D7.4 – BEYOND Evaluation Framework and Respective Validation Scenarios

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EXECUTIVE SUMMARY

The main objective of this task is to propose the evaluation framework of the BEYOND Project in the Demo Sites, ensuring that all of them are appropriately covered. Through this, the data collected and the calculation tools designed will allow us to establish a series of key indicators to make a series of economic, performance or other estimates at both end-user and business level.

End users will receive information on the services they have contracted, as well as the key indicators that will be displayed on the final platform developed for the BEYOND project.

The different businesses will have a series of data and indicators that will allow them to offer a high-quality energy service.

The different indicators have been divided into groups, as follows:

- Impact Assessment Metrics:
  - Energy
  - Social
  - Economic
  - Environmental
- Specific Beyond KPIs per Business Model
  - Common Data-relevant metrics
  - Aggregators
  - Retailers
  - ESCO
  - City Authorities
  - DSOs
- BEYOND Platform Technical Validation
  - Data-quality metrics
  - Platform technical metrics

Finally, a study of the validation scenarios has been carried out, where they have been analysed and mapped depending on the tools, data and entities involved in each of them.

The final list of KPIs may be subject to change during the testing phase of the BEYOND project.

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LIST OF ACRONYMS

Acronym	Modification(s)
AI	Artificial Intelligence
API	Application Programming Interface
BaU	Business-as-Usual
BM	Business Model
BS	Business Scenario
DR	Demand Response
DSO	Distribution System Operators
DSO	Distribution system operator
EaaS	Energy-as-a-Service
EE	Energy efficiency
EEM	Energy efficiency measure
ESCO	Energy Service Companies
EU	European Union
IPR	Intellectual Property Rights
KPI	Key Performance indicators
LCC	Life Cycle Cost
OPEX	Operational expenditures
O&M	Operation and maintenance
PMV	Performance Measurement & Verification
TRL	Technology Readiness Levels
UC	Use Case
VOC	Volatile organic compounds
VPP	Virtual Power Plant
WP	Work package

2 Objectives and scope

The main objective of this task is to define a global evaluation framework for the BEYOND validation activities. For this purpose, two BEYOND deliverables tackle the evaluation of the different aspects of the Project.

a) "Performance Measurement & Verification (PMV) Methodology", developed in T2.3, which focuses mainly on aspects related to energy performance verification methodologies.
b) "Definition of novel data-driven Business Models for the Buildings and Energy domains", D8.14, in which we find metrics more related to the business aspects.

Through the analysis and understanding of the documents, it is possible to obtain a series of objectives to be achieved and key performance indicators (KPIs) to be measured.

The assessment framework aims to individualise the evaluation of each pilot case, while still maintaining a uniformity in the evaluation methodology to obtain and report the results of the project. In addition to those metrics proposed in the above-mentioned deliverables, additional Key Performance Indicators (KPIs) related to technical or social issues have been studied and considered allowing a correct evaluation of the Project impact.

Regarding data validation, some metrics assess the quality of the data provided into the platform to ensure the proper functioning of the analytic tools. Other platform performance KPIs will measure the platform performance, such as uptime, average processing time, security breaches, processing resources, reliability, size, …

Finally, a mapping exercise is made to establish the relationship between demo cases, analytic tools and end-users' metrics, allocating the assessment metrics to every demo site scenario.

3 Introduction to Beyond demo sites

The BEYOND evaluation framework comprises four different locations and demonstrators: Spain, Finland, Serbia and Greece. Each demonstrator has several different characteristics, which means the collection of data from different types of buildings (offices, commercial, residential, sports centres…). In addition, this means that there are different players in the energy market: ESCOs, Distributors, Retailers, Facility manager and Urban planners.

Given this variety of demonstrators, the following section intends to give a brief introduction to each of them, showing the available data sources for the subsequent mapping to relate Demo Cases with Demo Sites.

3.1 BEYOND Demo Infrastructures

3.1.1 Greece

Artemidos Building (MYTILINEOS Headquarters in Maroussi)

An office building located in the district of Maroussi hosting approximately 600 employees and covering a total area of 12.000 m^2. The building is powered with electricity only.

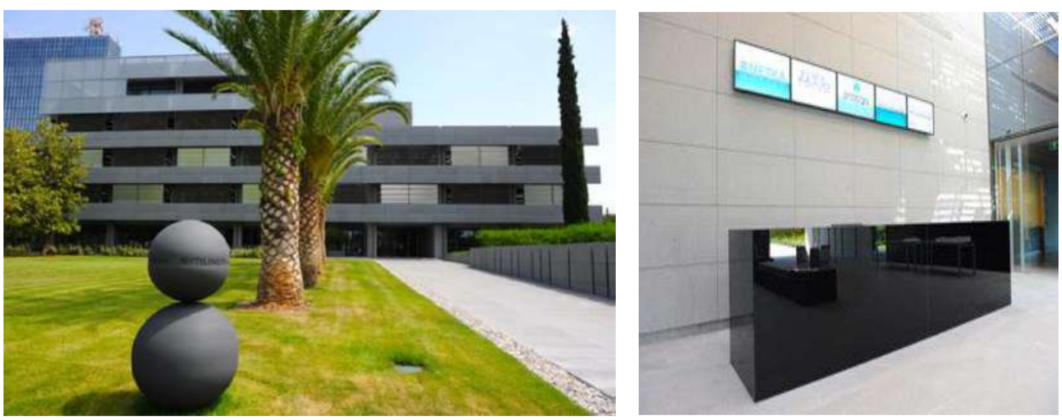


FIGURE 1 ARTEMIDOS BUILDING

As general data of this building can be highlighted:

- Year of Construction: 1985 and two additional structures in 2018
- Recent Renovation: 2011
- Gross Floor Area: 12.000 m^2
- Number of stories: 5 including ground floor
- Operating periods: approximately from 7:00 to 21:00
- Energy performance certificate: Available
- Energy Service Contract: Undefined period.

Marinou Antypa Building (MYTILINEOS offices)

An office building located in the district of Neo Irakleio, hosting approx. 150 employees and 40 visitors (on a daily basis), while covering a total area of 2.101 m^2. The building is powered with electricity only. Pilot buildings included in the Greek pilot are partially already equipped with the required sensors and smart meters/actuators to ensure the smooth operation of the BEYOND framework.

FIGURE 2 MARINOU ANTYPA BUILDING

As general data of this building can be highlighted:

- Year of Construction: 1993
- Recent Renovation: 2006
- Gross Floor Area: 2.101 m^2
- Number of stories: 4 including ground floor
- Operating periods: approximately from 7:00 to 21:00 h.
- Energy performance certificate: Available
- Energy Service Contract: Indefinitely period.

Residential Premises

More sophisticated services will be provided to carefully selected buildings that will enable the realization of human-centric energy performance optimization concepts. These Testbeds are located in the region of Attica.

The residential premises consist of over 50 residential dwellings, hosting approximately 170 residents, familiar with concepts of energy services and smart technologies. New installations in approximately 20 premises are expected during BEYOND. The dwellings cover a total area of 4,500 m^2 are powered with electricity only. Half of the building premises will set the residential pilot test bed at the Greek demo site.

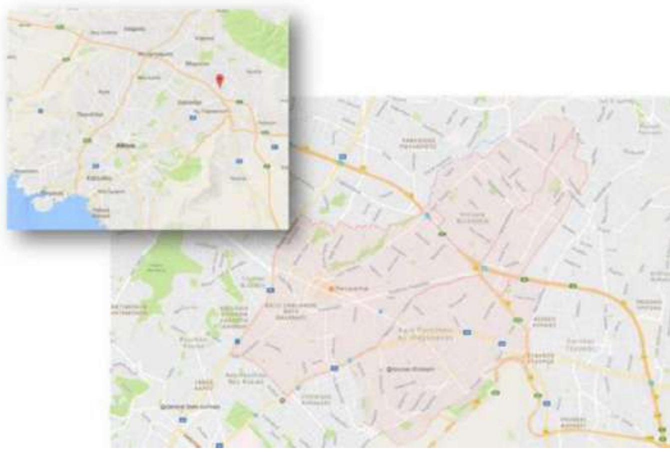


FIGURE 3 MAP OF THE GREEK DEMO

In general, the following tables describe the main hardware and software components for the Greek demo installations.

- **Hardware**

Main components	Technical Specifications
Heating Systems	<u>Residential</u> Manufacturer: • IMIT • Siemens • Rielo • Erriva • ABB • Campini • Heat Generator: Hot Water Radiators – Individual & Central • Energy Source: Diesel / Gas • DHW: Yes <u>Commercial</u> • Manufacturer: Interclima / Carrier • Heat Generator: Fan Coils – Individual • Energy Source: Electricity / Gas • DHW: No
Cooling systems	<u>Residential</u> Manufacturer: • DAIKINA • Fujitsu • Kerosun • Toyotomi • Mitsubishi • Bluesky • Panasonic • Cooling System: Air Conditioner - Individual

	• Energy Source: Electricity <u>Commercial</u> • Manufacturer: Interclima / Carrier • Cooling System: Fan Coils - Individual • Energy Source: Electricity • Nominal Power: N/A
Lighting devices	<u>Residential</u> • Type: LED, Incandescent, Fluorescent, Halogen, Compact Fluorescent • Dimming Capability: Mostly on/off but some of the bulbs have dimming capability • Smart controls: Remotely • Connectivity: Via Platform of H2020 Project • Data collection: On a daily basis <u>Commercial</u> • Type: Fluorescent • Dimming Capability: on/off • Smart controls: Remotely • Connectivity: Via Platform of H2020 Project • Data collection: On a daily basis
EV Charging Points	<u>Current Status:</u> • 2 AC Charging Stations with single output of 22kW, located in headquarters of Mytilineos, in Maroussi. • 2 AC Charging Stations with dual output of 22kW per socket, located in Marina Zea, in Piraeus. <u>Future Expansions:</u> • 19 AC Charging Stations with dual output of 22kW per socket, located in the broader area of the Municipality of Athens. The project will be completed by the end of April. • G2V and V2G capability not available. • Connectivity and data collection: via dedicated platform.
IoT Devices	• Smart Metering Energy Devices (Z-Wave Plus Aeotec Clamp Power Meter - Three Clamps (60A), connected and stored data on a cloud based platform, new installations in approximately 20 premises are expected during BEYOND • Ambient Sensing and Occupancy Sensing Devices • Aeon Labs Multisensor 6 - Z-Wave Plus (Temperature - Humidity - Light Sensor - Presence), connected and stored data on a cloud based platform, new installations in approximately 20 premises are expected during BEYOND
Smart metering	• Devices installed in approximately 20 premises in the broader area of Agia Paraskevi, covering multiple zones within each building (bedroom, kitchen, living room etc.) • Aeon Labs Multisensor 6 - Z-Wave Plus (Temperature - Humidity - Light Sensor - Presence), connected and stored data on a cloud based platform • 1 record per hour, stored on a cloud based platform

	• Encrypted data sharing is available with connectivity enabled via dedicated platform. • New equipment covering the needs of approximately 20 premises is expected to ensure the smooth operation of the project.

TABLE 1 GREECE HARDWARE COMPONENTS

- **Software**

Main components	**Technical Specifications**
Portfolio System/ Client Database System/ CRM: Galaxy by Singular Logic	Program which includes all active as well as inactive customers of Protergia, the energy Unit of Mytilineos. More specifically for each customer the following data, among others, can be found and are updated at least on a monthly basis: • Energy Data – Consumption, Costs, Invoices • Demographic Data – Gender, Location of Premise, Type of Premise etc. • Contract Data - Status of contract, Duration etc.
Consumer portal: My Protergia	An application offered to the customers of Protergia which enables: • Energy Consumption overview – The customer can see the energy consumption in detail through ease to understand charts, compare the consumption to previous periods, or that of neighbours and more efficient users and find out whether they saved energy and how much. • Input of Meter Readings – The customer can monitor their meter reading history and enter the readings themselves to receive a monthly clearance bill that reflects their actual use. • Energy Efficiency Tips – The customer gets smart tips and useful information to help them save even more energy.
BEMS	Fancoils • HVAC system installed in several zones of the main buildings of Protergia. • Distributed control • Integrated sensors (temperature, humidity) • Measurements performed (sensing values) • Recorded data can be accessed via Mytilineos's CRM system on a monthly basis as an energy consumption depiction. • Control Intelligence (manual control, fixed (clock) control) • Reporting capabilities (e.g., non-real-time total energy reporting per energy carrier)

TABLE 2 GREECE SOFTWARE COMPONENTS

- **Data Assets Availability**

ID	Data Asset Title	Description	Demo Site
GR_1	CRM	Energy Data – Consumption (kWh), Costs (€), Invoices (€) Demographic Data – Gender, Location of Premise, Type of Premise etc. Contract Data - Status of contract, Duration etc.	Residential Commercial
GR_2	My Protergia	Current consumption (W); Accumulated consumption (kWh)	Residential
GR_3	BEMS	Temperature [°C]; Humidity	Commercial

TABLE 3 DATA ASSETS AVAILABILITY GREECE

3.1.2 Spain

Cuerva Headquarters

CUERVA Headquarters are located in Churriana de la Vega (Granada). It is outside the Spanish distribution network. CUERVA has access to all the relevant information, they can install any device that could be interesting for the purposes of the project. Finally, CUERVA is the retailer for the building consumption.

- There is a PV plant monitored by CUERVA.
- Five EV Chargers also monitored by CUERVA.
- Office areas that can be useful for the demo cases assigned.

As general data of this building can be highlighted:

- Surface: 495.3 m^2 (ground floor 354.1 m2 + upper floor 141.2 m2)
- Number of people usually work in the building: 70 approximately
- Number of floors: 2
- Number of rooms:
  - Ground floor: 2 meeting rooms; 2 large separate rooms; 1 office
  - Upper floor: 3 meeting rooms; 1 large room; 1 small room
- Period of daily use: Monday to Thursday 8:00 to 18:00 h. and Friday 8:00 to 14:00 h.

FIGURE 4 CUERVA HEADQUARTERS LOCATION

- **Available datasets in CUERVA Headquarters**
  - Building infrastructure
  - Electric Consumption in the building
  - EV Chargers information
  - PV information (V, I, P and Q from the inverters).

- **CUERVA Headquarters Hardware**

Main components	Technical Specifications
Renewable energy sources	• Photovoltaic System PV • Power output electricity: 16 kWp (64 photovoltaic panels of 250 W each) • Annual Electricity Generation: 25782 kWh/year approximately • Self-consumption rate: 23 % • Connectivity and data collection: • The inverter is monitored (granularity 5 minutes). Moreover, there is consumption and production data through the telemetry fiscal meter. • Historical data available since 2020. All this data is stored in the Azure Datalake of CUERVA and some of it is processed in SQL Server for quick access.
EV Charging Points	• Number: 5. Tesla Charger • Type: Gen 3 Tesla Wall Connector. G2V • Power output: 22 kW. The maximum power rating for the wall connector is 22 kW or 32 A with a three-phase supply 400 V AC. • Load capacity: 32 A Ingerev Charger • Type: GARAGE GW116. G2V • Power output: 7,6 kW • Load capacity: 16 A • Connectivity and data collection: updates and configuration via USB. Download reports via USB. Post eVolve Smart charger • Type: C63 • Power output: 43 kW • Load capacity: 63 A • Connectivity by Ethernet port by default Circutor wall box • Type: RVE-WB2M-SMART-TRI. Code: V23530 • Number of connectors: 2 • Type: type 2 • Power output: 22 kW (each) • Load capacity: 32A • Connectivity by Ethernet port
Smart metering	• The fiscal meter measures the active and reactive power exported and imported per quadrant, with consumption, production and total balance (consumption-production) measurements. • Granularity of 15 minutes.

	Historical available since 2020. All this data is stored in the Azure Datalake of CUERVA and some of it is processed in SQL Server for quick access.

TABLE 4 KEY HARDWARE COMPONENTS OF THE CUERVA HEADQUARTERS

- **CUERVA Headquarters Software:**

Main components	Technical Specifications
HEMS	Optimization of the EV charge taking into account the PV generation and the general consumption of the building

TABLE 5 KEY SOFTWARE COMPONENTS OF THE CUERVA HEADQUARTERS

Industrial Area Profitegra

A portion of the distribution network operated by CUERVA in the region of Granada is used as the main electricity infrastructure to set the Granada Smart Grid Living Lab owned by CUERVA and Turning Tables. The MV distribution grid is connected directly to the HV network by a substation also operated by CUERVA. This distribution network feeds the Profitegra Industrial Park.

In Profitegra, over 40 companies of different sectors (industrial, manufacturer, food operators, waste treatment, recycling, etc.) are located

FIGURE 5 PROFITEGRA INDUSTRIAL PARK

Currently, the industrial park is connected to a 132/66/20 kV substation operated by CUERVA and has an installed power of 4,5MW (12900 MWh consumed yearly).

In terms of renewable energies, around 500kWp of self-consumption PV installed in the industries whose inverters are monitored by CUERVA. Moreover, the MV network of the industrial park is highly monitored, thus providing high resolution data.

On the other hand, the industrial park is fed by a gas network and several of the companies established includes thermal demand (both heating and cooling) to carry out their industrial processes.

Some of the details of the infrastructure:

- 132/66/20 kV Substation operated by CUERVA.
- High resolution data in the MV network
- 60 industrial supply points
- 4.5 MW of contracted power, 12900 MWh consumed yearly
- 3 MW increase expected in the next years
- Around 500 kWp of PV installed in the industries. All the inverters are monitored by CUERVA
- A complete digital twin model of the Medium Voltage Grid for the whole Industrial Park is available
- Smart metering technologies to monitor RES generation & storage at the distribution network
- SCADA & GIS data will be made available to create a lake of electrical data from the local network

- **Profitegra park hardware**

Main components	Technical Specifications
Smart metering	• All smart meters monitored. Two measurement technologies: o 17 clients with remote metering (5 min). o 20 customers with remote management meters system (15 min at transformer level and 1 hour at client level) • AMI infrastructure description: apart from the Smart meters of the clientele, some CTs within the Profitegra network have been monitored and remotely controlled. This allows to obtain measurements in real time and upload them to the SCADA. • Data collection (frequency) and storage: o V, I, P, Q per 15 min, on a cloud platform o Connectivity and data transmission: the information is dumped into a database (.xml and .json)

TABLE 6 KEY HARDWARE COMPONENTS OF THE PROFITEGRA INDUTRIAL PARK

- **Profitegra park software**

Main components	Technical Specifications
SCADA	• Single line schematic • Monitoring and control devices of the transformation centre • Automatic line protections • Real time data of smart meters (transformation centre level) • Real time data of border points • Monitoring and control of PV and generation systems

TABLE 7 KEY SOFTWARE COMPONENTS OF THE PROFITEGRA INDUSTRIAL PARK

Urbener Headquarters

Urbener Headquarters are located in Zaragoza. They have a system for measuring the consumption of the air conditioning system in real time. The main power connection is 3-phase. And the annual consumption is 15.317 kW. Energy uses in Urbener's offices are for lighting, air conditioning and for the use of computers and devices necessary for work. Moreover, there are two outdoor air conditioning units located on the roof of the building. These two outdoor units are connected to a duct system distributed throughout the office. The outdoor units that Urbener has are of the Hitachi brand, one is the RAS-3/4/5FSVNE model, while the other is the RAS-5FSVNME model. Urbener has installed different devices in four areas of the office.

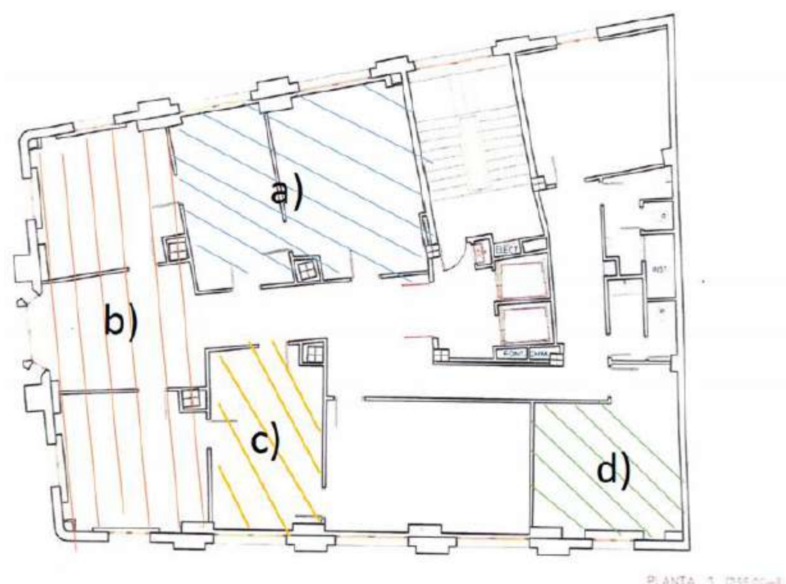


FIGURE 6 URBENER HEADQUARTERS

The following table shows the departments and the number of people working in each zone and the number of hours they are in each zone.

ZONE	NUMBER OF PEOPLE	WORK HOURS
a) Office 1	4	8
b) Office 2	5	8
c) Office 3	Meeting room	-
d) Office 4	1	7

TABLE 8 URBENER HEADQUARTERS

- **Installed devices**

Main components	Technical Specifications
INTESIS gateway	• Model: INMBSHIT016O000
Raspberry Pi 4 model B 2 GB	• Model B 2GB • Conexión:1 x MIPI DPI, 1 x GPIO, 2 x micro HDMI, 1 x MIPI CSI, 2 x USB 2.0, 1 x micro SD, 2 x USB 3.0 • Almacenamiento: 2GB • Unidad central de Procesamiento (CPU): Broadcom BCM2711, ARM v8, Quad-core Cortex-A72 64bit SoC@ 1,5GHz
Z-Wave. Me RaZberry 2 module	• Compatible Technology: Z-Wave Plus • Connected Home Protocol: Z-Wave • Model: RAZ2-EU • Type: Gateway
Aeotec Clam p Z-Wave Plus Power Meter	• 2 Units • Technology: Z-Wave Plus (868.42MHz) • Clamp Rating: 60A with 1% accuracy • Metering: current consumption (W) and accumulated consumption (kWh) • Power: 230VAC, 50Hz, 10mA
Aeon Labs Multisensor	• Model: Z Wave Plus • 5 Units • Temperature measure • Humidity Measure

TABLE 9 MAIN COMPONENTS URBENER HEADQUARTERS

The gateway is intended for the control of Hitachi indoor units, specifically up to 16 units. It is connected to the H-Link bus of the outdoor unit. This enables bidirectional control and monitoring of Hitachi VRF (Variable Refrigerant Volume) systems from a device that functions as a Modbus master.

The Z-wave, when linked to the raspberry, enables automation, in this case, of the air conditioning.

The two Z-Wave Plus Aeotec Clam p Power Meter are connected to a circuit board. One of them is connected to the general circuit, while the other is for the climate. The one for the general circuit is connected the device clamp to one phase of the main power supply at the circuit breaker beach. That of the climate circuit is connected one of the clamps of the device to the circuit breakers corresponding to the outdoor air conditioning unit 1 that distributes the air in zones a) and d); while the other clamp is connected to the outdoor air conditioning unit 2 that distributes the air in zones b) and c) of the office. This allows the electricity consumption to be measured in real time with 99% accuracy.

The multi-sensors measure the humidity and temperature of the room in which they are installed, as follows: 2 in zone a), 1 in zone b), 1 in zone c) and 1 in zone d).

The following image shows where are located the devices

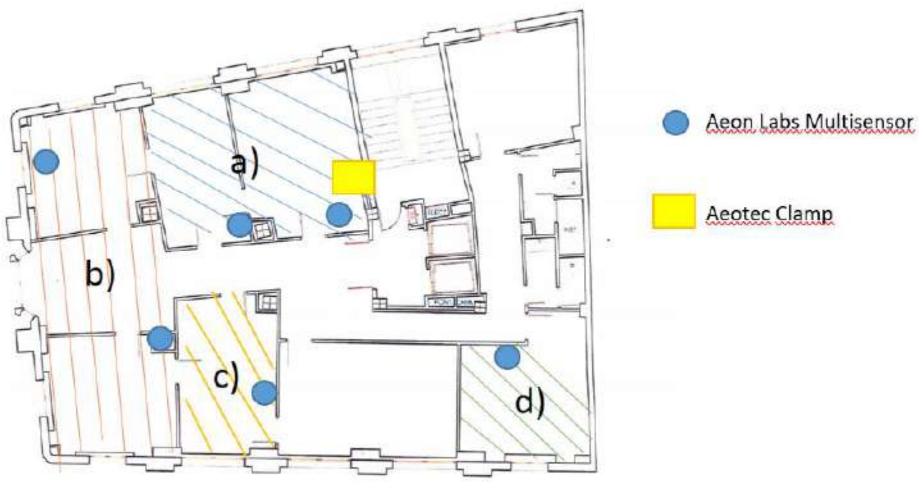


FIGURE 7 LOCATION OF THE DEVICES

- **Data Assets Availability**

ID	Data Asset Title	Description	Demo Site
CU_1	Renewable energy sources	Consumption (kWh) and production (kWh) measurements.	Cuerva Headquarter
CU_2	Smart metering	Consumption (kWh) and production (kWh) measurements.	Cuerva Headquarter
CU_3	HEMS	Optimization of the EV charge taking into account the PV generation and the general consumption of the building	Cuerva Headquarter
CU_4	SCADA	Monitoring and control of PV	Profitegra Industrial Park
UR_1	Aeotec Clam p Z-Wave Plus Power Meter	Current consumption (W); Accumulated consumption (kWh)	Urbener Headquarter
UR_2	Aeon Labs Multisensor	Temperature [°C]; Humidity	Urbener Headquarter

Table 10 Data Assets Availability Spain

3.1.3 Finland

FVH has identified mainly three commercial buildings for the Finnish demo cases: The KYMP House (Kaupunkiympäristötalo) which is the City of Helsinki's Urban Environment Division and the Viikki Environmental house (Viikin Ympäristötalo) which is a high-performance (energywise) office building in Helsinki, and Stadia Vocational School. These commercial buildings are selected so that they provide intra-building sophisticated services for energy performance optimization.

Urban Environmental House

The first core infrastructure available in Finnish demo site is the City of Helsinki's Urban Environment Division (KYMP) building. Built in 2020, the **KYMP House** has a floor area of 35,629 m^2 and is located in Työpajankatu 8, Kalasatama which is Helsinki's Smart City District. This demo infrastructure has a building automation system based on Schneider Ecostruxure that will be interfaced so that relevant datapoints (> 12,000 data end points – BACnet and KNX) will be forwarded to the platform and data analytics toolkit according to the consent of building owner, with the support of the SenseHel open-source software service and app to manage data consent and service associations on zone and space level.

FIGURE 8 THE KYMP HOUSE

The corresponding BEM system monitors all major electric loads, heating, air conditioning, lighting, and domestic water (hot & cold) as a centralized control unit. Additionally, there are some integrated sensors which measure CO2, temperature, ventilation flow values, and heating flow values. Heating and ventilation are controlled via sensor input and clock. Lights are controlled via KNX by clock, presence and ambient (constant lighting levels at rooms with windows). The data is partially available in real-time via Nuuka Open API. Furthermore, the building is designed to have smart grid readiness characteristics and smart grid integration is planned for the sake of demand elasticity.

- **Demo Asset Information**

Energy information	Carrier for District heating and electricity (10kV line) is Helsingin Energia Oy. Some consumption data is also available via Nuuka Open API.
Electric Heating system	Separated heat exchanger for air condition L101LS01 (1500kW) Heating L103LS01 (450kW) Floor heating L104LS01 (15kW) Ice removal L105LS01 (200kW) Warm water L170LS01 (500kW) All heat exchangers have their own energy metering
Electrical Cooling system	District cooling
Renewable energy on-site	Rooftop solar panels 42kWp. Energy measurements are available.
Lighting	KNX controlled LED lighting. Automatically controlled by presence, time and ambient light.
EV charging points	25 points and reserved capability to have a charger for every spot at the parking hall. Energy measurements are available.
IoT Devices	Consumption is widely measured and data is available online in live or small intervals.

TABLE 11 DATA ASSETS KYMP HOUSE

The Viikki Environmental House

The second optional infrastructure available in Finnish demo site is the Viikki Environmental House. Built in 2011, Viikki Environmental House has a floor area of 6,800 m² and is located in Viikinkaari 2. This demo infrastructure has a building automation system based on Schneider Ecostruxure that will be interfaced so that relevant datapoints (> 2,500 data endpoints) will be forwarded to the platform and data analytics toolkit according to the consent of building owner, with the support of the SenseHel open-source software service and app to manage data consent and service associations on zone and space level.

FIGURE 9 THE VIIKKI ENVIRONMENTAL HOUSE

Viikki Environment House is a high-performance office building in Helsinki. Part of the energy consumed in the building is produced on-site: the solar panels placed on the façade and roof cover 572m² and produce 20% of the energy consumption along with four wind turbines. The energy needed for heating water and interior spaces is supplied by Helsinki's district heating network. The cooling is supplied through a cost-free borehole water system that consists of 25 boreholes each 250 m deep and making 95% of the cooling energy renewable. Additionally, there are some integrated sensors which measure CO2, temperature, ventilation flow values, and heating flow values. Heating, ventilation and lighting are controlled via clock.The live data can be accessed via data dump.

The building automation system manages the building's indoor conditions such as heating, ventilation and air-conditioning. Another control system, including Siemens Siestorage electricity storage, manages the electricity production and use. The storage is connected to other building energy loads and greed (on demand) to enable better optimisation and provide the nearby public e-car charger with solar energy.

- **Demo Asset Information**

Energy information	Carrier for District heating and electricity is Helsingin Energia Oy. Access to annual numbers and costs from Carrier are not yet available for the project. Individual data points for heating and electricity are already available. Annual values can be formed from individual values, but not yet done. Consumption data also available via Nuuka Open API.
Electric Heating system	District heating system. Long term individual data points available, but as in energy information annual data calculations not yet available. Consumption data also available via Nuuka Open API.
Electrical Cooling system	Ground source cooling with 25 pcs of 250 meters deep wells. Annual energy consumption of 2 MWh/a for pumping (generates 68 MWh/a cooling power).
Renewable energy on-site	Solar about 45 MWh/a (provides about 20% of used electricity) besides 4 pcs 80 W Windside wind turbine.
Electricity storage	Siemens Siestorage 45 kWh storage. Maximum input and output power 90 kW. Storage power is controllable insteps and linear way.
Lighting	KNX controlled LED and T5 tube lighting. Timer, presence and on demand (demand elasticity) control of lighting levels.
EV charging points	Building has 2 EV charging points. Siemens Siestorage energy can be used to charge cars.
IoT Devices	Warm water measurement and data GW from measurement bus MBUS/MODBUS to Kafka / BEYOND platform.

Table 12 Data Assets Viikki Environmental House

Stadia Vocational School

Stadia Vocational School is an office and school building located in Vallila, a few minutes' walk from Kalasatama Smart City District. The building of Stadia Vocational School was constructed in 1946 and has a floor area of 25 000m². The building is powered with district heating and cooling, and electricity.

FIGURE 10 STADIA VOCATIONAL SCHOOL

The corresponding BEM system was manufactured by Buildercom and installed in 2016. The building's automation system has been implemented by Siemens Building Technologies Oy's DDC-based control and monitoring equipment. Cold and warm water meter and main electricity meter data is provided from BEM via Nuuka API. Heating, air conditioning, lighting, and domestic water are controlled via clock. Furthermore, there are integrated sensors for measuring CO2 level, temperature, ventilation flow values and heating flow values. The data is accessible via data dump. Lights are controlled via clock and (electricity network) on demand. The smart grid integration is considered for demand elasticity.

- **Demo Asset Information**

Energy information	Carrier for District heating and electricity is Helsingin Energia Oy. Access to annual numbers and costs from Carrier are not yet available for the project. Individual data points for heating and electricity are already available. Annual values can be formed from individual values, but not yet done. Consumption data also available via Nuuka Open API.
Electric Heating system	District heating system. Annual data calculations not yet available. Consumption data also available via Nuuka Open API.
Electrical Cooling system	District cooling
Lighting	LED and T5 tube lighting. On demand (demand elasticity) control of lighting levels.
IoT Devices	Visitor counter cameras on all the major doorways

TABLE 13 DATA ASSETS STADIA VOCATIONAL SCHOOL

- **Data Assets Availability**

There are several data assets covering the aspects of the demo site buildings' contextual/environmental and energy profiling data. However, it is important to keep in mind that not all of the data assets are available from all of the demo sites, due to the different nature and variability of the demo sites. Frequency, format and velocity of data collection varies considerably between demo sites. Nonetheless, the building automation systems provide thousands of data points that are not listed here since not seemed to be applicable at the moment, but it can be later included.

ID	Data Asset Title	Description	Demo Site
FI_FVH_1	Temperature	Temperature [°C]	The Vikki Environmental House
	Incoming air Temperature	Incoming air Temperature [°C]	
	Motor drive setting	Motor drive set value 0-100%	
	Convector water intake temperature	Incoming cooling water temperature	
FI_FVH_2	Visitor counter	Visitors coming in and out. Measurements from every exit	Stadia Vocational School
FI_FVH_3	Electricity consumption	Sub-metered electricity energy consumption	Kalasatama
FI_FVH_4	Temperature	Room temperature [°C]	
FI_FVH_5	Water consumption	Hot and cold water consumption	
FI_FVH_6	The Helsinki Energy and Climate Atlas datasets	https://hri.fi/data/en_GB/showcase/helsingin-energia-ja-ilmastoatlas - Solar energy potential - Heating demand prediction - Geoenergy potential - Energy data of buildings	NA

TABLE 14 DATA ASSETS AVAILABILITY

3.1.4 Serbia

Six Buildings District Heating

The Serbian Pilot Site consists in three buildings: two residential buildings (GeneralaŠtefanika, apartments from 29-31; and Generala Vladimira Kondića, apartments 5-7-9) and the Danilo Kiš elementary school.

The Serbian Pilot Site is located in the Stepa Stepanović neighbourhood, 5 km from the city centre of Belgrade. This neighbourhood covers 42 hectares of land, of which 434,000 m2 are residential and business space. It consists in 44 buildings with 4,616 apartments, 146 business premises, 1,430 garages, with 3,300 open parking places, one elementary school and one kindergarten, parks, green areas, sport grounds, playgrounds, and other accompanying public facilities.

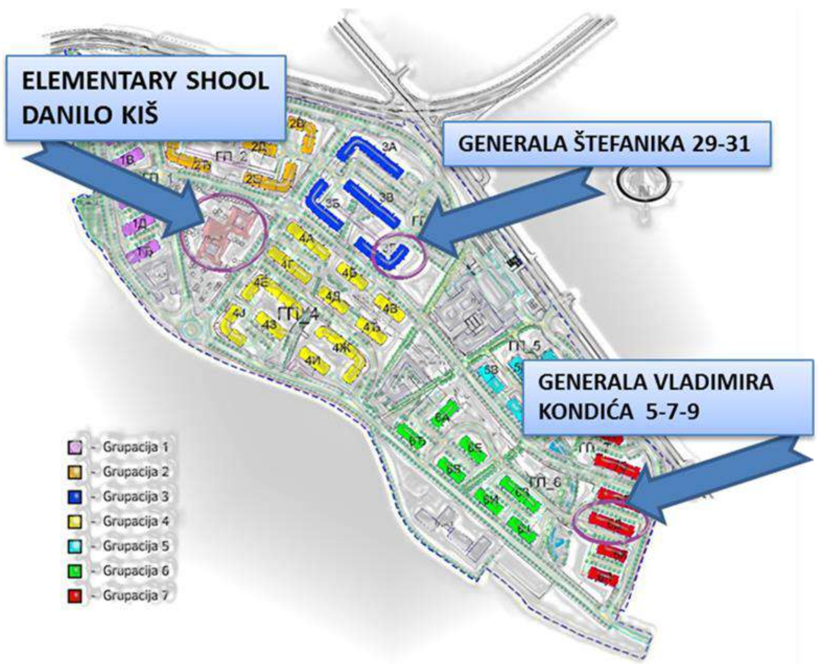


FIGURE 11 STEPA STEPANOVIĆ NEIGHBOURHOOD

FIGURE 12 SERBIAN PILOT BUILDINGS: GENERALA ŠTEFANIKA BUILDING (LEFT), GENERALA VLADIMIRA KONDIĆA (RIGHT), DANILO KIŠ ELEMENTARY SCHOOL (DOWN AT THE CENTRE)

Data shall be gather from 2 Substations and 6 Apartments from Generala Štefanika building (apartments 29-31), Generala Vladimira Kondića (apartments 5-7-9). There are existing devices in the residential apartments deployed in the previous MOEEBIUS and HOLISDER projects that included baseline data, already collected at real-time on hourly bases for the Process Control Units (Outdoor temperature (°C)) and the Primary and Secondary Heat Meters, which are:

- Cumulative Heat energy (kWh)
- Flow temperature (°C)
- Return temperature (°C)
- Cumulative flow (m3)
- Power (kW)

The baseline data collected 3 years ago in the framework of the HOLISDER project has been updated until 2021 to be used at the BEYOND project. The deployed equipment in the MOEEBIUS project is illustrated in following figure.

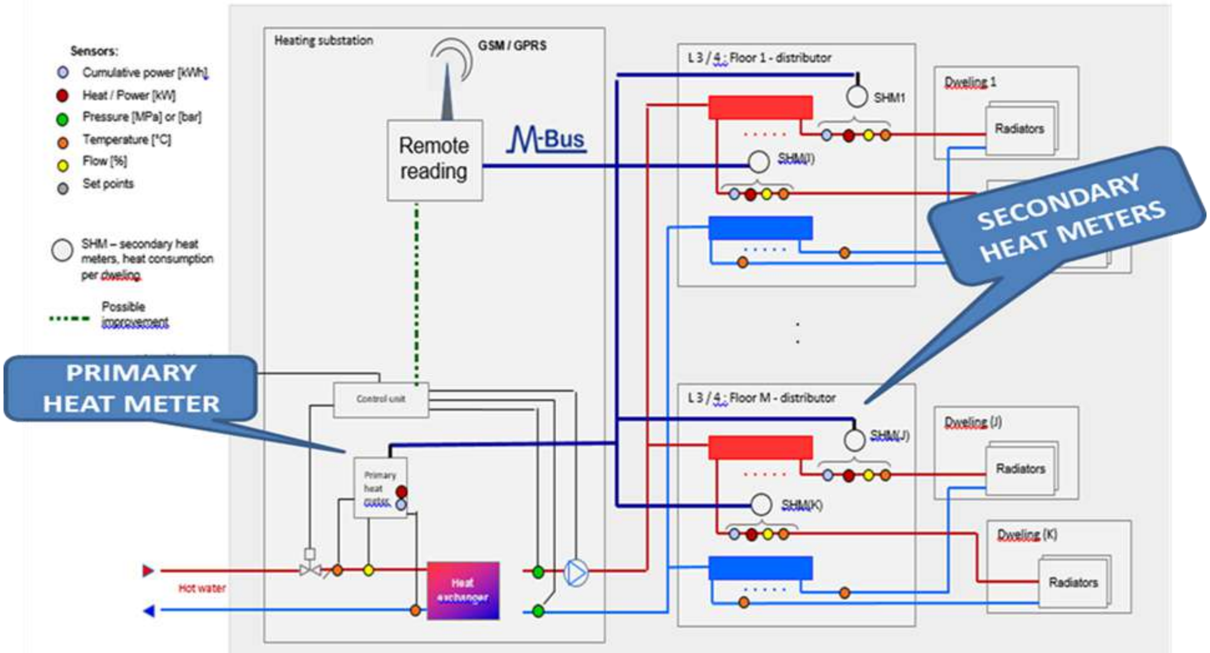


FIGURE 13 DEPLOYED DEVICES FROM MOEEBIUS PROJECT

This equipment got an addition under HOLISDER project when additional sensors were added in the apartments are depicted in detail in following table. The deployed equipment from the MOEEBIUS project is the one with the data availability of 3 years, and the new deployed equipment under the HOLISDER project is the one with recent available data.

Devices	Variables	Deployed	Gateway	Data availability
Smart heat meters at substation	• Cumulative Heat energy (kWh) • Flow temperature (°C) • Return temperature (°C) • Cumulative flow (m3) • Power (kW)	X	GT900 GSM TERMINAL +Modbus TCP at apartment level	3 years (monthly base) 1 year (hourly base)

Substation monitoring	• Pressure on primary side DH • Flow and return temperature secondary side • Main controller settings • Heating curve • Pump Fault indicator • Pump Operating indicator • Pump Actual control mode • Pump Actual head • Pump Actual flow • Pump Actual power consumption • Pump Operating hours • Pump Speed [rpm] • Pressure maintenance system secondary side set point level water in reservoir			Recent
Smart heat meters at all apartments	• Cumulative Heat energy (kWh) • Flow temperature (°C) • Return temperature (°C) • Cumulative flow (m3) • Power (kW)			3 years (monthly base) 1 year (hourly base)
Manual heat control at all apartments	• On/off manual valves			---
Remote heating control at 6 apartments	• On/off electric valves connected to smart thermostat in living room			Recent
Electrical meters at 6 apartments	• Global electricity consumption surveillance (power analysers); • AC electricity consumption			Recent

	• Water heater electricity consumption			
Indoor conditions at 6 apartments	• Ambient temperature and humidity sensors			Recent
Outdoor temperature	• Temperature (°C)			Recent

TABLE 15 DEVICES AT THE SERBIAN RESIDENTIAL BUILDINGS

In Danilo Kis elementary school there are existing smart heat meters installed at the substation of the school, which were deployed under the MOEEBIUS and HOLISDER projects. These smart heat meters already had a 3-year baseline data, collected at real-time (hourly bases), and is available to be used for BEYOND project.

Devices	Variables	Deployed	Gateway	Data availability
Smart heat meters at substation	• Cumulative Heat energy (kWh) • Flow temperature (°C) • Return temperature (°C) • Cumulative flow (m3) • Power (kW)	X	GT900 GSM TERMINAL	3 years (monthly base) 1 year (hourly base)
Electrical meters	• Global electricity consumption surveillance (power analysers)		GT900 GSM TERMINAL	Recent

TABLE 16 GENERAL DESCRIPTION OF DEPLOYED DEVICES AT THE SERBIAN SCHOOL

- **Data Assets Availability**

ID	Data Asset Title	Description	Demo Site
SR _1	Smart heat meters at substation	Cumulative Heat energy (kWh); Flow temperature (°C); Return temperature (°C); Cumulative flow (m3); Power (kW)	Residential Buildings Serbian School
SR_2	Substation monitoring	Pump control	Residential Buildings
SR_3	Smart heat meters at all apartments	Cumulative Heat energy (kWh); Flow temperature (°C); Return temperature (°C); Cumulative flow (m3); Power (kW)	Residential Buildings
SR_4	Manual heat control at all apartments	On/off manual valves	Residential Buildings
SR_5	Remote heating control at 6 apartments	On/off electric valves	Residential Buildings
SR_6	Electrical meters at 6 apartments	Electricity energy consumption	Residential Buildings
SR_7	Indoor conditions at 6 apartments	Temperature [°C] / Humidity	Residential Buildings
SR_8	Outdoor temperature	Temperature [°C]	Residential Buildings Serbian School

TABLE 17 DATA ASSETS AVAILABILITY SERBIA

4 BEYOND Evaluation Methodology and reference to BEYOND's general objectives

This section describes the methodology followed at the most important points of the deliverable. In addition, the different objectives of the BEYOND project are analysed and then grouped in a specific way depending on each business role.

The methodology followed in this deliverable involves the sequential steps described below:

1. Introduction to Demo Sites: A review is shown on each Demo Site, where information about the assets involved in the demonstration tests and the updated measurement and other data available at each demo site is collected as an introduction to developing the BEYOND evaluation.

2. BEYOND's General Objectives: Identification and analysis of the project objectives.

3. End users metrics: Through a review and analysis of the KPIs of D2.4 BEYOND PMV, all of them are adapted to measure results in end users related to energy, economy, social or environmental impact.

4. KPIs per Business Model: Through a review and analysis of D8.14, the objectives are adapted to metrics or KPIs to evaluate different aspects depending on each business model.

5. Platform Technical Validation: On the one hand, a revision of the metrics related to the quality of the monitoring data is made, to ensure the proper functioning of the tools, such as metrics of data quality and quantity, accuracy, frequency or validity. On the other hand, data platform performance KPIs are also proposed, such as Uptime, average processing time, security breaches, processing resources, reliability, size, etc.

6. Validation scenarios: The validation scenarios will be proposed by means of a scheme showing the relationship between Demo Cases, analytic tools and business actors with the different demo sites.

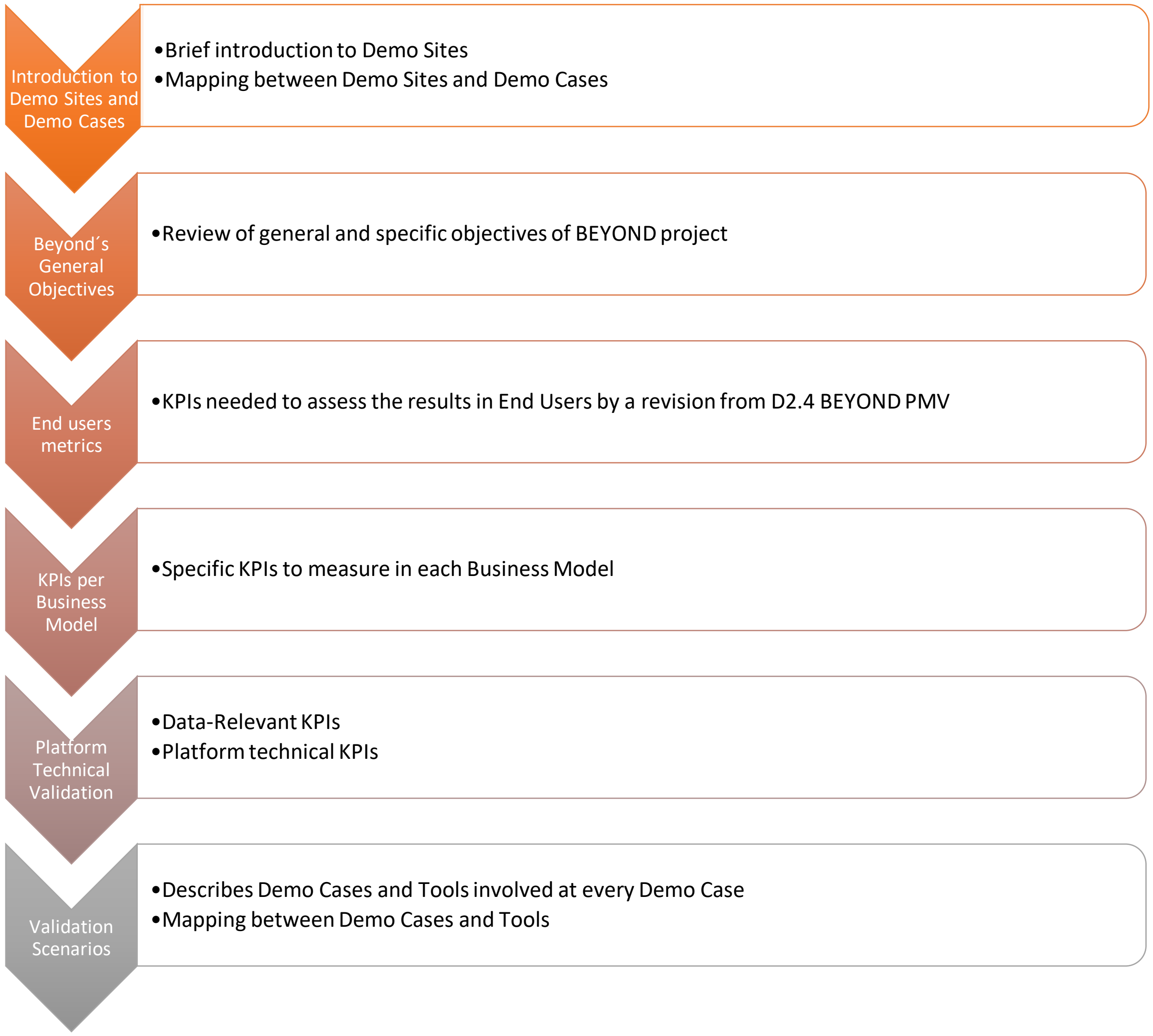


FIGURE 14 METHODOLOGY

The BEYOND Project is bringing forwards data-driven and data intelligence-enabled solutions to facilitate the transition to smarter and energy-efficient buildings. In addition, it considers an important objective such as the transition to a sustainable and fossil-free energy system.

To this end, different energy applications and services will be developed with the main objective of improving the efficiency and performance of buildings.

To do this, there are several general and specific objectives that must be met, according to the BEYOND Description of Action (DoA). Below, an overview of the general BEYOND objectives is made.

Objective 1:

“To deliver a novel Big Data reference architecture and platform powered by buildings’ data (energy and non-energy) that effectively addresses the complexity of building energy performance optimization and energy sector value chain interactions and allows for the delivery of innovative Energy-as-a-Service offerings, through central as well as federated experimentation with big data analytics, service composition, data sharing, assets reuse and value generation."

Specific Quantified Targets	Demo related	Type
1 Big Data Platform Reference Architecture and Implementation for the Building and Energy Market Value Chain	Project	Technical
1 On-Premise Environment configuration and 1 Secure Experimentation Playground	Project	Technical
1 expandable knowledge representation (in the form of a knowledge graph or ontology) and Common Information Model for the Building Sector data	Project	Technical
1 Querying API and 1 Real-time Analytics API with the relative documentation	Project	Technical
8 Data-driven Services Bundles (incl. 1 business brokerage engine) containing >25 data management services	Project	Business
8 innovative applications and services for a variety of electricity sector stakeholders	Project	Business

TABLE 18 SPECIFIC OBJECTIVES FOR OBJECTIVE 1

Objective 2:

"To integrate existing big data technologies, tools and libraries, with building sector legacy systems, external data sources and ICT-enabled assets and components to accelerate the data management and analysis cycle for powering the BEYOND platform, turning the four Big Data V's into Stakeholder Value."

Specific Quantified Targets	Demo related	Type
1 Big Data Platform Reference Architecture/ Implementation for the Building and Energy Market Value Chain	Project	Technical
Open APIs and reference demonstrators' adaptors implementation for legacy systems' integration	Demo/Project	Technical
1 expandable knowledge and Common Information Model for the Building Sector data	Project	Technical
Integration of technologies with TRL level being at least 6 and 7	Project	Technical
A unique framework for Data Sharing and Contract Management between building and energy market stakeholders over the BEYOND blockchain	Project	Technical
70% decrease of time to find, acquire and process datasets from diverse sources	Project	Technical

Contribution to the standardization efforts and promotion of the punch-list towards at least 3 relevant technical committees	Project	Technical

TABLE 19 SPECIFIC OBJECTIVES FOR OBJECTIVE 2

Objective 3:

"To deliver an innovative, secure, privacy preserving and IPR respecting multi-party data exchange and sharing framework, propelling the creation of a joint venture of data owners and analytics providers".

Specific Quantified Targets	Demo related	Type
1 Data Management Plan and Policy Framework	Project	Technical
>3 Multi-Party Data Contracts Templates under 1 Rights Expression Language	Project	Business
1 Assets brokerage Engine under the Data Sharing Services Bundle	Project	Technical
>3 demand-supply matchmaking algorithms under the Data Matchmaking Services Bundle	Project	Technical
1 Secure Data Playground Environment	Project	Social
1 Ethics monitoring framework	Project	Social
Successful data breaches attempts – Number of datasets acquired by unauthorised users: 0	Demo	Social
Stakeholders' trust in confidentiality and security features of the BEYOND platform: 5 (Likert 1-5 scale)	Demo	Social

TABLE 20 SPECIFIC OBJECTIVES FOR OBJECTIVE 3

Objective 4:

"To enable the delivery of innovative and added value services that satisfy emerging building and energy sector needs and effectively contribute to the short-, mid- and long-term targets for a better, more sustainable and more efficient operation of buildings, while facilitating the decarbonization of the energy system and the democratization of energy markets through the creation of integrated value chains and sustainable ecosystems of stakeholders of the energy sector around the BEYOND Big Data Platform and AI Analytics Toolkit".

Specific Quantified Targets	Demo related	Type
8 innovative applications and services for a variety of building and energy market stakeholders	Demo/Project	Technical
Over 15 Months of validation in 4 large-scale demonstrations and 10 demo cases	Demo/Project	Project
Peak-load reduction through human-centric DR, Self-consumption, Energy Efficiency: >35%	Demo	Energy

Energy Savings for consumers: 30-35% - Energy cost savings for energy consumers: 40%	Demo	Energy
Self-consumption achievement in buildings: 50-80%	Demo	Energy
Reduction of O&M Costs for Facility Managers: 30% on average	Demo	Economic
Gap reduction between predicted and actual energy performance of renovation projects to levels of less than 10%	Demo	Business
Reduction of Imbalance charges for electricity retailers: >35%	Demo	Business
Compliance with the 30% binding target for energy savings over the electricity retailers' portfolio	Demo	Energy
Regulated comfort and health in built environments at levels above 95%	Demo	Social
End-User acceptance of BEYOND interventions above 95%	Demo	Social
Contribution to the achievement of €50B deferred investment for energy network reinforcements by 2050 at EU level	Demo/Project	Economic
Contribution to 1bn tons annual CO_2 emissions reduction by 2050 due to renewables integration at EU level	Demo/Project	Environmental
Contribution to 14% reduction of EU energy imports and to the reduction of the percentage of EU population characterized as energy poor at levels below 10%	Demo/Project	Social

TABLE 21 SPECIFIC OBJECTIVES FOR OBJECTIVE 4

Objective 5:

"To bring forward novel collaborative business models driven by big data sharing and analytics services, benefiting the whole value chain of actors relevant to the building and (furthermore) to the energy domain in whole".

Specific Quantified Targets	Demo related	Type
BEYOND Data sharing-based business models focusing on at least 6 different collaborative approaches between value chain stakeholders	Project	Business
1 comprehensive evaluation report of the delivered business models	Project	Business
1 consortium-wide business innovation plan, including BEYOND platform sustainability plan and numerous individual exploitation plans	Project	Business

TABLE 22 SPECIFIC OBJECTIVES FOR OBJECTIVE 5

Objective 6:

“To deliver a reference big data platform architecture and implementation for the buildings’ data value chain, validated through a set of representatives, large-scale and long-lasting demonstrators BEYOND aspires to become one of the flagship and reference data intelligence platforms”.

Specific Quantified Targets	Demo related	Type
End-User Acceptance and Satisfaction (>95%)	Demo	Social
Pre-validation and Technical Verification of BEYOND in real-life lab environment	Demo	Technical
Validation of BEYOND in 4 large-scale demonstrators and 10 demo cases	Demo/Project	Technical
15-month Validation of the BEYOND framework and business models	Demo/Project	Business
6 building and energy market value chain stakeholders directly involved in the consortium and more than 30 to be reached through targeted living lab activities	Project	Project

TABLE 23 SPECIFIC OBJECTIVES FOR OBJECTIVE 6

Objective 7:

“Promote the adoption of the BEYOND solution as a next-generation Big Data Platform and AI Analytics Toolkit for (data sharing-based) Energy-as-a-Service (EaaS) applications through intense dissemination and knowledge transfer of the project’s outcomes towards the targeted stakeholders, reaching out to international audiences within and beyond EU”.

Specific Quantified Targets	Demo related	Type
Achievement of at least TRL 8 for the final project results	Project	Technical
At least 2 living lab workshops to be organized per demonstration country for the engagement of lo cal data hubs, stakeholders, third parties and local prosumers	Demo/Project	Project
Targeted collaboration and integration of the BEYOND platform with the EU Building Stock Observatory	Project	Project
Organization of at least 2 workshops annually with relevant projects and participation in relevant centrally organized events by ongoing initiatives at EU-level (BDVA, BRIDGE, EASME Projects)	Project	Project
Contribution to the standardization efforts and promotion of the punch-list towards at least 3 relevant technical committees	Project	Technical

20% Annual increase in the number of data provider organisations in the BEYOND platform	Project	Business
Interest of data providers willing to channel data through BEYOND platform: 5/5 (Likert 1-5 scale)	Project	Business
30% Annual increase in the number of data user/buyer organisations using BEYOND	Project	Business

TABLE 24 SPECIFIC OBJECTIVES FOR OBJECTIVE 7

Objectives per Business role

Before making a distribution of objectives depending on the Business role, an introduction is necessary to know each one of these.

Business role
All roles
Project wide targets
• End-User acceptance of BEYOND interventions above 95%. • Contribution to 1bn tons annual CO_2 emissions reduction by 2050 due to renewables integration at EU level. • Contribution to 14% reduction of EU energy imports. • At least 2 living lab workshops to be organized per demonstration country for the engagement of local data hubs, stakeholders, third parties and local prosumers. • Over 15 Months of validation in 4 large-scale demonstrations and 10 demo cases.

TABLE 25 SPECIFIC OBJECTIVES FOR ALL DEMOS

- **Aggregators:** Aggregators serve as a broker for transactions between energy suppliers and several houses. These aggregators can be utility companies, commercial aggregators, or community groups who enable prosumers and customers to participate and transact in blockchain market scheme and platform.

Business role
Aggregators
Project wide targets
• Peak-load reduction through human-centric DR.

TABLE 26 SPECIFIC OBJECTIVES FOR RETAILER

- **Retailers:** Energy retail markets provide the interface between retailers and their customers. They allow energy retailers to sell electricity, gas and energy services to residential and business customers.

Business role
Retailer
Project wide targets
• Compliance with the 30% binding target for energy savings over the electricity retailers' portfolio.

• Peak-load reduction through human-centric DR, Self-consumption, Energy Efficiency: >35%. • Reduction of Imbalance charges for electricity retailers: >35%.

TABLE 27 SPECIFIC OBJECTIVES FOR RETAILER

- **ESCOs:** An ESCO is a company that offers energy services which may include implementing energy-efficiency projects (and also renewable energy projects) and in many cases on a turn-key basis. The three main characteristics of an ESCO are:
  - ESCOs guarantee energy savings and/or provision of the same level of energy service at lower cost. A performance guarantee can take several forms. It can revolve around the actual flow of energy savings from a project, can stipulate that the energy savings will be sufficient to repay monthly debt service costs, or that the same level of energy service is provided for less money.
  - The remuneration of ESCOs is directly tied to the energy savings achieved.
  - ESCOs can finance or assist in arranging financing for the operation of an energy system by providing a savings guarantee.

Business role
ESCO / Facility Manager
Project wide targets
• Self-consumption achievement in buildings: 50-80%. • Gap reduction between predicted and actual energy performance of renovation projects to levels of less than 10%. • Energy Savings for consumers: 30-35% - Energy cost savings for energy consumers: 40%. • Regulated comfort and health in built environments at levels above 95%. • Reduction of O&M Costs for Facility Managers: 30% on average.

TABLE 28 SPECIFIC OBJECTIVES FOR ESCO / FACILITY MANAGER

- **DSO:**
  - Electricity Network Operator: are the companies in charge of managing the energy distribution networks. The networks they manage are typically long-distance, running from the place where the electricity is produced to the cities or industrial areas.

Business role
DSO: Electricity Network Operator
Project wide targets
• Contribution to the achievement of €50B deferred investment for energy network reinforcements by 2050 at EU level. • Peak-load reduction through human-centric DR, Self-consumption, Energy Efficiency: >35%.

TABLE 29 SPECIFIC OBJECTIVE FOR DSO

- District Heating Network Operator: are companies that are responsible for the distribution of heat generated at a single location via networks. This supplies heat and hot water to residents and businesses.

Business role
DSO: District Heating Network Operator
Project wide targets
• Peak-load reduction through human-centric DR, Self-consumption, Energy Efficiency: >35%.

Table 30 Specific objective for DSO

- **City authorities:** These entities have a vision and information about the consumption and production of energy, equipment and behaviour of people in all types of buildings, from public tertiary to residential.

Business role
City Authorities as Urban Facility Manager
Project wide targets
• Reduction of O&M Costs for Facility Managers: 30% on average. • Gap reduction between predicted and actual energy performance of renovation projects to levels of less than 10%. • Contribution to reduction of the percentage of EU population characterized as energy poor at levels below 10%. • Regulated comfort and health in built environments at levels above 95%.

Table 31 Specific objective for Urban Facility Manager

- **Consumer/Prosumer:** A consumer is defined as all natural or legal persons who contract electricity through a marketer or at a supply rate.

Business role
Consumer/Prosumer
Project wide targets
• End-User acceptance of BEYOND interventions above 95%. • At least 2 living lab workshops to be organized per demonstration country for the engagement of local data hubs, stakeholders, third parties and local prosumers.

Table 32 Specific objectives for all Demos

5 Impact Assessment Metrics

This section addresses the key performance indicators (KPIs) required to assess the results of energy efficiency improvement and demand flexibility achieved by BEYOND demonstration activities in the demo sites. They have been extracted from deliverable 2.4 "BEYOND PMV Methodology Specifications". In addition, these KPIs have been reviewed and analysed in detail to see how they apply to the project objectives and demo sites. The KPIs defined are categorized in four main categories.

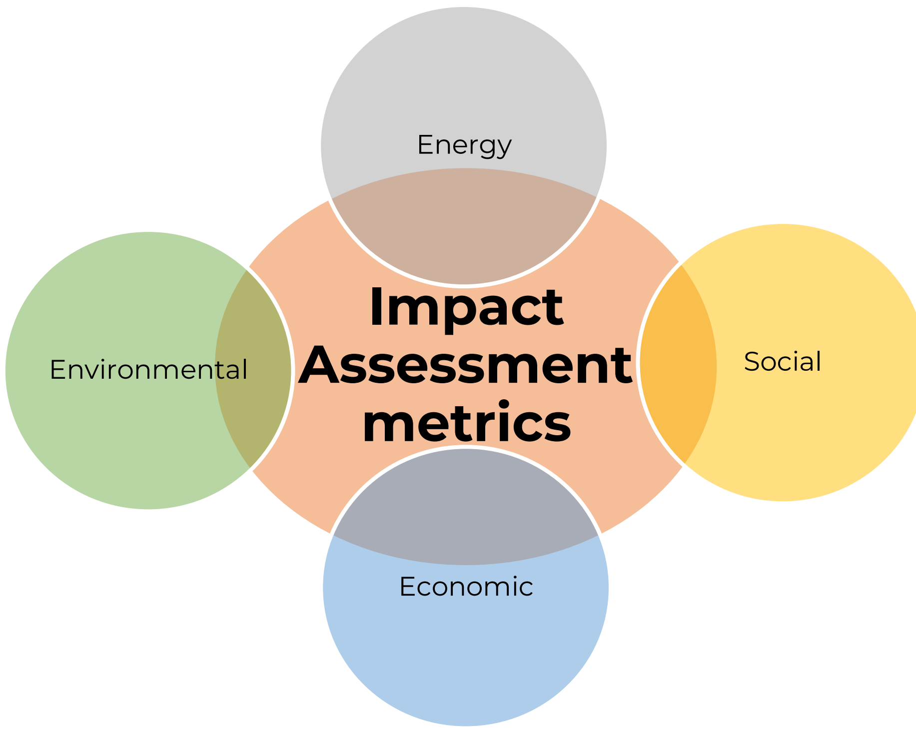


FIGURE 15 CATEGORIES FOR IMPACT ASSESSMENT METRICS

In the following sections, the KPIs are detailed, where we find a definition, the calculation method used and metric data.

KPI ID		
	ENERGY	
	EN1	Self-consumption ratio
	EN2	Energy saving
	EN3	(Buildings) Final consumption
	EN4	Total renewable energy consumption
	DR1	Peak load reduction
	DR2	Aggregated flexibility provided
	DR3	Amount of flexibility requested
	DR4	Prosumer compliance per request
	DR5	Flexibility provided vs. flexibility requested ratio
	SOCIAL	
	SOC1	System average interruption duration
	SOC2	Thermal discomfort factor
	SOC3	Trust and confidence
	SOC4	Visual discomfort factor
	ECONOMIC	
	EC1	Energy cost savings
	EC2	DR revenue
	EC3	Return on Investment
	ENVIRONMENTAL	
	ENV1	GHG Emissions reduction

TABLE 33: LIST OF KPIS

5.1 Energy

Within the KPIs related to energy, two differentiations are made, energy efficiency on the one hand and energy flexibility (demand response) on the other hand. The following tables show the energy KPIs to quantify electricity consumption or production as well as energy savings.

Self-consumption ratio: Measuring the efficiency of load shifting mechanisms and energy storage by quantifying the amount of electricity produced and consumed locally relative to the total electricity generation.

KPI ID	Formula	Unit
EN1	$EN1=EP/TEP\times 100$	%
Metrics / Data		
EP: amount of electricity produced and consumed locally [kWh] TEP: total electricity consumption [kWh]		

TABLE 34: SELF-CONSUMPTION RATIO KPI

Energy saving per building: Quantifying the difference between measured and reference consumption data in a building within a predefined period.

KPI ID	Formula	Unit
EN2	EN2=MEC-REC	kWh
Metrics / Data		
MEC: measured energy consumption in the period for the building [kWh] REC: reference energy consumption in the period as defined by the baseline for the building [kWh]		

TABLE 35: ENERGY SAVING PER BUILDING KPI

Energy saving per system: Quantifying the difference between measured and reference consumption data in a system within a predefined period.

KPI ID	Formula	Unit
EN3	EN3=MEC-REC	kWh
Metrics / Data		
MEC: measured energy consumption in the period for the system [kWh] REC: reference energy consumption in the period as defined by the baseline for the system [kWh]		

TABLE 36: ENERGY SAVING PER SYSTEM KPI

Final consumption: Quantifying the total amount of energy consumed in a building (or in a part of it) within a predefined period.

KPI ID	Formula	Unit
EN4	EN4=MEC	kWh
Metrics / Data		
MEC: measured energy consumption in the period for the system [kWh]		

TABLE 37: FINAL CONSUMPTION KPI

Total renewable energy consumption: Quantifying the total amount of renewable energy (electricity) consumed in a building (or in a part of it) within a predefined period.

KPI ID	Formula	Unit
EN5	$EN5 = \sum_{source} EPs$	kWh
Metrics / Data		
EPs: measured energy production per source [kWh]		

TABLE 38: FINAL CONSUMPTION KPI

Through KPIs related to DR and flexibility we can identify and quantify the aggregate and proportionate flexibility. Below are these metrics.

Peak load reduction: Calculating the demand peak reduction in comparison to the baseline value, for a period/event.

KPI ID	Formula	Unit
DR1	DR1=PLMe-PLRe	kWh
Metrics / Data		
PLRe: maximum peak load measured in the event [kW] PLMe: maximum peak load expected as reference energy for the event [kW]		

TABLE 39: AGGREGATED FLEXIBILITY PROVIDED KPI

Aggregated flexibility provided: Calculating the total flexibility provided in comparison to the baseline value, for a period/event.

KPI ID	Formula	Unit
DR2	DR2=MECe-RECe	kWh
Metrics / Data		
MECe: measured energy consumption in the event [kWh] RECe: reference energy consumption in the event [kWh]		

TABLE 40: AGGREGATED FLEXIBILITY PROVIDED KPI

Amount of flexibility requested: Registering the sum of flexibility requested to the prosumers for a period/event.

KPI ID	Formula	Unit
DR3	DR3=FRe	kWh
Metrics / Data		
FRe: amount of flexibility requested per event and customer [kWh]		

TABLE 41: AMOUNT OF FLEXIBILITY REQUESTED KPI

Prosumer compliance per request: Percentage of compliance with the flexibility requests for a customer.

KPI ID	Formula	Unit
DR4	DR4=TSA/TSD×100	%
Metrics / Data		
TSA: total number of signals where the flexibility request was accepted TSD: total number of signals dispatched		

TABLE 42: PROSUMER COMPLIANCE PER REQUEST KPI

Flexibility provided vs. flexibility requested ratio: Percentage of the flexibility requested that was finally provided for a period/event and specific consumer.

KPI ID	Formula	Unit
DR5	DR5=DR2/DR3×100	%
Metrics / Data		
DR2: see Table 40 DR3: see Table 41		

TABLE 43: FLEXIBILITY PROVIDED VS. FLEXIBILITY REQUESTED RATIO KPI

5.2 Social and wellbeing

The following tables show the social and wellbeing (comfort) KPIs. Through them, we identify situations in which comfort or social parameters are not correct.

System average interruption duration: Measuring the average outage duration that any given customer would experience (average restoration time).

KPI ID	Formula	Unit
SOC1	$SOC1 = \prod RT$	Seconds
Metrics / Data		
RT: restoration time [seconds]		

TABLE 44: SYSTEM AVERAGE INTERRUPTION DURATION KPI

Thermal discomfort factor: Assessing incidences outside the comfort conditions regarding the thermal environment in an event and specific prosumer.

KPI ID	Formula	Unit
SOC2	$SOC2 = \frac{TTD}{TED} \times 100$	%
Metrics / Data		
TTD: time that a prosumer has been in thermal discomfort conditions on automation event TED: time of the event duration		

TABLE 45: THERMAL DISCOMFORT FACTOR KPI

Trust and confidence: Stakeholders' trust in confidentiality and security features of the BEYOND platform.

KPI ID	Formula	Unit
SOC3	Survey	Likert 1-5 scale
Metrics / Data		

TABLE 46: TRUST AND CONFIDENCE KPI

Visual discomfort factor: Capturing the feeling of visual discomfort.

KPI ID	Formula	Unit
SOC4	$SOC4 = \frac{VIC}{TC} \times 100$	%
Metrics / Data		
VIC: number of customers with visual discomfort incidences TCC: total number of customers		

TABLE 47 VISUAL DISCOMFORT FACTOR KPI

5.3 Economic

In this section are the economic KPIs, where everything related to revenue generated and economic efficiency is located.

Energy cost savings: Summing up all economic savings derived from energy efficiency measures per customer.

KPI ID	Formula	Unit
EC1	$EC1 = 1 - \frac{CSc}{CRe} \times 100$	%
Metrics / Data		
CSc: The actual operational cost post EEM implementation CRe: The baseline operational cost (before BEYOND EEM implementation)		

Table 48: Energy cost savings KPI

DR revenue: Summing up all the revenue from the participation in DR markets per customer.

KPI ID	Formula	Unit
EC2	$EC2 = \sum DRR$	€
Metrics / Data		
DRR: DR event remuneration		

Table 49: DR revenue KPI

Return on Investment: Evaluating the economic efficiency of energy measures for the whole building.

KPI ID	Formula	Unit
EC3	$EC3 = \frac{EC1 \times TEC + EC2 - SPC}{TCO}$	Years
Metrics / Data		
EC1: see KPI EC1 TEC: total energy cost [€] EC2: see KPI EC2 SPC: Service Provision Cost (equipment and service subscription cost) TCO: total cost of operation [€]		

Table 50: Return on Investment KPI

5.4 Environmental

The following KPIs show how to assess environmental impact.

GHG Emissions reduction: Summing up all economic savings derived from energy efficiency measures.

KPI ID	Formula	Unit
ENV1	$\text{ENV1} = \sum_{\text{energy source}} \text{TECs} \times \text{CDRs} - \sum_{\text{energy source}} \text{RECs} \times \text{CDRs}$	tCO_2 equivalent
Metrics / Data		
TECs: total energy consumption per energy source [kWh] CDRs: carbon dioxide emissions ratio for the energy source [tCO_2/kWh] RECs: reference energy consumption per energy source [kWh]		

TABLE 51: CO2 EMISSIONS REDUCTION KPI

6 Specific BEYOND KPIs per Business Model

This section shows the specific KPIs per business model, differentiating between aggregators, retailers, ESCOs, municipal authorities and DSOs. They have been derived, starting from deliverable 8.14 "Definition of new data-driven business models for buildings and energy". Following the review and analysis of this deliverable, a set of targets and corresponding metrics have been established in order to account for them.

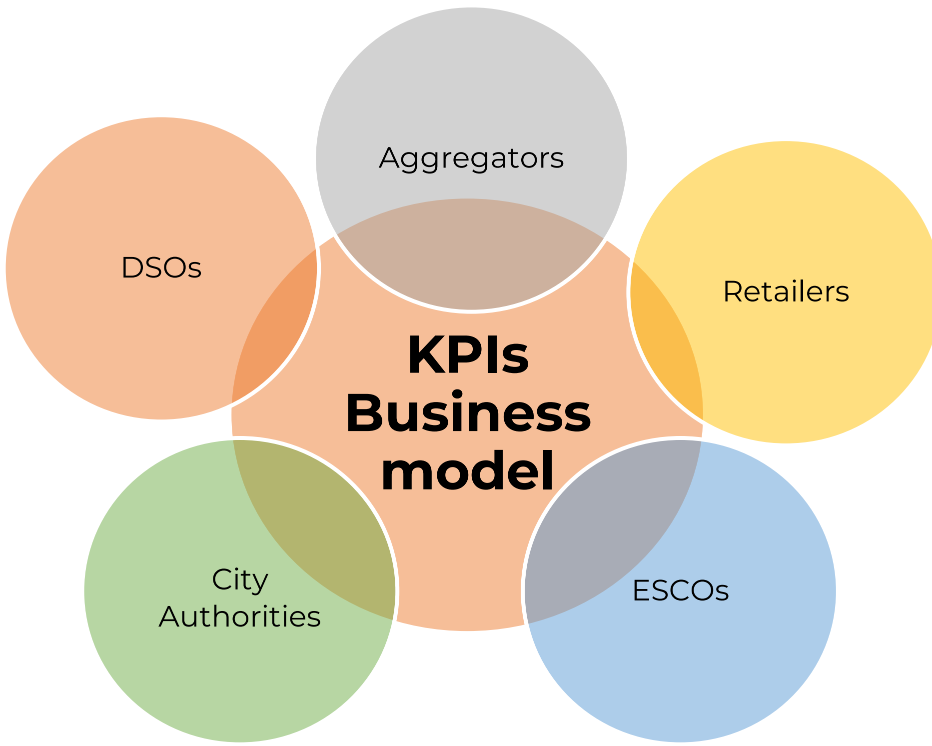


FIGURE 16 KPIS BUSINESS MODEL

6.1 Demand Response in Residential sector (Aggregators)

There are two business scenarios for Aggregators:

- Creation of new revenues through flexibility provision for ancillary services (Business Scenario 12)
- Improved profitability through utilization of the unleashed flexibility potential of the building sector (Business Scenario 13).

Business Scenario (12): Creation of new revenues through flexibility provision for ancillary services.

	Description	Metric	KPI ID
Objective 1	Revenues for the flexibility provided without compromising their comfort or scheduling	Monthly revenues for flexibility trading in open markets	BS12.OB1

KPI ID	Formula	Unit
BS12.OB1	$BS12.OB1 = \sum_{Flexibility} PMV\ flex \times MR$	€/Month
Metrics / Data		
PMV flex: PMV flexibility measurement (kWh) MR: Market retribution (€/kWh)		
Beneficiary Actors		
DSOs Aggregators Consumer/Prosumer		

TABLE 52 BUSINESS SCENARIO 12. OBJECTIVE 1

Business Scenario (13): Improved profitability through utilization of the unleashed flexibility potential of the building sector.

	Description	Metric	KPI ID
Objective 1	Advanced demand response schemes, flexibility and ancillary service markets	Aggregated monthly revenues for flexibility trading in ancillary service markets	BS13.OB1

KPI ID	Formula	Unit
BS13.OB1	$BS13.OB1 = \sum_{Flexibility} PMV\ flex \times AC\ MR$	€/Month
Metrics / Data		
PMV flex: PMV flexibility measurement (kWh) AC MR: Ancillary service market retribution (€/kWh)		
Beneficiary Actors		
DSOs/BRP Aggregators Consumer/Prosumer		

TABLE 53 BUSINESS SCENARIO 13. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Provisioning real time operational data of local generation assets, local storage, etc.	Revenues for the trading of real time operational data of local generation assets, local storage, etc.	BS13.OB2

KPI ID	Formula	Unit
BS13.OB2	$\mathrm{BS13.OB2} = \sum_{\mathrm{Revenues}} Revenues\ DR\ data\ trading$	€/Month
Metrics / Data		
Revenues data trading (€)		
Beneficiary Actors		
DSOs Aggregators ESCOs Facility Manager		

TABLE 54 BUSINESS SCENARIO 13. OBJECTIVE 2

In addition to these KPIs where certain objectives are covered, there are others that will be measured in the different tools created for the Project and that will affect to Aggregators.

Aggregator compliance per flexibility request - duration: Timestamp compliance per flexibility event.

KPI ID	Formula	Unit
DRT1	DRT1=DEP/DER×100	%
Metrics / Data		
DEP: Duration of event provided by the aggregator [h] DER: Requested duration of the event [h]		

TABLE 55 FLEXIBILITY EVENT KPI

Frequency of flexibility activation: Percentage of compliance with the flexibility requests from a third party (i.e., DSO).

KPI ID	Formula	Unit
DRT2	DRT2=FARs/FARq×100	%
Metrics / Data		
FARs: flexibility activation responses, number of dispatches FARq: flexibility activation requests, total number of flexibility activation requests		

TABLE 56 FREQUENCY OF FLEXIBILITY ACTIVATION KPI

Average validity of flexibility activations: Flexibility activation compliance with the flexibility requests from a third party (i.e., DSO).

KPI ID	Formula	Unit
DRT3	---	%
Metrics / Data		
FAR: flexibility activation response (O or 1) DRT2: Aggregated flexibility provided [kWh] FRe: amount of flexibility requested per event and customer [kWh] FARq: flexibility activation requests, total number of flexibility activation requests		

TABLE 57 FLEXIBILITY ACTIVATIONS KPI

Flexibility bottom boundary condition activations: Percentage of flexibility bottom boundary condition activations (marginal cases).

KPI ID	Formula	Unit
DRT4	DRT4=BBC/TFA×100	%
Metrics / Data		
BBC: bottom boundary condition activations (int) TFA: total flexibility activations (int)		

TABLE 58 FLEXIBILITY BOTTOM BOUNDARY CONDITION ACTIVATIONS KPI

Daily disruptions of a system caused by flexibility activation: Sum of daily interruptions or event triggered demand response events.

KPI ID	Formula	Unit
DRT5	DRT5=BWH-DEPs	%
Metrics / Data		
BWH: baseline daily working hours per system [h] DEPs: Duration of a flexibility event provided by a certain system [h]		

TABLE 59 DAILY DISRUPTIONS OF A SYSTEM CAUSED BY FLEXIBILITY ACTIVATION KPI

In addition to the aforementioned KPIs, we introduce an additional KPI that refers to the assessment of the viability of the business model for aggregators. This KPI utilizes the two following sub-KPIs (revenues vs cost items) with the aim to create a positive cash flow for Aggregators.

Revenue streams:

KPI ID	Formula	Unit
RS_1	$\mathrm{RS\_1} = \sum FSR + HCFS + RDAT$	€/year
Metrics / Data		
FSR: Service remuneration for flexibility provision to Network Operators HCFS: Service revenues for human-centric flexibility control services. RDAT: Revenues from data asset transactions for flexibility analytics to 3rd parties.		

TABLE 60 REVENUE STREAMS KPI (RS_1)

Cost items:

KPI ID	Formula	Unit
CI_1	$CI\_1 = \sum DSA + DTF + DQS + DASC$	€/year
Metrics / Data		
DSA: Data subscription and acquisition from Collaborators DTF: Data Transaction Fees as Portion of Data Contract Value DQS: Data Quality Service Costs DASC: Data Analytics Service Costs		

TABLE 61 COST ITEMS KPI (CI_1)

Business Model Assessment KPI:

KPI ID	Formula	Unit
BMA_1	$\max DSA\ for\ which\ BMA\_1 = RS\_1 - CI\_1 > 0$	€/year
Clarifications		
The KPI aims at determine the maximum value of the metric DSA (see KPI CI_1) for which the business model presents a positive cash flow		

TABLE 62 BUSINESS MODEL ASSESSMENT KPI (BMA_1)

6.2 EaaS for retailers. Energy management and non-Energy services (Retailers)

There are five business scenarios for Retailers:

- EPC optimization through real-time monitoring and improvement of energy performance of buildings, as well as, through predictive maintenance of building assets (Business Scenario 8)
- Energy costs savings with preservation of well-being preferences through the deployment of personalized and advanced human-centric energy services incl. self-consumption (Business Scenario 11)
- Improved profitability through utilization of the unleashed flexibility potential of the building sector (Business Scenario 13).
- New revenues through provision of services to Network Operators (Implicit DR) and avodiance of unncessary charges through imbalance management (Business Scenario 14)
- Increased profitability and long-term sustainability through the transformation of their business-as-usual (BaU) to data and intelligence-driven Energy-as-a-Service offerings (Business Scenario 15)

Business Scenario (8): EPC optimization through real-time monitoring and improvement of energy performance of buildings, as well as, through predictive maintenance of building assets.

	Description	Metric	KPI ID
Objective 1	Revenues from real-time monitoring and improvement of energy performance of buildings	PMV verified economic energy savings	BS8.OB1

KPI ID	Formula	Unit
BS8.OB1	$\text{BS8. OB1} = \sum_{PMV\ savings} \text{PMV savings} \times \text{EC}$	€/Month
Metrics / Data		
PMV savings: PMV verified savings (kWh) EC: Energy cost (€/kWh)		
Beneficiary Actors		
Retailers Facility Managers Consumer/Prosumer		

TABLE 63 BUSINESS SCENARIO 8. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Revenues from predictive maintenance of building assets	Aggregated monthly revenues from predictive maintenance services	BS8.OB2

KPI ID	Formula	Unit
BS8.OB2	$\text{BS8. OB2} = \sum Number\ of\ services * CS$	€/Month
Metrics / Data		
Number of services (units) CS: Cost of service (€)		
Beneficiary Actors		
Facility Managers Consumer/Prosumer ESCOs		

TABLE 64 BUSINESS SCENARIO 8. OBJECTIVE 2

Business Scenario (11): Energy costs savings with preservation of well-being preferences through the deployment of personalized and advanced human-centric energy services incl. self-consumption.

	Description	**Metric**	**KPI ID**
Objective 1	Savings from optimized energy use locally and optimize self-consumption.	Differences before / after of Savings from self-consumption.	BS11.OB1

KPI ID	**Formula**	**Unit**
BS11.OB1	$BS11.OB1 = \sum_{Savings} (SSC_B - SSC_A) * EC$	€/Month
Metrics / Data		
SSC_B = Before of Savings from self-consumption (kWh) SSC_B = After of Savings from self-consumption (kWh) EC = Energy cost (€/kWh)		
Beneficiary Actors		
Facility Managers Consumer/Prosumer ESCOs		

TABLE 65 BUSINESS SCENARIO 11. OBJECTIVE 1

	Description	**Metric**	**KPI ID**
Objective 2	Revenues from data sales to retailers, for the provision of non-energy services such as well-being and comfort preservation and security.	Human centric non-energy services	BS11.OB2

KPI ID	**Formula**	**Unit**
BS11.OB2	$BS11.OB2 = \sum Revenues\ Non\ Energy\ services\ data\ trading$	€/Month
Metrics / Data		
Revenues Non Energy services data trading (€)		
Beneficiary Actors		
Retailers Facility Managers Consumer/Prosumer ESCOs		

TABLE 66 BUSINESS SCENARIO 11. OBJECTIVE 2

Business Scenario (13): Improved profitability through utilization of the unleashed flexibility potential of the building sector.

	Description	Metric	KPI ID
Objective 1	Advanced demand response schemes, flexibility and ancillary service markets	Aggregated revenues for flexibility for participation in ancillary service markets	BS13.OB1

KPI ID	Formula	Unit
BS13.OB1	$\mathrm{BS13.OB1} = \sum_{\mathrm{Flexibility}} \mathrm{PMV\ flex} \times \mathrm{AC\ MR}$	€/Month
Metrics / Data		
PMV flex: PMV flexibility measurement (kWh) AC MR: Ancillary service market retribution (€/kWh)		
Beneficiary Actors		
DSOs/BRP Aggregators Consumer/Prosumer		

Table 67 Business scenario 13. Objective 1

	Description	Metric	KPI ID
Objective 2	Provisioning real time operational data of local generation assets, local storage, etc.	Revenues for the trading of real time operational data of local generation assets, local storage, etc.	BS13.OB2

KPI ID	Formula	Unit
BS13.OB2	$\mathrm{BS13.OB2} = \sum_{\mathrm{Revenues}} Revenues\ DR\ data\ trading$	€/Month
Metrics / Data		
Revenues data trading (€)		
Beneficiary Actors		
DSOs/BRP Retailers Aggregators		

Table 68 Business scenario 13. Objective 2

Business Scenario (14): New revenues through provision of services to Network Operators (Implicit DR) and avodiance of unncessary charges through imbalance management.

	Description	Metric	KPI ID
Objective 1	Savings from implicit DR against anticipated imbalances and charges	Aggregated revenues for flexibility for imbalance penalty and charge avoidance	BS14.OB1

KPI ID	Formula	Unit
BS14.OB1	$BS14.OB1 = \sum_{Flexibility} PMV\ flex \times MP$	€/Month
Metrics / Data		
MP= Market penalty for imbalances (€/kWh)		
Beneficiary Actors		
DSOs/BRP Retailers Aggregators Consumer/Prosumer		

TABLE 69 BUSINESS SCENARIO 14. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Compliance with energy obligations, Optimization of pricing schemes	Revenues for Compliance with energy obligations, Optimization of pricing schemes	BS14.OB2

KPI ID	Formula	Unit
BS14.OB2	$BS14.OB2 = \sum PMV\ savings \times EOP$	€/Month
Metrics / Data		
PMV Savings (€) EOP: Energy obligations price (€)		
Beneficiary Actors		
Retailers DSOs		

TABLE 70 BUSINESS SCENARIO 14. OBJECTIVE 2

Business Scenario (15): Increased profitability and long-term sustainability through the transformation of their business-as-usual (BaU) to data and intelligence-driven Energy-as-a-Service offerings.

	Description	Metric	KPI ID
Objective 1	Personalized energy analytics for energy efficiency service to Buildings,	Aggregated revenues of new Beyond services	BS15.OB1

KPI ID	Formula	Unit
BS15.OB1	$\mathrm{BS15.OB1} = \sum \mathrm{BaU\ revenues} - \mathrm{BMR}$	€/Year
Metrics / Data		
BaU revenues (€) BMR: BEYOND model revenues (€)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 71 BUSINESS SCENARIO 15. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Revenues from services related to intelligent control/smart automation and non-E services	Aggregated revenues of new Beyond automation and non-energy services	BS15.OB2

KPI ID	Formula	Unit
BS15.OB2	Number of services * cost service $\mathrm{BS15.OB2} = \sum \mathrm{NS} \times \mathrm{CS}$	€/Year
Metrics / Data		
NS: Number of services (units) CS: Cost service (€)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 72 BUSINESS SCENARIO 15. OBJECTIVE 2

In addition to the aforementioned KPIs, we introduce an additional KPI that refers to the assessment of the viability of the business model for aggregators. This KPI utilizes the two following sub-KPIs (revenues vs cost items) with the aim to create a positive cash flow for Retailers.

Revenue streams:

KPI ID	Formula	Unit
RS_2	$\mathrm{RS\_2} = \sum RESS + RNESS + AIC + RCR + REP$	€/year
Metrics / Data		
RESS: Revenues from energy service subscriptions. RNESS: Revenues from non-energy service subscriptions. AIC: Avoidance of imbalance charges and EE obligations non-compliance penalties. RCR: Reduced churn rate (avoidance of revenue losses) and brand enhancement, leading to an increased market share and associated revenues. REP: Potential future revenues from elasticity/ flexibility provision to DSOs.		

TABLE 73 REVENUE STREAMS KPI (RS_2)

Cost items:

KPI ID	Formula	Unit
CI_2	$\mathrm{CI\_2} = \sum DSA + DTF + DQS + DASC + ESCS$	€/year
Metrics / Data		
DSA: Data subscription and acquisition from Collaborators DTF: Data Transaction Fees as Portion of Data Contract Value DQS: Data Quality Service Costs DASC: Data Analytics Service Costs ESCS: Services to ESCOs for know-how and expertise acquisition (as a portion of the relevant subscription fees to the associated energy services provided with the support of ESCOs).		

TABLE 74 COST ITEMS KPI (CI_2)

Business Model Assessment KPI:

KPI ID	Formula	Unit
BMA_2	$\max DSA\ for\ which\ \mathrm{BMA\_2} = \mathrm{RS\_2} - \mathrm{CI\_2} > 0$	€/year
Clarifications		
The KPI aims at determining the maximum value of the metric DSA (see KPI CI_2) for which the business model presents a positive cash flow		

TABLE 75 BUSINESS MODEL ASSESSMENT KPI (BMA_2)

6.3 AI-driven EPC and renovation (ESCO)

There are three business scenarios for ESCOs:

- Reinforcement of the effectiveness and de-risking of the viability of Energy Performance Contracting through reliance on accurate occupancy-related schedules (Business Scenario 6)
- New revenue creation through new services for real-time energy performance certification, complemented by Smart Readiness Certification services (Business Scenario 7)
- EPC optimization through real-time monitoring and improvement of energy performance of buildings, as well as, through predictive maintenance of building assets (Business Scenario 8)

Business Scenario (6): Reinforcement of the effectiveness and de-risking of the viability of Energy Performance Contracting through reliance on accurate occupancy-related schedules.

	Description	Metric	KPI ID
Objective 1	Enhanced accuracy of energy performance simulations, real-time performance data of the building for computing simulations, safer investment payback	Average mean error of BEYOND forecast simulations	BS6.OB1

KPI ID	Formula	Unit
BS6.OB1	$BS6.OB1 = \sqrt{\frac{(FP^2 - AC^2)}{NS}}$	kWh
Metrics / Data		
FP: Forecast Prediction (kWh) AC: Actual consumption (kWh) NS: Number of simulations (Unit)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 76 BUSINESS SCENARIO 6. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Engagement of buildings in investments	Total and per person investment triggered in building retrofitting and system deployment	BS6.OB2

KPI ID	Formula	Unit
BS6.OB2	$BS6.OB2 = \sum_{Investment} Investments$	€/Year
Metrics / Data		
Total and per person investment		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 77 BUSINESS SCENARIO 6. OBJECTIVE 2

<u>Business Scenario (7):</u> New revenue creation through new services for real-time energy performance certification, complemented by Smart Readiness Certification services.

	Description	Metric	KPI ID
Objective 1	Revenues from new services for accurate and real -time Energy Performance Certification	Energy performance certification	BS7.OB1

KPI ID	Formula	Unit
BS7.OB1	$BS7.OB1 = \sum(S * CSE)$	€
Metrics / Data		
S: Services (Unit) CSS: Service Cost Energy performance certification (€)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 78 BUSINESS SCENARIO 7. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Revenues from Smart readiness Certification services	Smart readiness Certification	BS7.OB2

KPI ID	Formula	Unit
BS7.OB2	$BS7.OB2 = \sum(S * CSS)$	€/Year
Metrics / Data		
S: Services (Unit) CSS: Service Cost Smart readiness certification (€)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 79 BUSINESS SCENARIO 7. OBJECTIVE 2

Business Scenario (8): EPC optimization through real-time monitoring and improvement of energy performance of buildings, as well as, through predictive maintenance of building assets.

	Description	Metric	KPI ID
Objective 1	Revenues from real-time monitoring and improvement of energy performance of buildings	PMV verified economic energy savings	BS8.OB1

KPI ID	Formula	Unit
BS8.OB1	$BS8.OB1 = \sum_{PMV\ savings} \text{PMV savings} \times \text{EC}$	€
Metrics / Data		
PMV savings: PMV verified savings (kWh) EC: Energy cost (€/kWh)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 80 BUSINESS SCENARIO 8. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Revenues from predictive maintenance of building assets	Aggregated monthly revenues from predictive maintenance services	BS8.OB2

KPI ID	Formula	Unit
BS8.OB2	$\mathrm{BS8.OB2} = \sum Number\ of\ services * CS$	€/Month
Metrics / Data		
Number of services (units) CS: Cost of service (€)		
Beneficiary Actors		
Consumer/Prosumer ESCOs Facility Manager		

TABLE 81 BUSINESS SCENARIO 8. OBJECTIVE 2

In addition to these KPIs where certain objectives are covered, there are others that will be measured in the different tools created for the Project and that will affect to ESCOs.

Gap between predicted and actual heating/cooling energy consumption: This indicator shows the ability of the application/tool to reduce the gap between predicted and actual energy consumption of individual buildings

KPI ID	Formula	Unit
VPP.1	$\mathrm{R2} = \sum(\mathrm{y\hat{}i} - \mathrm{y})2\ /\sum(\mathrm{yi} - \mathrm{y})2$ $\mathrm{RMSE} = \ \mathrm{S}\ (1/\mathrm{n} \sum (\mathrm{yi} - \mathrm{y\hat{}i})2)$ $\mathrm{NRMSE} = \mathrm{RMSE}/(\ \mathrm{ymax}\ \ - \mathrm{ymin}\ )$	mW
Metrics / Data		
NRMSE - Normalized root-mean-square error, R^2 - coefficient of determination, y_i is the observation, y is its mean, and $\hat{y}_i$ is predicted value, y_{max} and y_{min} are the maximum and minimum values of y, respectively		

TABLE 82 GAP PREDICTED KPI

Time saving: This indicator shows the ability of the application/tool to reduce the time needed to identify the required renovation actions

KPI ID	Formula	Unit
VPP.2	$\Delta\mathrm{T} = \mathrm{Tsimul}\ \text{-}\ \mathrm{Tai}$	Hour
Metrics / Data		
ΔT - time saving, T_{simul} - time used to simulate number (N) of renovation cases with commercial tools (e.g. IDA ICE), T_{ai} - time used to simulated number (N) of renovation cases using AI/real data based renovation support app developed in BEYOND		

TABLE 83 TIME SAVING KPI

Cost saving: This indicator shows the ability of the application/tool to reduce the costs invested to identify the required renovation actions

KPI ID	Formula	Unit
VPP.3	$C = \Delta T \times Ch + \Delta Ct$	€
Metrics / Data		
C - cost saving, ΔT - time saving (see previous KPI_XX), C_h - cost of work (€/hour), ΔC_t - cost difference for used tools (e.g. licenses)		

TABLE 84 COST SAVING KPI

In addition to the aforementioned KPIs, we introduce an additional KPI that refers to the assessment of the viability of the business model for aggregators. This KPI utilizes the two following sub-KPIs (revenues vs cost items) with the aim to create a positive cash flow for ESCOs.

Revenue streams:

KPI ID	Formula	Unit
RS_3	$RS\_3 = \sum RPFP + REPOS + OPEXR + RFT$	€/year
Metrics / Data		
RPFP: Revenues from highly effective Pay-for-Performance EPC contracts REPOS: Revenues from Advanced Data-driven Energy Performance Optimization Services OPEXR: OPEX Reduction for on-site auditing. RFT: Possible future revenues from flexibility transactions		

TABLE 85 REVENUE STREAMS KPI (RS_3)

Cost items:

KPI ID	Formula	Unit
CI_3	$CI\_3 = \sum DSA + DTF + DQS + DASC$	€/year
Metrics / Data		
DSA: Data subscription and acquisition from Collaborators DTF: Data Transaction Fees as Portion of Data Contract Value DQS: Data Quality Service Costs DASC: Data Analytics Service Costs		

TABLE 86 COST ITEMS KPI (CI_3)

Business Model Assessment KPI:

KPI ID	Formula	Unit
BMA_3	$\max DSA\ for\ which\ \mathrm{BMA\_3} = \mathrm{RS\_3} - \mathrm{CI\_3} > 0$	€/year
Clarifications		
The KPI aims at determining the maximum value of the metric DSA (see KPI CI_3) for which the business model presents a positive cash flow		

TABLE 87 BUSINESS MODEL ASSESMENTKPI (BMA_3)

6.4 Urban data brokering (City authorities)

There is one business scenario for City Authorities:

- More effective decision-making for urban planning and evidence-based realistic target setting for their transformation to smart and sustainable ecosystems, through advanced forecasting of demand in buildings (Business Scenario 16)

Business Scenario (16): More effective decision-making for urban planning and evidence-based realistic target setting for their transformation to smart and sustainable ecosystems, through advanced forecasting of demand in buildings.

	Description	Metric	KPI ID
Objective 1	Better investment allocation for urban planning and more accurate predictions urban planning scenarios	Revenues from optimization of urban planning scenarios	BS16.OB1

KPI ID	Formula	Unit
BS16.OB1	$\mathrm{BS16.OB1} = \mathrm{BaU\ BCOC} - \mathrm{BBCOC}$	€/Year
Metrics / Data		
BaU BCOCC: BaU Building and city operation costs (€) BBCOC: BEYOND Building and city operation costs (€)		
Beneficiary Actors		
City Authorities Facility Manager		

TABLE 88 BUSINESS SCENARIO 16. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Open governance, new business opportunities, jobs creation and GDP growth	New business opportunities / New job creation / GDP growth	BS16.OB2

KPI ID	Formula	Unit
BS16.OB2	New BEYOND business opportunities New job creation related to BEYOND GDP growth related to BEYOND	N° opportunities / year New jobs / year % growth / year
Metrics / Data		

Beneficiary Actors		
City Authorities Facility Manager Citizens		

TABLE 89 BUSINESS SCENARIO 16. OBJECTIVE 2

In addition to the aforementioned KPIs, we introduce an additional KPI that refers to the assessment of the viability of the business model for aggregators. This KPI utilizes the two following sub-KPIs (revenues vs cost items) with the aim to create a positive cash flow for Cities.

Revenue streams:

KPI ID	Formula	Unit
RS_4	$\mathrm{RS\_4} = \sum FES + AUC + TRI + RIC$	€/year
Metrics / Data		
FES: Significant future energy savings, achieved through the on-time realization of the SECAP. AUC: Avoidance of unnecessary costs caused by erroneous or inaccurate investment decisions. TRI: Increase of tax revenues through GDP increase and new jobs creation. RIC: Reduced investment costs due to the attraction of investors to participate and contribute to the SECAP realization		

TABLE 90 REVENUE STREAMS KPI (RS_4)

Cost items:

KPI ID	Formula	Unit
CI_4	$\mathrm{CI\_4} = \sum DSA + DTF + DQS + DASC$	€/year
Metrics / Data		
DSA: Data subscription and acquisition from Collaborators DTF: Data Transaction Fees as Portion of Data Contract Value DQS: Data Quality Service Costs DASC: Data Analytics Service Costs		

TABLE 91 COST ITEMS KPI (CI_4)

Business Model Assessment KPI:

KPI ID	Formula	Unit
BMA_4	$\max DSA \; for \; which \; \mathrm{BMA\_4} = \mathrm{RS\_4} - \mathrm{CI\_4} > 0$	€/year
Clarifications		
The KPI aims at determining the maximum value of the metric DSA (see KPI CI_4) for which the business model presents a positive cash flow		

TABLE 92 BUSINESS MODEL ASSESSMENT KPI (BMA_4)

6.5 Network management, sizing and planning (DSOs)

There are two business scenarios for DSOs:

- Avoidance of costly investments through evidence-based, data-driven sizing of energy networks (Business Scenario 9)
- Cost-effective planning of network operation, OPEX reduction and avoidance of peak loads and network congestion through accurate estimation and utilization of flexibility offered by building assets (Business Scenario 10)

Business Scenario (9): Avoidance of costly investments through evidence-based, data-driven sizing of energy networks.

	Description	Metric	KPI ID
Objective 1	Reduced total cost of owning and operating their network	Differences of BaU ownership and operating costs respect to BEYOND model	BS9.OB1

KPI ID	Formula	Unit
BS9.OB1	$\mathrm{BS9.OB1} = \sum BaU\,(CO + PC) - BEYOND\,(CO + PC)$	€/Year
Metrics / Data		
CO: Cost Ownership (€) OC: Operating Cost (€)		
Beneficiary Actors		
City Authorities Facility Manager Citizens		

TABLE 93 BUSINESS SCENARIO 9. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Avoidance of unnecessary network investments	Savings in network investment	BS9.OB2

KPI ID	Formula	Unit
BS9.OB2	$BS10.OB2 = \sum BaU\ PI - \ BI$	€/Year
Metrics / Data		
BaU PI: BaU planned investment (€) BI: BEYOND Investment (€)		
Beneficiary Actors		
DSOs		

TABLE 94 BUSINESS SCENARIO 9. OBJECTIVE 2

Business Scenario (10): Cost-effective planning of network operation, OPEX reduction and avoidance of peak loads and network congestion through accurate estimation and utilization of flexibility offered by building assets.

	Description	Metric	KPI ID
Objective 1	Lower OPEX costs for network operation and security of supply	Difference between BaU operating costs and BEYOND operating costs	BS10.OB1

KPI ID	Formula	Unit
BS10.OB1	BS10.OB1 = Grid BaU Opex – Grid BEYOND Opex	€/Year
Metrics / Data		
Grid BaU Opex (€) Grid BEYOND Opex (€)		
Beneficiary Actors		
DSOs		

TABLE 95 BUSINESS SCENARIO 10. OBJECTIVE 1

	Description	Metric	KPI ID
Objective 2	Reduced need for maintenance and increased network assets life time	Difference of grid LCC after BEYOND model implementation	BS10.OB2

KPI ID	Formula	Unit
BS10.OB2	$BS10.OB2 = \sum BaU\ LCC - BEYOND\ LCC$	€
Metrics / Data		
BaU LCC (€) BEYOND LCC (€)		
Beneficiary Actors		
DSOs		

TABLE 96 BUSINESS SCENARIO 10. OBJECTIVE 2

In addition to the aforementioned KPIs, we introduce an additional KPI that refers to the assessment of the viability of the business model for aggregators. This KPI utilizes the two following sub-KPIs (revenues vs cost items) with the aim to create a positive cash flow for Network Operators.

Revenue streams:

KPI ID	Formula	Unit
RS_5	$\mathrm{RS\_5} = \sum OPEXR + AUC + RFSA + RPCE + LPL$	€/year
Metrics / Data		
OPEXR: OPEX minimization. AUC: Cost savings through the avoidance of unnecessary investments for network expansion and reinforcement to manage an increased number of distributed assets and resources. RFSA: Reduction of costs for flexibility service acquisition and utilization of much cheaper flexibility sources for the necessary services RPCE: Reduction of penalties for congestion events. LPL: Increased efficiency of the network (through de-centralized management), leading to lower power losses		

Table 97 Revenue streams KPI (RS_5)

Cost items:

KPI ID	Formula	Unit
CI_5	$\mathrm{CI\_4} = \sum DSA + DTF + DQS + DASC$	€/year
Metrics / Data		
DQS: Data Quality Service Costs DASC: Data Analytics Service Costs		

Table 98 Cost items KPI (CI_5)

Business Model Assessment KPI:

KPI ID	Formula	Unit
BMA_5	$\mathrm{BMA\_5} = \mathrm{RS\_5} - \mathrm{CI\_5}$	€/year

Table 99 Business Model Assessment KPI (BMA_5)

7 BEYOND Platform Technical Validation

This set of metrics is devoted to assess the technical performance of the BEYOND's data platform, as well as data quality to ensure a smooth provision of data and energy services.

7.1 BEYOND Data-relevant KPIs

KPIs Name: Data Overall Quality Assessment Indicator

KPI Description: A qualitative indicator that aims at assessing a variety of aspects around data quality, such as Data Suitability, Data Usability, Data Reliability, Data Security, Data Accuracy, Data Accessibility, Data Confidentiality and Data Availability, considering the perceptions and overall experience of the users of the platform during their interaction with the BEYOND platform.

KPI ID	Formula	Unit
Data01	Qualitative Analysis	1-5 Likert Scale
Aspects to be assessed through a questionnaire		
Data Suitability, Data Usability, Data Reliability, Data Security, Data Accuracy, Data Accessibility, Data Confidentiality and Data Availability		

TABLE 100 DATA OVERALL QUALITY ASSESSMENT INDICATOR

KPIs Name: Data Error Rate

KPI Description: The KPI aims at assessing in a quantitative manner the correctness of data available in the BEYOND platform. The KPI needs be calculated before the dataset is ingested in the Platform, before the dataset is retrieved from the Platform and periodically, during its existence in the platform.

KPI ID	Formula	Unit
Data02	Data Error Rate = Erroneous Datasets/ Total Datasets*100	%
Metrics / Data		
Erroneous Datasets (number of datasets presenting mistakes and errors) Total Datasets (total number of datasets available in the BEYOND platform)		

TABLE 101 DATA ERROR RATE

KPIs Name: Data Completeness Rate

KPI Description: The KPI aims at assessing the completeness of data, in relation to the needs of the BEYOND applications for functioning in the proper manner. The KPI needs be calculated before the dataset is ingested in the Platform, before the dataset is retrieved from the Platform and periodically, during its existence in the platform.

KPI ID	Formula	Unit
Data03	Data Completeness Rate = Provided Datasets/ Necessary Datasets*100	%
Metrics / Data		
Provided Datasets (number of datasets requested by the BEYOND apps and offered through the BEYOND platform) Necessary Datasets (total number of necessary datasets from the BEYOND apps)		

TABLE 102 DATA COMPLETENESS RATE

KPIs Name: Data Security Rate

KPI Description: The KPI aims at assessing security of the data made available through the BEYOND platform.

KPI ID	Formula	Unit
Data04	Data Security Rate = Compromised Datasets/ Total Datasets*100	%
Metrics / Data		
Compromised Datasets (number of datasets compromised) Total Datasets (total number of datasets available in the BEYOND platform)		

TABLE 103 DATA SECURITY RATE

KPIs Name: Data Interoperability Rate

KPI Description: The KPI aims at the level of interoperability achieved during the connection and data exchange with external systems

KPI ID	Formula	Unit
Data05	Data Interoperability Rate = Integrated Systems/ Total Systems*100	%
Metrics / Data		
Integrated Systems (number of systems that can effectively operate with the use of the data available in BEYOND) Total Systems (total number of related systems, originally planned to be integrated with the BEYOND platform)		

TABLE 104 DATA INTEROPERABILITY RATE

KPIs Name: Data Efficiency Rate

KPI Description: The KPI aims at assessing the efficiency of the data stored and retrieved through the BEYOND platform.

KPI ID	Formula	Unit
Data06	Data Efficiency = Data Volume Stored/ Load Time	Byte/Sec
Metrics / Data		
Data Volume Stored (amount of data stored in the platform in bytes) Load Time (time needed in seconds, for the respective data to load in the platform)		

TABLE 105 DATA EFFICIENCY RATE

KPIs Name: Data Reliability

KPI Description: The KPI aims at assessing the reliability of the data offered through the BEYOND platform in terms of recoverability and backups.

KPI ID	Formula	Unit
Data07	Data Reliability = Data Recoverability + Data Backup	Integer [0..2]
Metrics / Data		
Data Recoverability (Boolean value that declares if there is a mechanism about the recovery of the data, apart from backups (0-1)) Data Backup (Boolean value that declares if there is a mechanism for the frequent backup of data available in the platform (0-1))		

TABLE 106 DATA RELIABILITY

7.2 BEYOND Platform Technical KPIs

Besides the assessment of Data-relevant KPIs (focusing on Data Quality Aspects) in the BEYOND platform, a number of additional KPIs is required for assessing the overall performance and stress tolerance of the platform, towards identifying the maximum limits that it can effectively and correctly operate. The aim of such KPIs is to identify the extremes within which the platform can operate normally without its behaviour being seriously affected, thus enabling the concurrent identification of its breaking point and robustness.

The following tables present the relevant KPIs that have been identified by the consortium and will be measured during the pre-validation and verification activities of the project, prior to the launch of the demonstration activities.

KPI ID	PLAT01	Batch Data Volume Uploaded through a browser
	PLAT02	Concurrent Data Ingestion Jobs executed
	PLAT03	API Data Ingestion Jobs in time (Jobs execution per a specific time duration)
	PLAT04	Number of real-time messages received per minute through the use of PubSub mechanisms
	PLAT05	Maximum number of datasets available in the platform
	PLAT06	Number of Data Contracts signed per second
	PLAT07	Number of concurrent analytics jobs executed (analysis to be done for different levels of input records e.g., hundreds, thousands, 1-10 millions, over 10 millions, etc.)
	PLAT08	Number of Retrieval Queries executed per a specific time duration)

TABLE 107 PLATFORM TECHNICAL KPIS

8 BEYOND Validation Scenarios and Evaluation Process

The following list of demonstration cases intends to cover the evaluation of the business models, the data transfer between actors and the tools associated with every business model.

1. **Energy Performance Optimization and Self-Consumption Maximization through the application of the digital twin concept in buildings.**

"This demo case will enable direct data sharing between different types of buildings located in Athens, Helsinki and Belgrade (sharing realtime BEMS, generation and IoT information from myriads of devices in buildings with more detailed data generation capabilities as presented before) and the respective demo partners (Mytilineos, FVH and BEOELEK), with the latter taking over the detailed analysis (flexibility extraction) and optimization of building assets, through real-time energy consumption optimization (human-centric control of major building loads) and self-consumption maximization (real-time matching of demand and supply utilizing the flexibility offered from the demand side) with ultimate aim to increase the energy performance of such buildings with the utilization of the Building Digital Twins Environment for Energy Performance Optimisation, Self-consumption Maximisation and Predictive Maintenance (BEPO) that will be configured by VTT during the project implementation."

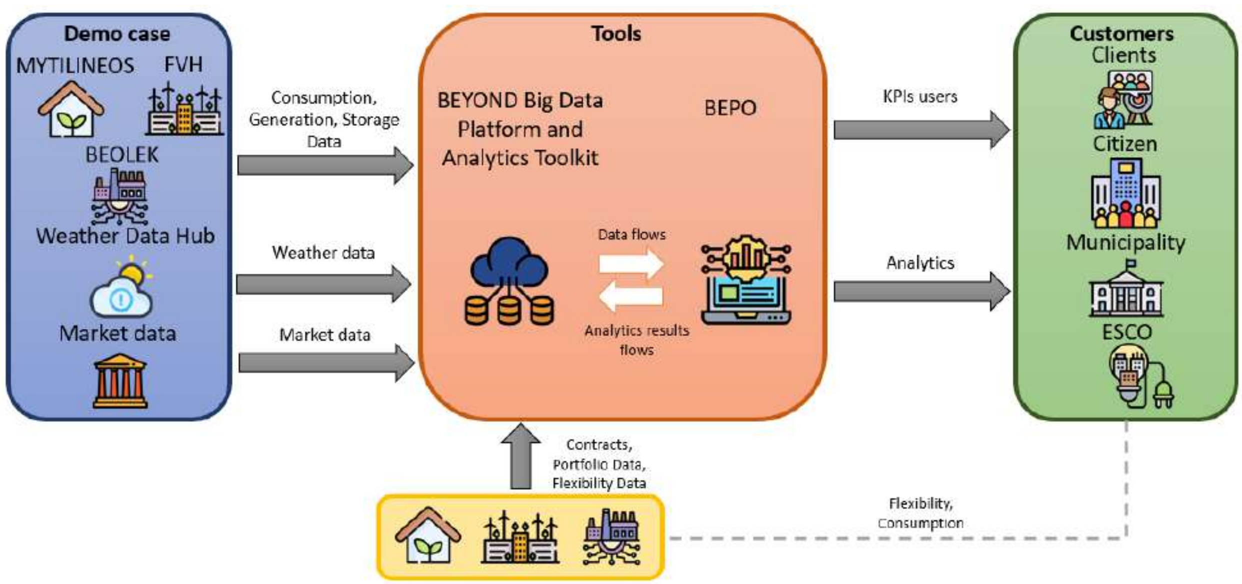


FIGURE 17 MAPPING DEMO CASE 1

2. Predictive Maintenance Improvement through Digital Twins and Enhanced AI Analytics.

"This demo case will enable direct data sharing between different types of buildings located in Helsinki (sharing real-time BEMS and IoT information from myriads of devices (sensors, actuators) in buildings with more detailed data generation capabilities as presented before) and FVH, with the latter taking over the detailed analysis and optimization of building assets, through predictive maintenance services (enabling accurate fault diagnosis and characterization over critical systems and equipment, probability assessment of fault occurrence, early prediction of faults and facilitate increased reliability and efficiency of building assets)."
This will be done with the tool: Building Digital Twins Environment for Energy Performance Optimisation, Self-consumption Maximisation and Predictive Maintenance (BEPO).

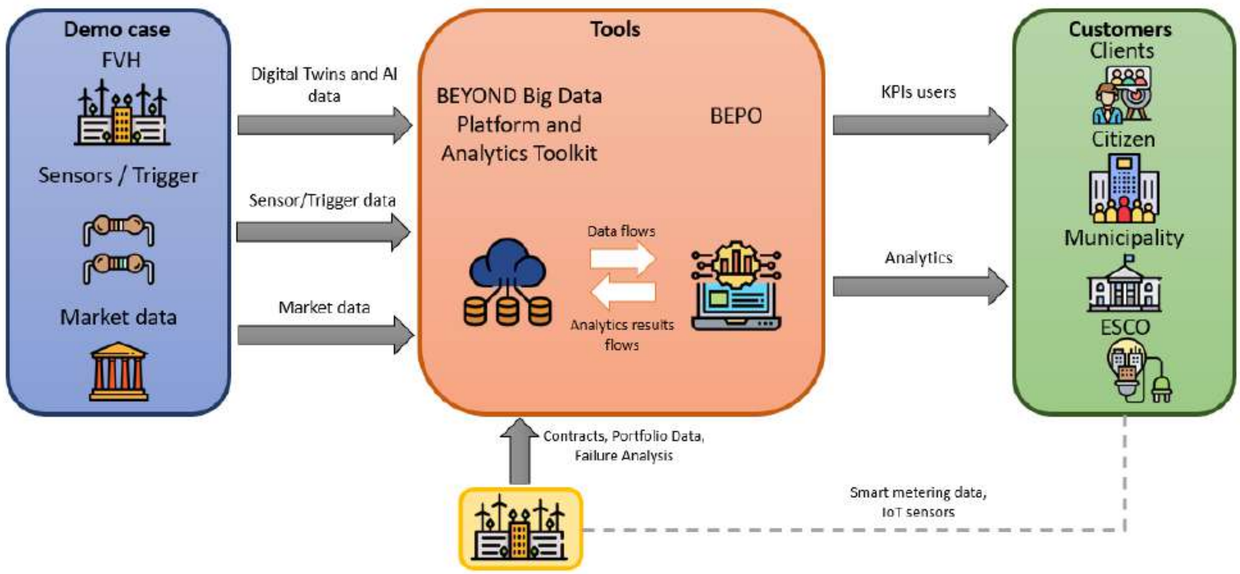


FIGURE 18 MAPPING DEMO CASE 2

3. Building Portfolio Management Optimization for Energy Efficiency through Portfolio Energy Analytics and better-suited Billing Strategies.

"The realization of this demo case will be based on the validation of a complete toolbox for energy retailers for comprehensive portfolio analysis, towards optimizing a series of business objectives. In more detail the Portfolio Analysis toolbox will utilize smart meter and consumption data from buildings belonging in the porfolio of energy retailers involved in the demo activities of the project, together with weather data, energy market/ price data and customer data (demographic, location-based, smart home/ IoT data) to offer a holistic view and respective insights over the customer portfolio of energy retailers (hundreds of thousands buildings belonging in the portfolio of Mytilineos, Cuerva and BEOELEK) towards (i) significantly reducing imbalances caused by forecasting errors, thus avoiding extremely high imbalance charges; (ii) examining advanced billing concepts (e.g. dynamic energy pricing) by segmenting, clustering and analysing consumption behaviours, inferring the elasticity of specific clusters against varying energy pricing levels and deploying highly effective implicit demand response strategies, towards optimizing the performance of their portfolio while hedging against non-anticipated imbalances; (iii) monitoring their compliance to Energy Efficiency obligations imposed by the European Commission and adopted by the Member States and designing appropriate portfolio management/ energy efficiency strategies and campaigns to achieve the anticipated targets; and (iv) analysing spatio-temporal patterns of their portfolio, identifying trends and outliers and receiving valuable knowledge for the design and delivery of added value services per individual customer or clusters of them to satisfy their needs for energy cost reduction through targeted innovative energy service bundles."

Furthermore, different analytic tools will be developed for the demo case deployment: Building Portfolio Management Optimisation Tool (BPMO) and Personalised Energy Analytics Tool for Guidance on Energy Performance Optimisation and Human-Centric Control Automation (PEASH).

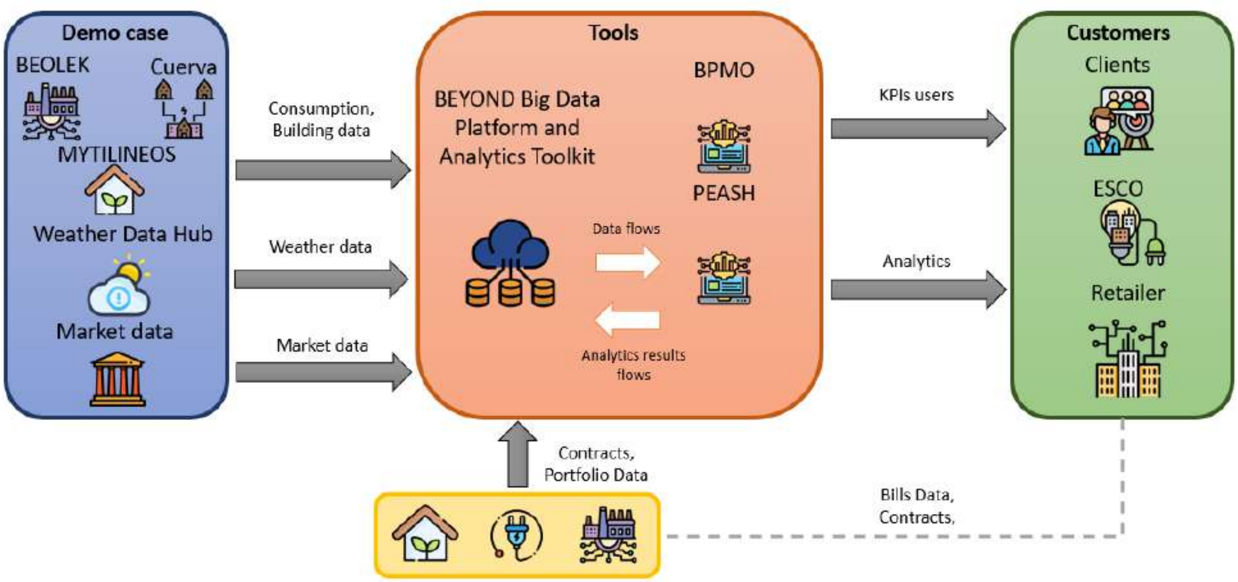


Figure 19 Mapping Demo Case 3

4. Personalized Energy Analytics and Energy Efficiency Optimization Guidance, including Human-Centric features for well-being of occupants.

"Capitalizing on the previous use case, this use case will move one step beyond and will realize advanced and innovative energy service concepts for selected customers of Myilineos, Cuerva and BEOELEK, focusing on personalized energy efficiency guidance, demand response, smart home automation and non-energy services for security, comfort and well-being, in collaboration with IGM (ESCO) that will facilitate the transformation of retailers' business model towards a service-oriented one through data sharing and business synergies between Retailers and ESCOs. Data streams from building systems and IoT devices (metering, control, ambience sensing) will be fed into the BEYOND Big Data Platform and Analytics Toolkit towards analyzing the flexibility of individual consumers and generating personalized insights on how they can save energy and optimize their energy performance through the respective application that will be developed by Suite5. In turn, targeted guidance will provided by retailers to consumers, through the collaboration with ESCOs holding the expertise for Energy Efficiency measures, for manual interventions over their devices and loads, while in limited cases, the demo case will experiment with advanced human-centric automation concepts for properly balancing energy consumption with individual preferences regarding comfort, security and well-being."

The Analytics Tool will be developed by S5, Personalised Energy Analytics Tool for Guidance on Energy Performance Optimisation and Human-Centric Control Automation (PEASH).

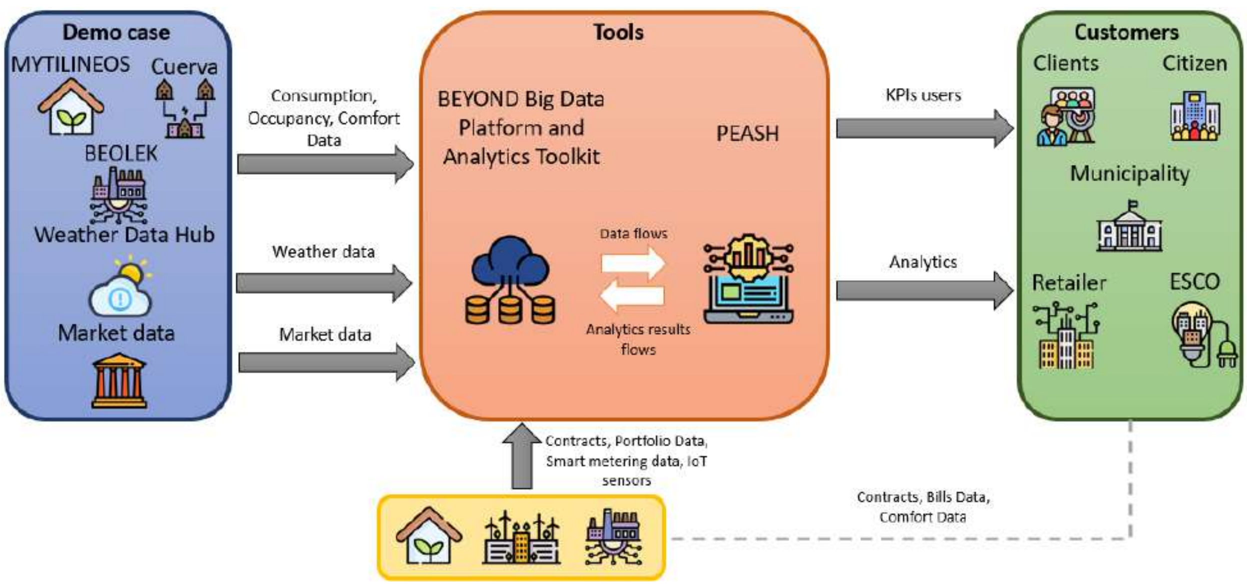


FIGURE 20 MAPPING DEMO CASE 4

5. Real-time Building Energy Performance and Smart Readiness Certification. "This demo case will enable direct and real-time interactions between buildings and their systems (sharing real-time BEMS, generation and IoT information from myriads of devices in their buildings) with energy retailers and ESCOs involved in the project (Mytilineos, Cuerva, BEOELEK and IGM), with the latter taking over the detailed analysis of data streams coming from the building systems regarding energy consumption and occupancy, along with weather data coming from open sources to enable real-time energy performance certification (applying innovative operational rating and appropriate normalization methodologies and approaches) of buildings based on real-life data streams (instead of aggregated data batches), that can point out specific areas of improvement (through energy analytics described in the previous case) and act as an enabler for further optimizing the performance of buildings from an energy point of view."

Through the application of the Energy Performance and Smart Readiness Certification Tool (EPSRC), developed by Belit, this objective will be possible.

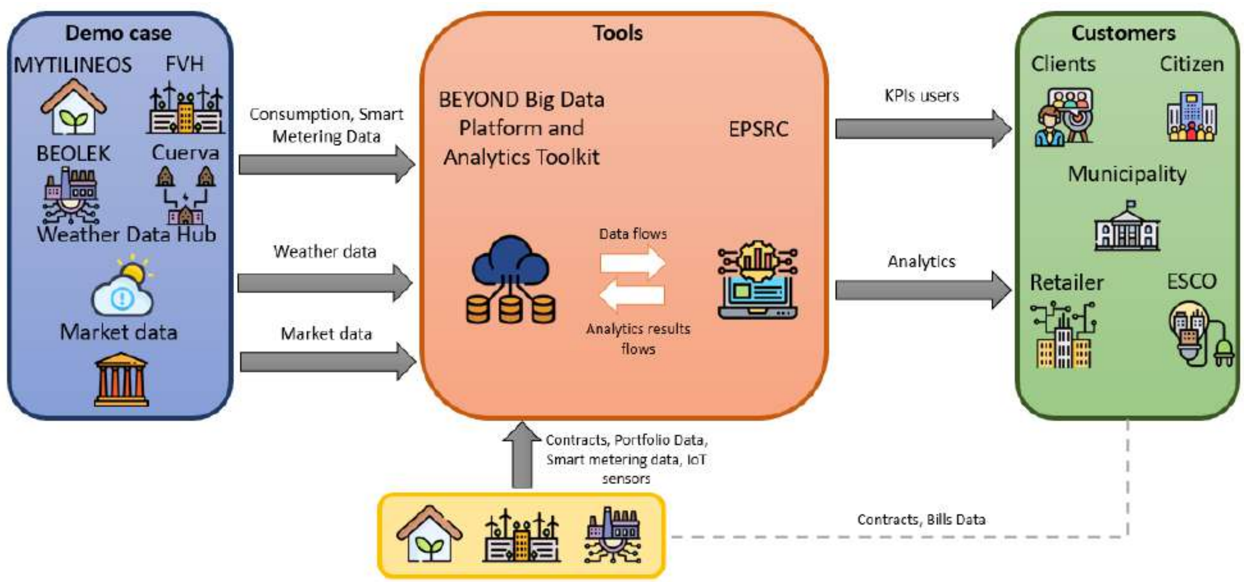


Figure 21 Mapping Demo Case 5

6. Optimal VPP configuration and Consumer-Centric Demand Response Optimization Module.

"The realization of the demo case is based on the validation of a novel module for aggregators that will facilitate the management of demand and flexibility profiles in order to forecast and decide upon the optimal management of flexibility sources (demand, generation, storage, EVs). Smart metering data from building customers of Cuerva, sub-metering data from local prosumers/ clients of Mytilienos, IoT and sensing data from prosumer premises, local generation data, local storage data, EV charging stations data, weather data, along with information provided by Cuerva regarding flexibility requirements and characteristics will comprise the main inputs for the AI analytics that will be performed within the tool, which will embed all functionalities pertaining to the tool chain for segmenting and classifying flexibility profiles at different spatio-temporal granularity and clustering/ managing them in order to establish optimal Virtual Power Plant (VPP) composition for the delivery of grid services to DSOs. Its main innovation will be that rather than matching the assumed flexibility profile to a generic class and then extracting flexibility estimations, it will cluster and segment flexibility sources and profiles based on their actual, locally estimated flexibility (incorporating where available detailed information about low-level devices existing at the demand side and how they are used by consumers).

Specially focusing in the case of the Greek demo, the demo case will build on top of the baseline personal data analytics of BEYOND to enable the realization of consumer-centric demand response programmes. Detailed comfort profiles will be advanced to context-aware demand flexibility profiles to enable the realization of novel automated control (demand response) programmes over specific devices (lights, heating/ cooling) and clusters of consumers, towards shedding or shifting demand away from peak hours and, thus, satisfying in real-time emerging requirements for improving the performance of buildings according to the grid requirements, without compromising comfort of consumers or significantly affecting their daily schedules.

With regards to the Spanish demo, Smart metering data provided by local prosumers, together with distributed generation data (PV) and SCADA information from the DSO (Cuerva) will be jointly analysed to extract accurate demand and generation forecasts (in the short- and mid-term) and estimate anticipated events in the distribution network and the required flexibility to effectively address them. Such flexibility requirements will be communicated to the local aggregator (URBENER), together with smart metering, distributed generation and local storage information, allowing for (i) analysis of the flexibility that can be provided by each type of DER at different spatio-temporal granularity, (ii) segmentation and classification of the different types of flexibility according to their characteristics and capability to provide alternative services to the grid operator, (iii) optimal clustering of local flexibility sources and formulation of dynamic VPPs to address evolving distribution grid needs and requirements. Dynamic VPP schedules for flexibility activation will be communicated back to the DSO (CUERVA), allowing for the optimal scheduling of the distribution network operation with these additional flexibility amounts in hand. In turn, the DSO will generate the appropriate signals towards local prosumers and DERs (when required) to enable the provision of the available flexibility with the ultimate target to increase network resilience and operational efficiency, maximize RES integration, minimize power losses, increase power quality and safeguard network availability against anticipated congestions, imbalances or voltage violations."

The Flexibility-based VPP Configurator and DR Strategy Optimisation Tool (FLEXopt), developed by Belit, will analyse the data exchanged between the DSO and the aggregators to forecast and decide about the optimal energy management.

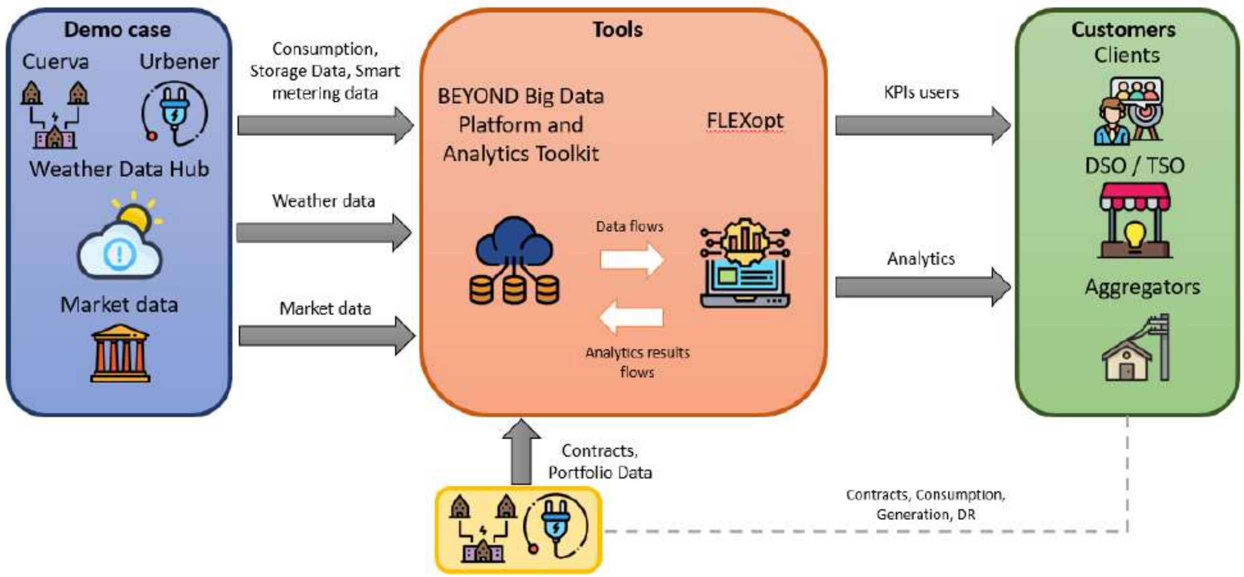


FIGURE 22 MAPPING DEMO CASE 6

7. **Informed and evident policy making (predictive modelling) at urban and macro-level enabled by detailed Impact Assessment for Holistic Energy Optimization.**

This demo case will capitalize on the baseline industrial data analytics in order to enhance the forecasting capabilities and simulation accuracy of the Impact Assessment Tool for Energy Policy Making at Urban Level (EPUL) of Artelys, towards providing better informed evidence the Helsinki City Authority (represented by FVH) for optimized energy policy making. Instead of forecasting the future energy performance of buildings (which constitute the major energy demand in urban contexts) based on high-level and low granularity metering data, this demo case will focus on equipping the Impact Assessment Tool for Energy Policy Making at Urban Level (EPUL) with building demand forecasts of higher accuracy to enhance its predictive capabilities and, thus, allow the tool to provide a more accurate representation of the environmental and energy state in specific urban contexts, subsequently enabling the better informed identification of local energy/ sustainability requirements and the design of more realistic policy measures to achieve mid- and long-term sustainability objectives. Demand (and generation) forecasting models for different types of buildings will be made available to the impact assessment tool (together with batch statistic data from well-known repositories of open building data and the Smart Urban Platform containing data about more than 36,000 buildings in the city area), to enable a more representative and realistic population of the tool's impact assessment (simulation) models and, subsequently, more accurate and robust predictions of the impact achieved by alternative policy scenarios designed for the city of Helsinki with the ultimate objective to support them in making the optimal decision for the timely and effective satisfaction of energy and sustainability objectives set out in action plans for the mid- and long-term.

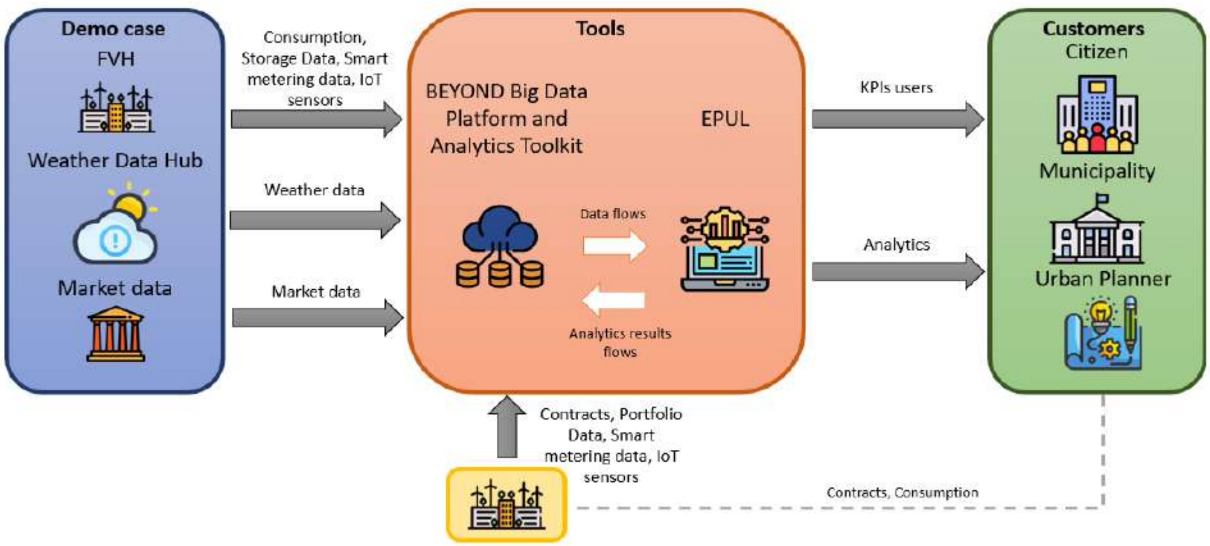


Figure 23 Mapping Demo Case 7

8. Informed decision-making on building-relevant energy infrastructure sizing and planning (electricity grid).

"As part of this demo case, electricity grid planning algorithms that simulate the operation of the networks in appropriate horizons (related to regulatory regimes and asset lifetimes) will be developed to automatically calculate grid reliability, performance and quality metrics based on different infrastructure and assets installation setups, their characteristics and planned/unplanned events. The algorithms will incorporate functionality to assess the performance of the networks under various demand and generation uncertainties. Optimization algorithms will be appropriately configured to enable the study of optimal planning and sizing of grid assets such as new connections, charging points for EVs and battery storage, needs for expansion or enhancement, considering also needs for further investments. The algorithms will have the capability to embed all information arising from Cuerva (DSO) systems, flexibility analytics, short-, mid- and longterm forecasting analytics for demand and generation (referring to the buildings belonging in the Cuerva Portfolio and for which smart meter data will be made available – approx. 16,000 customers), along with batch static data coming from well-known repositories of open building data (statistical information about the building stock) in order to perform a comprehensive simulation-based analysis of performance and reliability metrics (utilizing and further enhancing the RTDS simulator of CIRCE for the delivery of the respective application) in specific parts of the electricity grid under alternative penetration scenarios for new energy infrastructure and assets that will be generated to satisfy the needs of the grid operator."

This will be possible using the tool developed by Artelys, Distribution Grid Planning and Infrastructure Sizing Tool (DGPIST).

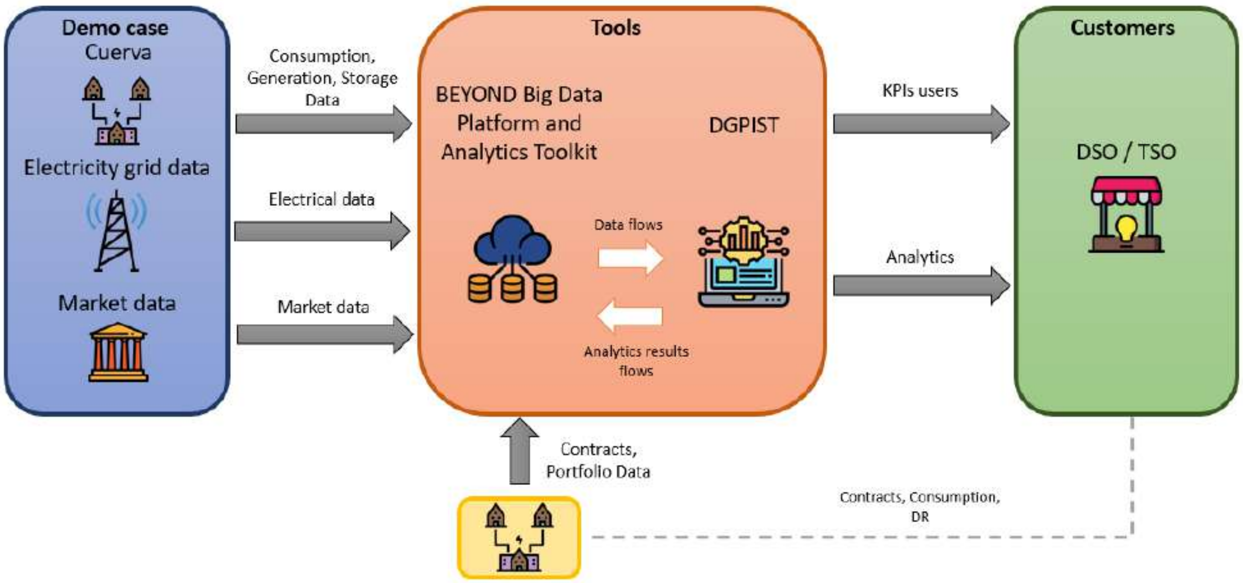


FIGURE 24 MAPPING DEMO CASE 8

9. **Informed decision-making on building-relevant energy infrastructure sizing and planning (district heating network).**

"Similarly to the previous case, district heating network planning algorithms that simulate the operation of the network in appropriate horizons (related to regulatory regimes and asset lifetimes) will be developed to automatically calculate network performance and congestion metrics based on different infrastructure and assets installation setups, their characteristics and planned/unplanned events. The algorithms will incorporate functionality to assess the performance of the networks under various demand and generation uncertainties. Optimization algorithms will be appropriately configured to enable the study of optimal planning and sizing of network assets such as new connections, needs for expansion or enhancement, considering also needs for further investments. The algorithms will have the capability to embed all information arising from BEOELEK (network operator) systems, flexibility analytics, short-, mid- and long-term forecasting analytics for demand and generation (referring to the buildings belonging in the BEOELEK Portfolio and for which metering data and more detailed IoT and smart metering/ sub-metering data will be made available – approx. 330,000 customers), along with batch static data coming from well-known repositories of open building data (statistical information about the building stock) in order to perform a comprehensive simulation-based analysis of performance metrics (utilizing and further enhancing the DHC Route Optimizer tool of Artelys for the delivery of the respective application) under alternative network reinforcement and planning scenarios."

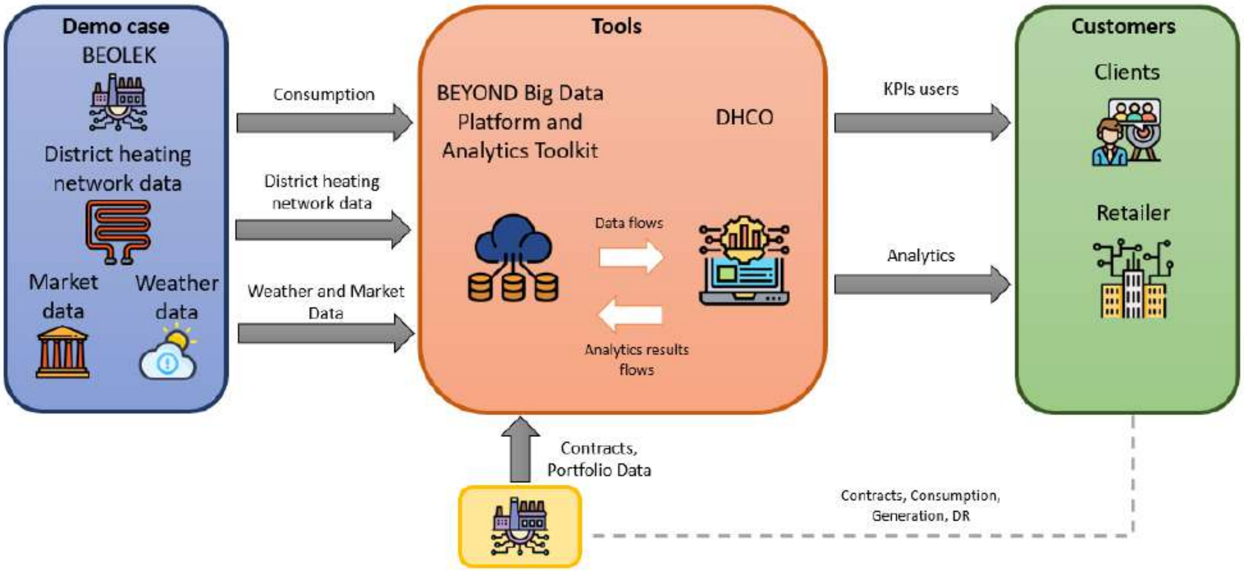


FIGURE 25 MAPPING DEMO CASE 9

10. Advanced renovation support for accurate energy-efficient design of buildings towards optimized investment decision-making and de-risking.

"This demo case will focus on significantly reducing the gap between predicted and actual energy performance of buildings during the design of renovation projects. BEMS data from the buildings involved in the Greek and Finnish demonstrators (offered by the portfolio of buildings managed by FVH and the customers of Mytilineos) and low-level intra-building sensing, metering, actuating data (IoT devices) will enable the definition of accurate occupants' behaviour and comfort profiles (based on baseline personal AI analytics available in the BEYOND toolkit). Such profiles will be made available to IGM in order to introduce them in iterative simulation loops of alternative renovation scenarios of selected buildings (performed the respective Renovation Optimisation Decision Support Tool (ROST) developed by VTT), thus replacing generic routines and schedules currently used, with real data coming from the actual operation of the building-to-be-renovated. Additional analytics will be performed over simulation results to identify energy performance outliers and enable further devising renovation approaches and scenarios to achieve (in a highly accurate manner) optimal balancing between anticipated energy performance, renovation project costs and indoor air quality/ occupants' comfort. The demo case will validate highly accurate results for the anticipated energy performance of to-be-renovated buildings. On the other hand, it will validate significant benefits for IGM (as an ESCO) through facilitating further penetration of the Energy Performance Contracting (EPC) model for ESCOs, allowing for the reduction of uncertainty and respective risks of EPC business models, due to the reduction of the performance gap between predicted and actual energy performance of buildings, which in many cases can lead to a total project failure, since ESCOs fund such projects themselves and are paid back by the savings achieved; so any significant deviation between actual and predicted values of savings may drastically affect the payback and overall (investment) success of renovation projects."

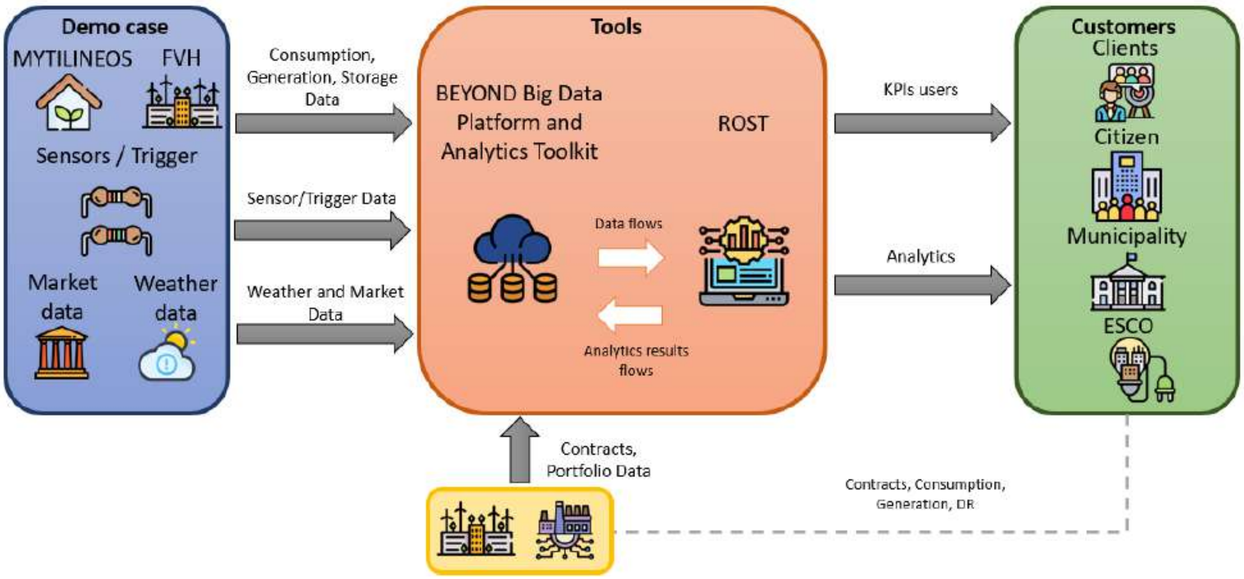


FIGURE 26 MAPPING DEMO CASE 10

In order to create a visual map between demonstration sites and demo cases, the following table is attached, showing which Demo Case is related to which Demo Site.

Demostrators	Greece	Spain	Spain	Spain	Finland	Finland	Finland	Serbia
PARTNERS	Mytilineos	CUERVA	CUERVA	URBENER	FVH	FVH	FVH	BEOLEK
Demo Sites	Artemidos Building (Mytilineos Headquarters) Marinou Antypa Building (Mytilineos offices) Residential Premises	Cuerva Headquarters	Ind Area Profitegra	Urbener Headquarters	Viikki Environmental House	Urban Environmental House	Stadia Vocational School	6 Buildings Disctrict Heating
Demo Cases								
Energy Performance Optimization and Self-Consumption Maximization through the application of the digital twin concept in buildings - Data sharing between buildings and ESCOs involved in Energy Performance Contracting	X				X	X		X
Predictive Maintenance Improvement through Digital Twins and Enhanced AI Analytics - Data sharing between buildings and ESCOs						X	X	
Building Portfolio Management Optimization for Energy Efficiency through Portfolio Energy Analytics and better-suited Billing Strategies - Data sharing between buildings and Energy Retailers	X	X						X
Personalized Energy Analytics and Energy Efficiency Optimization Guidance, including Human-Centric features for well-being of occupants - Data sharing between buildings, Energy Retailers and ESCOs	X	X						X
Real-time Building Energy Performance and Smart Readiness Certification - Data sharing between buildings ,Energy Retailers and ESCOs	X	X			X	X	X	X
Optimal VPP configuration and Consumer-Centric Demand Response Optimization Module - Data sharing between buildings and aggregators as well as between aggregators and DSOs			X	X				
Informed and evident policy making (predictive modelling) at urban and macro-level enabled by detailed Impact Assessment for Holistic Energy Optimization - Data sharing between buildings and City Authorities								
Informed decision-making on building-relevant energy infrastructure sizing and planning (electricity grid) - Data sharing between buildings and DSOs			X					
Informed decision-making on building-relevant energy infrastructure sizing and planning (district heating network) - Data sharing between buildings and District Heating Network Operators								X
Advanced renovation support for accurate energy-efficient design of buildings towards optimized investment decision-making and de-risking - Data sharing between buildings and ESCOs/ Construction Companies	X				X	X		

TABLE 108 MAPPING BETWEEN DEMO CASES AND DEMO SITES

9 Conclusions

Through the metrics drafted during this document, we ensure that all areas are adequately covered and the data and tools established will allow estimation and reporting of the different key performance indicators.

The different indicators have been divided into groups, as follows:

- Impact Assessment Metrics:
  - Energy
  - Social
  - Economic
  - Environmental
- Specific Beyond KPIs per Business Model
  - Common Data relevant metrics
  - Aggregators
  - Retailers
  - ESCO
  - City Authorities
  - DSOs
- BEYOND Platform Technical Validation
  - Data-quality metrics
  - Platform technical metrics

In addition, a study of the validation scenarios has been carried out, thus allowing the analysis and mapping of the different cases, tools, data and entities. With this, we get to see in a graphic way what and who is involved in each demonstration case.

The final list of KPIs may be subject to change during the testing phase of the BEYOND project.

10 References

GRANT AGREEMENT, NUMBER 957020, BEYOND project

D2.1 “End-user & Business requirements analysis for big datadriven innovative energy services & ecosystems - a”, BEYOND project, 2021

D2.2 “End-user & Business requirements analysis for big datadriven innovative energy services & ecosystems - b”, BEYOND project, 2021

D2.3 “Socio-economic and regulatory analysis of obstacles to innovation”, BEYOND project, 2021

D2.4 “BEYOND PMV Methodology Specifications”, BEYOND project, 2021

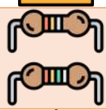
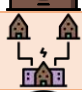
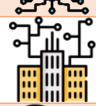
D2.5 “Ex-Ante Pilot Audits and Pilot Deployment Plan”, BEYOND project, 2021

D2.6 “BEYOND Framework Architecture including functional, technical and communication specifications - a”, BEYOND project, 2021

D2.7 “BEYOND Framework Architecture including functional, technical and communication specifications - b”, BEYOND project, 2021

D8.14 “Definition of novel data-driven Business Models for the Buildings and Energy domains”, BEYOND project, 2021

11 Annex 1

Figure	Meaning
	BEYOND Big Data Platform
	Tool
	Weather Data
	Market Data
	Sensor/Trigger Data
	Electricity Grid Data
	Clients
	Citizen
	Municipality
	DSO / TSO
	Cuerva
	Urbener
	FVH
	Mytilineos
	Beolek
	Retailer
	ESCO
	Aggregator
	Urban Planner