage with the service. Links between the FORTESIE app and the CCO2 app should allow for a simple and attractive UX for all pilots users. Some data should be redundant on both apps (automated rewards gains credited in €G credited on the user CCO2 account, as defined in the smart EPC) some data should not (energy consumption, answer to quiz and incentive programs.

		Data analysis Service	7	The data analysis service is responsible for performing pre-defined analyses over the stored data. In particular, the data analysis service requests and receives data from the Data Sovereignty. The requested data contains the before and/or current energy consumption for the building, information about comfort and personal preferences. Then, the data analysis service performs a number of pre-defined analyses, which include comparing before and after energy consumption, investigating seasonal trends and correlations as well as running personalised analyses. These analyses will provide valuable input in the process of rewarding the user.
		Improvements Achieved calculation service and Green Euro Rewarding service (Green Euro component)	6	The museum visitor (Pilot 1) and office employees (Pilot 5) contribute to green operations through FORTESIE mobile app. They are notified about the results and the relevant rewardings through both the FORTESIE mobile app and the CCO2 app. Links between the FORTESIE app and the CCO2 app should allow for a simple and attractive UX for all pilots users. Some data should be redundant on both apps (automated rewards gains credited in €G credited on the user CCO2 account, as defined in the smart EPC) and some data should not (energy consumption, answer to quiz and incentive programs).
F12	The FORTESIE solution shall be able to offer an OSS that provides presential and online services, via a marketplace.	OSS – Marketplace Services (Renovation Recommendation Service)	5c	The OSS marketplace informs about the renovation packages including renovation components, digitisation components, and clear guarantees, financing options and the terms of the Smart contracts tailored to specific target group The OSS offers this information through a user-friendly web interface with recommendations regarding each building type.
		OSS – Marketplace Services (Info & funding service)	5b	This OSS Marketplace component provides information about funding opportunities for building renovation projects (e.g. application process, eligibility criteria or funding requirements). Online documentation could also exist describing the system in detail. Online FAQ easily accessible, responding to most of questions and describing the system and its rational could be also added.
		OSS – Marketplace Services (Match-making service)	5d	The OSS marketplace offers Searches for local partners and services, as well as renovation packages which match to the location, group type, thus helping them to find the right partners and

				build successful collaborations on building renovation projects.

2.2 Non-Functional Requirements

Non-functional requirements (defined in D2.1) for FORTESIE platform components are outlined in the following table.

Table 2 Non-Functional Requirements for Components Specifications

UR#	Component Specification category	Description of Non-Functional User Requirement
NF1	Accuracy	The FORTESIE solution must be able to have accurate calculations in order to increase trust of stakeholders.
NF2	Interoperability	The FORTESIE solution shall be able to incorporate a new type of currency based on ESIE performance improvements (Green euro).
NF3	Interoperability	The FORTESIE solution may use green euros to finance green achievements.
NF4	Supportability /Scalability	The FORTESIE approach shall be able to guide the stakeholders to design and implement innovative financing models based on ESIE measures to improve comfort and living conditions.
NF5		The FORTESIE approach shall be able to guide the stakeholders to design and implement building renovations using innovative state-of-the-art materials.
NF6		The FORTESIE approach shall be able to guide the stakeholders to design and implement building renovations that improve ESIE measurements and comfort.
NF7		The FORTESIE approach shall be able to guide the stakeholders to design and implement dissemination strategies focusing on **informative** aspects related to ESIE concepts to generate **trust**.
NF8		The FORTESIE approach shall be able to guide the stakeholders to design and implement dissemination strategies focusing on the **green / environmental** impact of ESIE concepts.
NF9		The FORTESIE approach shall be able to guide the stakeholders to design and implement dissemination strategies focusing on **economical** benefits related to ESIE concepts.

NF10		The FORTESIE approach shall be able to guide the stakeholders to design and implement dissemination strategies focusing on **new business opportunities** related to ESIE concepts.
NF11		The FORTESIE approach shall be able to guide the stakeholders to design and implement **motivation** strategies focusing on **informative** aspects related to ESIE concepts to generate **trust**.
NF12		The FORTESIE approach shall be able to guide the stakeholders to design and implement **motivation** strategies focusing on the **green / environmental** impact of ESIE concepts.
NF13		The FORTESIE approach shall be able to guide the stakeholders to design and implement **motivation** strategies focusing on **economical** benefits related to ESIE concepts.
NF14		The FORTESIE approach shall be able to guide the stakeholders to offer a OSS that provides information regarding façade renovation technologies, innovative digital services for a renovation and attractive and innovative financing schemes for renovation processes.
NF15	Compliance	The FORTESIE solution shall be able to guarantee GDPR compliance.
NF16	User friendliness	The FORTESIE solution shall be able to provide a user-friendly and easy-to-use interface for the parts that the final user needs to interact with it.

3 Architecture overview (ED)

3.1 FORTESIE Components

The FORTESIE platform unifies different interdisciplinary modules which will be presented in this section. By taking into consideration the user requirements and system requirements, FORTESIE converges into an overall platform that aims to provide a friendly and useful tool to the end users.

The FORTESIE project will provide the measurement and monitoring of energy consumption with aim to incentivise more energy efficient behaviour, personalised recommendations and the use of an alternative green-euro currency.

The users will be provided with a mobile application to connect. The measurements will be retrieved through a local gateway device and stored to the Esthesis platform (Data Sovereignty module). Data consuming Applications (the Behavioural model, the Recommendation Engine and the Data Analytics component) will provide Analytics, Recommendations and Notifications as input to the relevant components of the Architecture.

The residential users will be able to use the FORTESIE mobile application and create a profile providing some information related to their energy consumption. Through the FORTESIE mobile application, the users will be able to continuously monitor their energy consumption and earn green-euro.

In a high level architecture the FORTESIE platform consist of the following main parts:

1. The **FORTESIE mobile application** will be the main interface that the users (i.e. consumers) will use in order to interact with the FORTESIE platform. It will provide the user interfaces which collect the **end-users' input** (e.g. inserting information about their energy consumption behaviour, preferences, configurations or actions) and send it to the FORTESIE platform to be stored. It will communicate with the FORTESIE platform to fetch data from data consuming applications (e.g. analytics for energy measurements, recommendations, notifications, green-euro application-wallet) and display them to the users (**data visualization, notifications and recommendations component**). Display functionality will be implemented for the energy measurements of the sensing components to be accessible to the mobile application of the end-user. The **green-euro wallet** will be the main application to collect and spend green-euro credits, i.e. enable the circulation of the green-euro currency within the FORTESIE ecosystem. The green-euro credit mobile application will be linked to the FORTESIE mobile application. It will also be connected to Energy Performance Contracts (Smart Contracts) in order to be fed and updated with the relevant information. Energy payment data, when available, could also be sent back to the FORTESIE Platform, as a check on user's energy usage.
   In addition, the FORTESIE platform is responsible to store the user's input (i.e. profile, preferences, energy consumption related behaviour etc.), provided by the FORTESIE mobile application. This data will be input for the Data Consuming Applications (i.e. analytics, recommendations, notifications etc.) which will be able to be displayed in the FORTESIE mobile application.
2. **Building Components**: These consist of:
   a. The **sensing components** or devices will be installed and will measure the energy consumption of the relevant building or other building conditions (e.g. temperature, humidity, air quality).

   b. The **external systems** that will provide additional data and measurements namely the region climate conditions and the indoor climate conditions i.e. temperature, humidity.
   c. The **FORTESIE gateway device**: The FORTESIE gateway will optionally be installed in each building in order to collect and forward all measurements to the data sovereignty module. The building gateway will be developed for the project in line with the relevant specifications. It communicates with the above mentioned sensing components, collects all data and measurements and sends them to the FORTESIE data sovereignty platform for storage.
3. **Data Sovereignty module** (Esthesis platform for the museum of pilot 1): This is a cloud-based, multi service platform which handles the data collection of the sensing components and the external systems through the gateway device and is responsible to store the data and to manage the deployed building gateways. Data can be communicated in standardised format through relevant integration with FIWARE platform.
4. **Data Consuming Applications** include all FORTESIE sub-systems which consume /process data that are stored in the FORTESIE platform (obtained from the sensing components, the external systems or provided by the user). These are the **M&V (Measurement & Verification) component, the Energy Performance Contract (Smart Contract) Data Analytics module**, the **Behavioural model** and the **Recommendation Engine**:
   a. The **M&V (Measurement & Verification) component** constitutes a standardised and trusted data layer which will be used to infeed customizable smart contracts ready for the implementation in various use cases of energy performance contracts. The development of this component in blockchain will have as a priority to be standardised following the typical data structures and hardware specifications commonly used in the industry. M&V components takes by Analytics component as input calculations, for example, of the final energy consumption after the renovation activities.
   b. The **Energy Performance Contract (Smart Contract)** will provide access to ESCOs in charge of the EPC. It will ensure that the insights in terms of the balance between public and private information collected will be ensured. These smart energy performance contracts will let the stakeholders see transparently how they are enforced and which actions can be taken for the improvement of the energy consumption patterns. All of the information on this data layer will be available for use through digital solutions, empowering with trust.
   c. **Analytics component** will be tailored to detect patterns from real energy consumption data, distinguishing among the consumption derived from the energy fabric, energy systems and user behaviour.
   d. **The behavioural models** as well as the **recommendation engine** will be extended to an intelligent rule based system that captures the user behaviour and current performance progress. Therefore, the end-users will be supported in the direction of optimising their long-term behaviour.

The overall FORTESIE Functional Architecture is presented in the Figure below. Each of the respective component in the architecture overview is described in previous section.

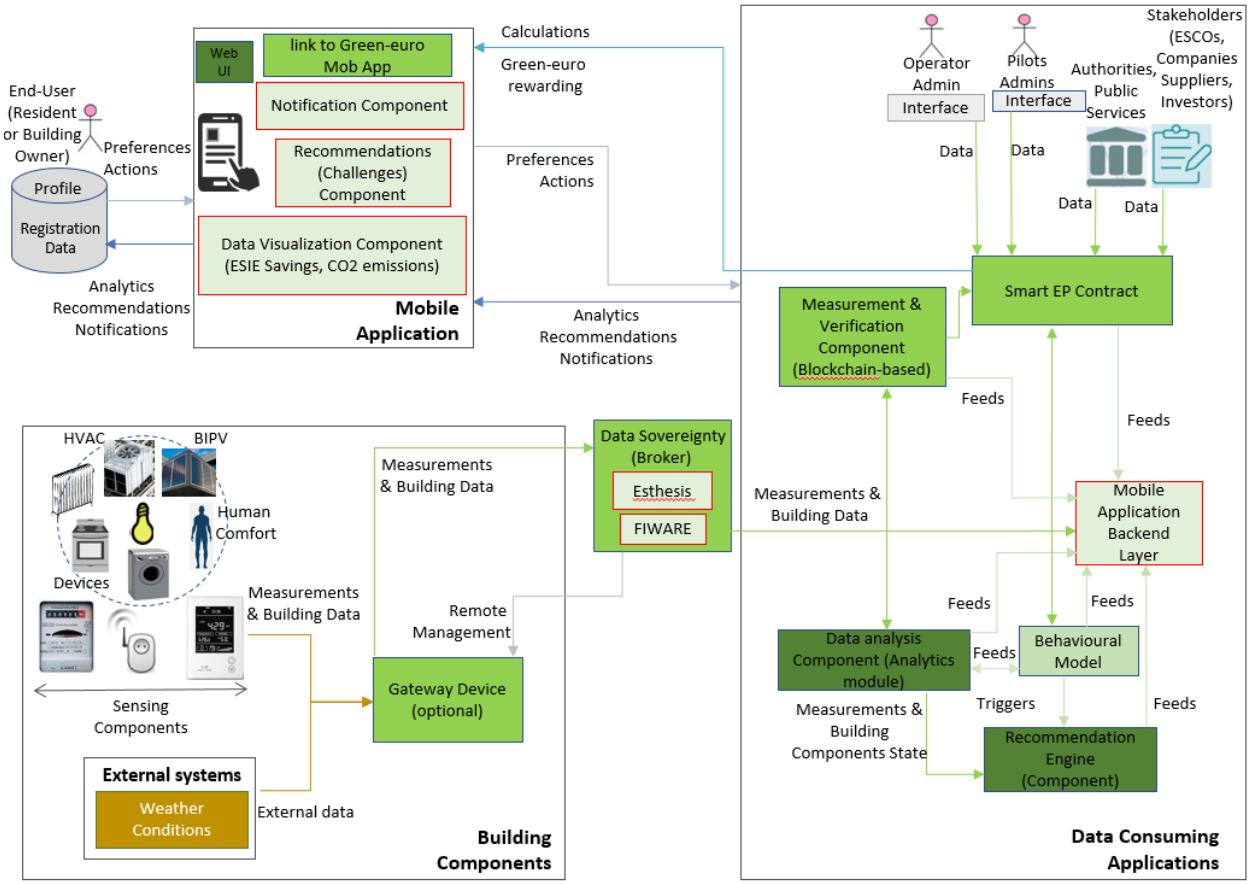

Figure 7 High level FORTESIE platform architecture

4 Conclusions

The present Deliverable D2.3 depicts the general Architecture of the FORTESIE platform. Throughout this document, the overall architectural framework of the project is described both as an overall system and through its individual interdisciplinary sub-systems as well so that to facilitate the forthcoming project development and implementation stages and to stimulate the work and activities of the FORTESIE technical development.

Apart from serving the abovementioned project goals, the present Deliverable will act as a reference point in all stages of research and development for the internal communication among the FORTESIE partners involved in the development of the FORTESIE platform. To this respect, this document indicates how the work should evolve within the Work Package 3, by showing and specifying the development paths, and the functional and non-functional parameters to be followed in order to finally meet the user needs.