E-Laas

Energy optimal urban Logistics As A Service

Deliverable report

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1. Summary

In line with the project proposal, report D0.3 addresses two related tasks carried out under WP0. The first is the identification and characterisation of scenarios representing selected urban logistics systems and segments. This task defined which delivery processes may be subject to further analysis in the project, including ready-made food delivery, boxed meal delivery, deliveries to parcel lockers and direct parcel deliveries to individual recipients. Pharmaceutical deliveries and B2B freight were also identified as potential directions for further research, beyond the scope of the subsequent project reports. These scenarios provide a basis for further work in WP2, WP3 and WP4, as they define transport relations, system actors, transport modes, decision variables and potential assessment indicators.

The second task is the development of reference variants, understood as the specification of data, assumptions and configurations needed for later scenario analysis. While the first task indicates which logistics systems and processes are considered, the second specifies the attributes, parameters and variants needed to describe them so that they can be used in simulation modelling, what-if analyses, model validation and the assessment of energy, emission and operational indicators.

Consequently, report D0.3 documents a set of urban logistics system scenarios developed within WP0. The scenarios were prepared for the Polish reference case RC1, the Metropolis GZM. The purpose of the report is to present an organised catalogue of base and alternative scenarios that can be used as a basis for further surveys, simulation modelling, energy and emission analyses, and recommendations for sustainable urban logistics.

The report organises five main scenario areas related to different segments of urban logistics: ready-made food delivery, boxed meal delivery, parcel delivery, pharmaceutical delivery and B2B freight. Following the refinement of the project scope, it was assumed that subsequent WP2 reports and studies will focus mainly on three active scenario groups: ready-made food delivery, boxed meal delivery and parcel delivery, including home delivery, parcel locker delivery and drone-based variants. Pharmaceutical and B2B scenarios are retained in the report as valuable directions for further research, beyond the scope of the analyses planned in the subsequent E-Laas project reports.

The developed scenario set structures potential changes in urban logistics, in particular: changes in modal split, the use of low-emission vehicles, bicycles, e-bikes, scooters, e-scooters, autonomous delivery vehicles and drones, increased demand for selected logistics services, changes in parcel collection behaviour, the use of delivery concentration points and the organisation of consolidated transport. At this stage, parameters related to transport charging infrastructure were not included as scenario variables. These issues may be addressed in later parts of the project, but they are not treated as a core scenario variable in this D0.3 report.

The report is a logical continuation of D0.2. D0.2 defined the structure for describing reference cases and scenarios, while D0.3 applies that structure to identify specific urban logistics scenarios for GZM. The D0.3 scenarios also provide a starting point for further work in WP2, in particular for designing user preference surveys, building simulation models, defining KPI and preparing recommendations for sustainable urban logistics.

2. Introduction

The main intention of WP0 was to create a set of multimodal urban freight scenarios described by different attributes. These scenarios can be used to define reference cases, including cases based on real urban conditions as well as virtual cases. This D0.3 report focuses on the real reference case RC1 - GZM Metropolis. Virtual Reference Cases, defined in D0.2 as possible derived or theoretical reference cases, may provide a valuable direction for future research after the project, for example for testing model scalability, what-if analyses or hypothetical configurations of urban logistics systems.
Following the refinement of the project scope, D0.3 focuses primarily on the organisation of delivery processes, modal structure, demand, transport relations, concentration points and the way recipients are served. Elements related to parking, charging and energy bases remain part of the broader E-Laas context, but in this report they are not developed as a main scenario variable for each variant.
The E-Laas project focuses on developing an approach for assessing and shaping urban logistics systems in terms of energy use, operational efficiency, environmental impact and user behaviour. One of the first stages of the project was to prepare a set of reference cases and scenarios that could provide a basis for further analyses, simulations and recommendations.
Report D0.3 closes the conceptual work in WP0 related to the identification of logistics system scenarios. Its role is to move from the general set of attributes and data structures defined in D0.2 to concrete scenarios that can be used in modelling and analysis. The scenarios described in this report are not yet detailed simulation experiments. They are structured variants of urban logistics process organisation, indicating which transport relations, actor groups, transport modes, decision parameters and assessment indicators should be considered in later research stages.
This report documents the scenario set developed by WUT for the GZM Metropolis reference case, used as the Polish reference case in the project. The focus on GZM results from WUT's role in the project, the availability of expert knowledge on this area and the importance of GZM as a complex, polycentric metropolitan area. GZM is characterised by a multi-centre settlement structure, a diverse transport network, a large population, a high share of economic activity and many types of urban freight flows.
The report assumes that scenarios should be broad enough to cover different forms of urban logistics, while also being specific enough to support the development of simulation models and input datasets. For this reason, the report distinguishes scenarios intended for further use in the project from scenarios retained as recommended directions for future research.

3. Purpose and scope

The purpose of report D0.3 is to identify and describe logistics system scenarios for reference case RC1 - GZM Metropolis. The report has an organising and methodological character. Its task is to prepare a scenario catalogue that can be used in the subsequent project stages, in particular in WP2, WP3 and WP4.
The scope of the report includes:
- identification of reference case RC1 - GZM Metropolis,

- description of base scenarios representing selected urban logistics segments,
- description of alternative scenarios that modify selected parameters of the base scenarios,
- identification of the main scenario variables,
- identification of potential KPI for further analyses.

The report does not include detailed simulation results, survey results or a full assessment of urban policy variants. These elements will be developed in WP2 reports, in particular D2.1, D2.2, D2.3 and milestone M2. Report D0.3 also does not replace the M0 data repository, but provides a logical basis for its development.

Report D0.3 is directly linked to report D0.2. D0.2 defined the attribute structure describing reference cases and scenarios, and also indicated the possibility of defining Virtual Reference Cases, treated as a potential extension of the E-Laas methodology for future research. D0.3 should therefore be viewed as a bridge between the conceptual data structure and further simulation and decision-support studies. The report specifies which cases of logistics process organisation should be analysed in later stages and which data groups will be needed for their parameterisation.

The main recipient of the D0.3 results is WP2, which concerns the emulated analysis of energy-optimal urban logistics flows. In WP2, the scenarios may serve the following functions:

- provide a basis for selecting the urban logistics segments included in the studies,
- support the identification of stakeholder groups included in the analysis,
- define transport relations to be represented in models,
- indicate transport modes and modal split variables,
- provide structures for preparing input data for macro and micro models,
- indicate KPI for assessing delivery organisation variants,
- support the preparation of recommendations for sustainable urban logistics.

In WP3 and WP4, the scenarios may provide a context for formulating planning and optimisation models. This applies mainly to scenarios in which decisions on system structure, modal split, delivery concentration points, route organisation and the use of alternative transport modes are important. However, not all D0.3 scenarios need to be developed in full detail in WP3 and WP4. Some of them serve as a catalogue of potential research problems. Therefore, D0.3 adopts the scenario classification presented in Table 1.

Table 1. Classification of scenarios developed in D0.3

Scenario type	Meaning
Core project scenarios	Scenario intended for further analysis within WP2 and possible linkage with D2.2, D2.3 and M2
Supporting scenarios	Supporting scenario that may help interpret results or design variants, but does not have to be analysed in full detail
Future research proposals	Scenario retained as a valuable direction for further research, not intended for development in subsequent project reports

4. Reference case RC1 – GZM Metropolis

The reference case analysed in the study is RC1 - GZM Metropolis, i.e. the Metropolis GZM. It is one of the most important and complex metropolitan areas in Poland. The area is polycentric, includes many cities and municipalities, and its spatial structure generates diverse transport and logistics behaviours and relations.

GZM was selected as a suitable reference case for the E-Laas project for several reasons. First, it is an area with high population density and a significant concentration of economic activity. Second, it includes different types of urban flows, such as food delivery, courier delivery, parcel locker operations, deliveries to service points, deliveries to public and private facilities and potential B2B deliveries. Third, the polycentric structure of GZM makes it possible to study not only typical centre-periphery flows, but also flows between multiple urban centres.

From the scenario perspective, GZM is treated as an area for which scenarios may be defined for the whole metropolis as well as for selected cities, districts, traffic zones or test areas. This approach is important for the later integration of macro- and microsimulation models. At the macro level, the structure of zones and the transport network can be included, while at the micro level the detailed logic of deliveries can be represented in selected parts of the area.

In report D0.2, GZM serves as the Polish reference case for which a set of urban logistics scenarios was identified. These scenarios are structural and methodological. Not all of them are planned for full implementation in the subsequent project stages. Their role is to organise potential analysis directions and indicate which of them are particularly useful for WP2 studies.

5. Overview and classification of identified scenarios

The report adopts a simplified and consistent scenario nomenclature with two basic scenario types:

- Base Scenario - BS: a base scenario describing the existing or reference organisation of a given urban logistics segment,
- Alternative Scenario - AS: an alternative scenario describing a variant of change relative to the base scenario.

Scenario numbering is based on the RC1 structure. The first number denotes the reference case, while the second number denotes the base scenario within that case. Alternative scenarios are numbered as extensions of the corresponding base scenarios.

For example:

- **BS 1.1 denotes the first base scenario within RC1,**
- **AS 1.1.1 denotes the first alternative scenario for BS 1.1,**
- **AS 1.1.2 denotes the second alternative scenario for BS 1.1.**

The scenarios were divided into three groups according to their further use:

- **Core project scenarios (CS) - scenarios recommended for further development in WP2.**
- **Supporting scenarios (SS) - scenarios that may support result interpretation or provide comparative variants.**
- **Future research proposals (FS) - scenarios described as valuable directions for further research, but not planned for development in subsequent project reports.**

In addition, parcel delivery scenarios assume different transport mode structures within a single scenario. This is because separate parcel service relations were distinguished:

- **hub-to-home - direct deliveries from the hub to the recipient,**
- **hub-to-parcel-locker - supply of parcel lockers,**
- **parcel-locker-to-home by client - self-pick-up of the parcel by the recipient,**
- **parcel-locker-to-home by drone - delivery from a parcel locker to the recipient by drone.**

This approach makes it possible to account for both the customer's delivery channel choice and constraints resulting from package mass, volume or eligibility for parcel locker or drone handling. This means that even in drone-based scenarios, some parcels may still be served through the hub-to-home relation if the parcel is too large, not eligible for a parcel locker, or if the customer selected direct home delivery.

The pharmaceutical and B2B scenarios are retained as future research proposals and moved to the end of the catalogue, respectively as BS/AS 1.4 and BS/AS 1.5. They are not planned for development in subsequent WP2 reports, but they remain in the report as potential directions for extending the E-Laas methodology.

Table 2 lists the scenarios identified for reference case RC1 - GZM Metropolis. The table organises the scenarios by logistics service type, transport relation, main actors, transport modes, decision variables, potential KPI and further-use status in the project.

Table 2. Scenarios identified in D0.3

Scenario ID	Scenario name	Type	Status	Transport relation	Main actors	Transport modes	Main decision variables	KPI
BS 1.1	Ready-made food delivery	Base Scenario	CS	restaurants -> individual recipients	restaurants, couriers, customers	bicycles, e-bikes, scooters, e-scooters, conventional cars, EVs	base demand, restaurant and recipient locations, base modal split, order assignment	delivery time, distance, fuel use, energy use, CO2, served orders
AS 1.1.1	Low-emission modal split in ready-made food delivery	Alternative Scenario	SS	restaurants individual recipients	restaurants, couriers, customers	increased share of e-bikes, e-scooters and EVs	modal split change with unchanged demand	delivery time, distance, energy, fuel, CO2
AS 1.1.2	Demand increase and high low-emission share in ready-made food delivery	Alternative Scenario	SS	restaurants individual recipients	restaurants, couriers, customers	higher share of low-emission modes	demand increase, low-emission modal structure	delivery time, distance, energy, CO2, vehicle utilisation, served/unserved orders
AS 1.1.3	Demand increase and zero-emission structure in ready-made food delivery	Alternative Scenario	SS	restaurants individual recipients	restaurants, couriers, customers	zero-emission or predominantly zero-emission modes	demand increase, zero-emission delivery structure	delivery time, distance, energy, CO2, resource utilisation
BS 1.2	Boxed meal delivery to homes and offices	Base Scenario	CS	catering companies residential buildings and offices	catering companies, couriers, individual recipients, offices	conventional vans, electric vans, selected larger delivery vehicles	base demand, home and office recipients, base vehicle structure, delivery time windows	punctuality, delivery time, distance, energy, fuel, CO2, vehicle utilisation
AS 1.2.1	Electric mix in boxed meal delivery	Alternative Scenario	SS	catering companies residential buildings and offices	catering companies, couriers, recipients	increased share of electric vehicles	vehicle structure change with unchanged demand	punctuality, distance, energy, CO2, vehicle utilisation

Scenario ID	Scenario name	Type	Status	Transport relation	Main actors	Transport modes	Main decision variables	KPI
AS 1.2.2	Demand increase and electric vans in boxed meal delivery	Alternative Scenario	SS	catering companies residential buildings and offices	catering companies, couriers, recipients	electric vans and selected electric delivery vehicles	demand increase, changed vehicle structure	punctuality, time, distance, energy, CO2, served orders
AS 1.2.3	Demand increase and zero-emission boxed meal delivery	Alternative Scenario	SS	catering companies residential buildings and offices	catering companies, couriers, recipients	zero-emission or predominantly electric vehicles	demand increase, zero-emission delivery structure	punctuality, time, distance, energy, CO2, vehicle utilisation
BS 1.3	Parcel delivery with home and parcel locker channels	Base Scenario	CS	hubs individual recipients; hubs parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-home: road vehicles; hub-to-parcel-locker: road vehicles; parcel-locker-to-home: client trips	common parcel demand, channel split: home delivery / parcel locker delivery	time, distance, operator energy, recipient energy, CO2, service accessibility
AS 1.3.1	Low-emission moderate parcel delivery	Alternative Scenario	SS	hubs home / parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-home: moderate low-emission structure; hub-to-parcel-locker: moderate low-emission structure; parcel-locker-to-home: client trips	vehicle structure change with base home/locker channel split	time, distance, energy, CO2, vehicle utilisation
AS 1.3.2	Low-emission high parcel delivery	Alternative Scenario	SS	hubs home / parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-home: high low-emission structure; hub-to-parcel-locker: high low-emission structure; parcel-locker-to-home: client trips	stronger low-emission vehicle structure with base channel split	time, distance, energy, CO2, vehicle utilisation
AS 1.3.3	Zero-emission parcel delivery	Alternative Scenario	SS	hubs home / parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-home: zero-emission structure; hub-to-parcel-locker: zero-emission structure; parcel-locker-to-home: client trips	zero-emission vehicle structure with base channel split	time, distance, energy, CO2
AS 1.3.4	Drone delivery from parcel lockers	Alternative Scenario	SS	hubs home; hubs parcel lockers recipients	courier operators, parcel locker operators, drone operators, recipients	hub-to-home: road vehicles; hub-to-parcel-locker: road vehicles; parcel-locker-to-home: drones	use of drones for the last leg from parcel lockers, while non-eligible or direct parcels remain in hub-to-home service	time, road distance, flight distance, energy, CO2, drone delivery share
AS 1.3.5	Parcel locker only channel	Alternative Scenario	SS	hubs parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-parcel-locker: road vehicles; parcel-locker-to-home: client trips	0% home delivery, 100% parcel locker delivery	operator distance, recipient distance, energy, CO2, accessibility
AS 1.3.6	Major parcel locker share	Alternative Scenario	SS	hubs home / parcel lockers recipients	courier operators, parcel locker	hub-to-home: road vehicles; hub-to-parcel-locker: road vehicles;	25% home delivery, 75% parcel locker delivery	time, distance, energy, CO2, accessibility

Scenario ID	Scenario name	Type	Status	Transport relation	Main actors	Transport modes	Main decision variables	KPI
					operators, recipients	parcel-locker-to-home: client trips		
AS 1.3.7	Equal home and parcel locker share	Alternative Scenario	SS	hubs home / parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-home: road vehicles; hub-to-parcel-locker: road vehicles; parcel-locker-to-home: client trips	50% home delivery, 50% parcel locker delivery	time, distance, energy, CO2, accessibility
AS 1.3.8	Minor parcel locker share	Alternative Scenario	SS	hubs home / parcel lockers recipients	courier operators, parcel locker operators, recipients	hub-to-home: road vehicles; hub-to-parcel-locker: road vehicles; parcel-locker-to-home: client trips	75% home delivery, 25% parcel locker delivery	time, distance, energy, CO2, accessibility
AS 1.3.9	Direct home parcel delivery only	Alternative Scenario	SS	hubs individual recipients	courier operators, couriers, recipients	hub-to-home: road vehicles	100% home delivery, 0% parcel locker delivery	time, distance, energy, fuel, CO2, served parcels
AS 1.3.10	Drone-only direct parcel delivery	Alternative Scenario	SS	hubs individual recipients	courier operators, drone operators, recipients	hub-to-home: drones; parcel locker channel inactive	100% direct deliveries served by drones	time, flight distance, energy, CO2, service availability, operational restrictions
BS 1.4	Pharmaceutical delivery in urban areas	Base Scenario	FS	wholesalers pharmacies/hospitals; pharmacies individual recipients	wholesalers, pharmacies, hospitals, patients, couriers	delivery vehicles, EVs, bicycles, e-bikes, scooters, drones	delivery relations, modal split, shift from individual pharmacy trips to deliveries	time, energy, fuel, CO2, cost, service availability
AS 1.4.1	Modal split change in institutional pharmaceutical deliveries	Alternative Scenario	FS	wholesalers pharmacies/hospitals	wholesalers, pharmacies, hospitals, logistics operators	conventional vehicles, EVs, autonomous delivery vehicles	modal split in institutional pharmaceutical deliveries	time, energy, fuel, CO2, cost, reliability
AS 1.4.2	Pharmacy-to-home delivery	Alternative Scenario	FS	pharmacies individual recipients	pharmacies, patients, couriers	passenger cars, EVs, bicycles, e-bikes, scooters, drones	share of home delivery, reduction of individual trips to pharmacies	time, energy, CO2, cost, accessibility
BS 1.5	B2B urban freight deliveries	Base Scenario	FS	suppliers/hubs business recipients	companies, schools, hospitals, restaurants, construction sites, logistics operators	trucks, delivery vehicles, EVs	modal split, consolidation, B2B delivery structure	time, energy, fuel, CO2, cost, reliability
AS 1.5.1	Alternative low-emission modes in B2B deliveries	Alternative Scenario	FS	hubs/suppliers business recipients	B2B operators, business recipients, public institutions	trucks, electric trucks, delivery vehicles, EVs	partial electrification, consolidation, last-mile organisation	time, energy, CO2, cost, organisational feasibility, reliability

6. Detailed description of scenarios

BS 1.1. Ready-made food delivery (to individual recipients)

Base scenario BS 1.1. Ready-made food delivery concerns on-demand delivery of prepared meals from restaurants to individual recipients. It is a reference scenario for demand-responsive deliveries, characterised by short delivery times, high intra-day demand variability and dispersed origins and destinations.

In the base scenario, origins are restaurants located in the urban area, while destinations are individual customers. The transport relation is dispersed: many restaurants may serve many recipients. Deliveries are performed using the existing transport network and the base structure of transport modes adopted for simulation analyses.

In the model, this scenario may account for variation in transport modes depending on delivery distance. For shorter relations, bicycles, e-bikes, scooters or e-scooters may be more important, while for longer relations combustion and electric cars may have a larger share. As a result, the base scenario is not only a simple description of average vehicle shares, but can reflect operational differences resulting from trip length.

Scenario BS 1.1 provides the point of reference for alternative variants in which the effects of modal structure change, a higher share of low-emission modes and demand growth are analysed. The base variant should preserve the current or reference level of demand, the spatial structure of restaurants and recipients, and the basic operational parameters of deliveries.

The main scenario attributes include restaurant locations, recipient locations, number of orders, temporal distribution of orders, transport modes, service times, travel speeds, transport mode capacities, energy or fuel consumption and emission factors. The main KPI include delivery time, distance travelled, energy use, fuel use, CO2 emissions and number of served orders.

AS 1.1.1. Low-emission modal split in ready-made food delivery

Alternative scenario AS 1.1.1. Low-emission modal split in ready-made food delivery assumes a change in modal structure for ready-made food delivery while maintaining the base demand level. This means that the number of orders, restaurant locations and recipient locations remain consistent with BS 1.1, while the shares of individual transport modes used for deliveries change. The variant is used to assess to what extent a higher share of low-emission modes, such as e-bikes, e-scooters or electric vehicles, affects the operational and environmental performance of the system. The scenario separates the effect of transport technology change from the effect of demand growth.

The main decision variable in AS 1.1.1 is the modal split, i.e. the percentage share of transport modes in order handling. The key KPI include delivery time, distance, energy use, fuel use and CO2 emissions. Comparison with BS 1.1 makes it possible to determine whether a change in transport mode structure alone can improve the energy and environmental efficiency of deliveries.

AS 1.1.2. Demand increase and high low-emission share in ready-made food delivery

Scenario AS 1.1.2 assumes a simultaneous increase in demand for ready-made food delivery and a higher share of low-emission modes. This variant corresponds to a situation in which growth in the food delivery market increases the number of orders, while operators or urban policy promote more energy-efficient transport modes.

Unlike AS 1.1.1, this scenario analyses not only a change in modal split, but also the system load resulting from a higher number of orders. This makes it possible to examine whether the

increased share of low-emission modes is sufficient to handle higher demand without reducing service quality.
The active scenario attributes are the demand multiplier, number of orders, temporal distribution of orders, share of low-emission modes, available number of couriers or vehicles and their utilisation. The main KPI include delivery time, number of served and unserved orders, distance travelled, energy use, CO_2 emissions and utilisation of transport resources.

AS 1.1.3. Demand increase and zero-emission structure in ready-made food delivery

Scenario AS 1.1.3 assumes demand growth with a dominant or full use of zero-emission modes for ready-made food delivery. This variant is more radical than AS 1.1.2, as it focuses on examining the feasibility of handling increased demand while strongly reducing or eliminating transport modes using conventional fuels.
The scenario makes it possible to assess whether a delivery system based on zero-emission modes is operationally feasible under higher order volumes. Particular importance is attached to constraints related to speed, range, capacity, courier availability and service time.
The main decision variables include demand level, the structure of zero-emission transport modes and order assignment to available resources. KPI include delivery time, number of served orders, vehicle or courier utilisation, energy use and CO_2 emissions. The scenario allows the feasibility limits of a zero-emission system to be assessed under growing demand.

BS 1.2. Boxed meal delivery to homes and offices

Base scenario BS 1.2 concerns deliveries of ready-made boxed meals from catering companies to residential buildings and offices. Unlike on-demand ready-made food delivery, boxed meal deliveries are more planned and repetitive. Orders are usually known in advance, and deliveries are carried out in specific time windows, most often at night, in the morning or before recipients start work.
Origins are catering companies preparing meal sets, while destinations are individual recipients in residential buildings and recipients located in office buildings. Including offices is important because part of the demand for boxed meals may be generated by workplaces, not only by households. The scenario therefore covers two recipient types: residential recipients and office recipients.
The base scenario assumes a reference demand level, the existing location structure of catering companies and recipients, and a base transport mode structure. Due to repeat orders and the possibility of planning routes in advance, this scenario is well suited to analysing the influence of route organisation, vehicle capacity, time windows and fleet structure on delivery energy efficiency.
The main scenario attributes include catering company locations, residential and office building locations, number of orders, spatial and temporal demand distribution, delivery time windows, vehicle types, vehicle capacity, service times and fuel or energy consumption. The main KPI include delivery punctuality, delivery time, distance travelled, energy use, fuel use, CO_2 emissions and vehicle utilisation.

AS 1.2.1. Electric mix in boxed meal delivery

Alternative scenario AS 1.2.1 assumes a change in the vehicle structure used for boxed meal delivery while maintaining the base demand level. The number of orders, catering company locations and recipient locations remain the same as in BS 1.2, while the share of electric vehicles in delivery operations changes.
The purpose of the scenario is to assess whether partial fleet electrification can improve energy efficiency and reduce CO2 emissions without lowering service quality. Due to the planned nature of boxed meal deliveries, this scenario is particularly useful for analysing electric vehicle use, since routes can be planned in advance and range and capacity constraints can be accounted for more easily than in on-demand deliveries.
The main decision variable in AS 1.2.1 is the share of electric vehicles in the delivery structure. Active attributes include vehicle type, energy source, vehicle capacity, speed, energy use, number of available vehicles and assignment of vehicles to routes. KPI include punctuality, route length, energy use, CO2 emissions and vehicle utilisation.

AS 1.2.2. Demand increase and electric vans in boxed meal delivery

Scenario AS 1.2.2 assumes growth in demand for boxed meal deliveries and a higher share of electric vehicles, including electric vans. This variant corresponds to a situation in which the boxed meal market is growing and operators try to serve more orders while reducing emissions and the use of conventional fuels.
In this scenario, both demand level and fleet structure are changed. An increase in the number of orders may lead to higher vehicle workload, longer routes, more delivery points and greater pressure to meet time windows. The use of electric vans makes it possible to test whether higher vehicle capacity and electric propulsion can mitigate the negative effects of demand growth.
The active scenario attributes are the demand multiplier, number of orders, location of additional recipients, share of electric vehicles, vehicle type, capacity, range, energy use and vehicle assignment to routes. KPI include punctuality, delivery time, distance, energy use, CO2 emissions, number of served orders and vehicle utilisation.

AS 1.2.3. Demand increase and zero-emission boxed meal delivery

Scenario AS 1.2.3 assumes growth in demand for boxed meal delivery while using a zero-emission or predominantly zero-emission service structure. It is a more advanced variant than AS 1.2.2, as it focuses on examining the feasibility of serving higher demand while strongly reducing the use of combustion vehicles.
The scenario makes it possible to assess whether the boxed meal delivery system can operate with a higher number of orders while using transport modes with zero local emissions. Because boxed meal deliveries are planned, repetitive and can be assigned to vehicles in advance, this segment may be particularly suitable for testing zero-emission variants.
The main decision variables include demand level, share of zero-emission vehicles, route structure, assignment of recipients to routes and use of vehicle capacity. KPI include delivery punctuality, delivery time, distance travelled, energy use, CO2 emissions, number of served orders and vehicle utilisation. The scenario makes it possible to assess whether zero-emission boxed meal delivery is operationally feasible under demand growth.

BS 1.3. Parcel delivery with home and parcel locker channels

Base scenario BS 1.3 concerns the service of common parcel demand using two main delivery channels: direct home delivery and delivery to a parcel locker. In this scenario, parcel demand is not treated as two independent streams, but as one parcel flow that is then divided between delivery channels.

Origins are hubs or distribution centres of courier operators. Destinations are individual recipients in the case of home delivery and parcel lockers in the case of self-service delivery. In the latter case, the scenario also includes analysis of trips made by recipients to collect parcels from parcel lockers.

In parcel scenarios, the transport mode structure is defined separately for individual service relations. The hub-to-home relation describes direct deliveries from the hub to the recipient. The hub-to-parcel-locker relation describes the supply of parcel lockers. The parcel-locker-to-home by client relation describes self-pick-up by the customer. The parcel-locker-to-home by drone relation is used in scenarios where a parcel locker acts as a local launch point for drone deliveries.

The base scenario assumes a reference delivery channel split, in which some parcels are delivered directly to homes and others to parcel lockers. The base variant also accounts for the fact that some parcels may not be eligible for parcel locker handling because of their mass or volume. Such parcels should remain in the direct home delivery channel, regardless of the assumed parcel locker share.

The main scenario attributes include hub locations, recipient locations, parcel locker locations, parcel demand, delivery channel split, package type, package mass and volume, parcel locker eligibility, parcel collection mode, transport modes and recipient behaviour. KPI include service time, operator distance, recipient distance, operator energy use, recipient energy use, CO2 emissions and service accessibility.

AS 1.3.1. Low-emission moderate parcel delivery

Alternative scenario AS 1.3.1 assumes a moderate increase in the share of low-emission vehicles in parcel demand service while maintaining the base delivery channel split. This means that the share of home deliveries and parcel locker deliveries remains consistent with BS 1.3, while the structure of transport modes used by operators changes.

The change in vehicle structure applies separately to the hub-to-home and hub-to-parcel-locker relations. For parcels directed to parcel lockers, the client pick-up leg, i.e. parcel-locker-to-home by client, is also included. As a result, the KPI assessment covers not only courier operator activity, but also energy use and emissions resulting from recipient trips to parcel lockers.

The purpose of the scenario is to assess whether a moderate fleet change can produce visible energy and emission effects without rebuilding the entire parcel service model. This variant may represent a realistic, staged implementation of low-emission vehicles by courier operators.

The active scenario attributes are the share of low-emission vehicles, vehicle type, fuel or energy consumption, vehicle capacity, speed and vehicle assignment to routes. KPI include delivery time, distance, energy use, fuel use, CO2 emissions and vehicle utilisation.

AS 1.3.2. Low-emission high parcel delivery

Scenario AS 1.3.2 assumes a high share of low-emission vehicles in parcel demand service. Compared with AS 1.3.1, this is a stronger fleet transformation variant, while the base delivery channel split between home delivery and parcel locker delivery is still maintained.
In this variant, the transport mode structure is also defined by relation. One vehicle structure may be assigned to the hub-to-home relation and another to the hub-to-parcel-locker relation. The parcel-locker-to-home by client leg remains linked to recipient behaviour and the mode used to reach the parcel locker.
The scenario makes it possible to assess whether a higher share of low-emission vehicles improves energy and environmental results without reducing service quality. It is particularly important to verify whether low-emission vehicles can take over a larger share of delivery tasks while maintaining the required number of served parcels and acceptable delivery time.
The main decision variables include the share of low-emission vehicles, fleet structure, assignment of parcels to delivery channels and vehicle assignment to routes. KPI include time, distance, energy, CO_2 emissions, vehicle utilisation and number of served parcels.

AS 1.3.3. Zero-emission parcel delivery

Scenario AS 1.3.3 assumes the use of a zero-emission or predominantly zero-emission vehicle structure for parcel demand service. This variant is used to assess whether parcel service involving home delivery and parcel locker delivery can be carried out while strongly reducing the use of combustion vehicles.
The base delivery channel split is retained, while the transport mode structure changes for the hub-to-home and hub-to-parcel-locker relations. This means that the influence of technological fleet transformation on energy use, CO_2 emissions and service quality is analysed. At the same time, for parcels collected from parcel lockers, the leg performed by the recipient must still be included, as it may affect the system-wide energy balance.
Active attributes include the share of zero-emission vehicles, vehicle energy parameters, capacity, speed, range, parcel eligibility for individual channels and use of transport resources. KPI include time, distance, energy use, CO_2 emissions, vehicle utilisation and served parcels.

AS 1.3.4. Drone delivery from parcel lockers

Scenario AS 1.3.4 assumes the use of parcel lockers as local launch points for drone deliveries. However, this variant does not mean that all parcels are served by drones. The scenario retains the division of demand into the direct home delivery channel and the parcel locker channel.
In AS 1.3.4, the hub-to-home and hub-to-parcel-locker relations are still served by road vehicles according to the adopted vehicle structure. Drones are used on the parcel-locker-to-home by drone relation, i.e. on the final leg from the parcel locker to the recipient. This means that parcels directed to direct home delivery, parcels that are too large or too heavy, and parcels not eligible for parcel locker or drone handling remain in road-based service.
The scenario makes it possible to examine whether using parcel lockers as intermediate points can shorten the leg served by road vehicles and reduce energy use in the final delivery segment. This variant is particularly relevant for assessing the possibility of transforming parcel lockers into local distribution points.
Active attributes include parcel locker locations, share of drone deliveries, drone range, drone capacity, package mass and volume constraints, flight time, service time, drone energy use and

the share of parcels remaining in the road-based channel. KPI include delivery time, road vehicle distance, flight distance, energy use, CO2 emissions, share of drone deliveries and service accessibility.

AS 1.3.5. Parcel locker only channel

Scenario AS 1.3.5 assumes that all eligible parcel demand is directed to parcel lockers. This means abandoning voluntary direct home deliveries in favour of the parcel locker network. In practice, however, parcels not eligible for lockers because of mass or volume may require separate handling.

In this variant, courier operators deliver from hubs to parcel lockers on the hub-to-parcel-locker relation, while recipients collect parcels themselves on the parcel-locker-to-home by client relation. The hub-to-home relation is inactive for locker-eligible parcels, but may remain necessary for oversized parcels or parcels not eligible for parcel locker handling.

The scenario makes it possible to assess how a full or almost full transition to the parcel locker channel affects operator work, recipient behaviour, route length, energy use and CO2 emissions. It is important for assessing whether reducing door-to-door delivery actually reduces the total energy footprint of the system, or whether part of the effect is shifted to recipient trips.

Active attributes include the share of the parcel locker channel, parcel locker locations, parcel locker capacity, recipient distance to lockers, the mode used by recipients to reach lockers, the operator vehicle structure and parcel eligibility. KPI include operator distance, recipient distance, operator energy use, recipient energy use, CO2 emissions and accessibility of pick-up points.

AS 1.3.6. Major parcel locker share

Scenario AS 1.3.6 assumes a dominant share of parcel lockers in parcel demand service. In this variant, most parcels go to parcel lockers, while a smaller share is delivered directly to homes. The variant changes the shares of home delivery and parcel locker delivery, but the vehicle structure remains defined separately for the hub-to-home and hub-to-parcel-locker relations. For parcels served by parcel lockers, the mode used by the recipient to reach the locker, i.e. parcel-locker-to-home by client, is also included.

The purpose of the scenario is to assess whether increasing the share of parcel lockers can reduce courier operator transport work and improve energy and emission indicators. At the same time, the scenario accounts for the effect of recipient trips to parcel lockers, which is necessary for a reliable assessment of the system-wide energy balance.

The main decision variables include parcel locker channel share, home delivery share, parcel locker locations, parcel collection mode and the structure of transport modes used by recipients. KPI include time, distance, operator energy, recipient energy, CO2 emissions and service accessibility.

AS 1.3.7. Equal home and parcel locker share

Scenario AS 1.3.7 assumes an equal split of parcel demand between direct home deliveries and parcel locker deliveries. This variant represents an intermediate situation between dominance of home deliveries and dominance of parcel lockers.

In this variant, the hub-to-home and hub-to-parcel-locker relations have similar importance in serving total parcel demand. For parcels directed to parcel lockers, the parcel-locker-to-home by client leg is also included. The scenario therefore makes it possible to compare the combined energy balance of the operator and the recipient in a system with balanced use of both channels. The scenario makes it possible to assess whether an equal demand split can provide a compromise between recipient convenience, operator efficiency and emission reduction. It is useful for interpretation because it lies between the extreme scenarios of full home delivery and full parcel locker service.

Active attributes include delivery channel shares, recipient locations, parcel locker locations, parcel collection mode, operator vehicle structure and recipient behaviour. KPI include delivery time, operator distance, recipient distance, energy, CO2 emissions and service accessibility.

AS 1.3.8. Minor parcel locker share

Scenario AS 1.3.8 assumes a smaller share of parcel lockers and dominance of direct home deliveries. This variant is close to the traditional courier delivery model, but with partial use of parcel lockers.

In this scenario, most parcels are served through the hub-to-home relation, while a smaller share is served through the hub-to-parcel-locker relation and subsequent self-pick-up by the customer. The vehicle structure for operator relations remains defined separately for direct deliveries and parcel locker supply.

The purpose of the scenario is to assess how a limited parcel locker share affects operational and environmental indicators. It allows verification of whether even partial use of parcel lockers can improve results compared with full home delivery.

The active scenario attributes are home delivery share, parcel locker share, recipient locations, parcel locker locations, operator route structure and recipient behaviour. KPI include time, distance, energy, fuel, CO2 emissions, service accessibility and number of served parcels.

AS 1.3.9. Direct home parcel delivery only

Scenario AS 1.3.9 assumes that all parcel demand is served by direct deliveries to individual recipients. Parcel lockers are not used as a collection channel in this variant.

This variant primarily activates the hub-to-home relation. The hub-to-parcel-locker, parcel-locker-to-home by client and parcel-locker-to-home by drone relations remain inactive. It represents the classical courier door-to-door delivery model.

The scenario is an important comparison point for variants involving parcel lockers, as it allows assessment of how time, distance, energy and emissions change when the self-service channel is not used. It also enables comparison of whether greater recipient convenience is associated with higher operator transport work and higher system energy intensity.

The main attributes include hub locations, recipient locations, parcel demand, vehicle structure, vehicle capacity, routing rules and service times. KPI include delivery time, distance, fuel use, energy use, CO2 emissions, vehicle utilisation and number of served parcels.

AS 1.3.10. Drone-only direct parcel delivery

Scenario AS 1.3.10 assumes direct parcel deliveries to individual recipients using drones. It is an extreme and experimental variant aimed at assessing the potential energy and operational effects of full drone use in direct parcel demand service.

In this variant, the parcel locker channel is not active. The hub-to-home relation is served by drones, while hub-to-parcel-locker, parcel-locker-to-home by client and parcel-locker-to-home by drone do not constitute the main service mechanism. The scenario makes it possible to determine the potential limits of drone application in direct parcel distribution.

The scenario requires consideration of constraints related to range, package mass, package volume, availability of take-off and landing locations, service time, operational conditions and the ability to serve different parcel types. In particular, parcels that are too heavy or too large may not be eligible for drone service, which should be noted as an interpretative limitation of this variant.

Active attributes include drone share, drone range, payload, flight time, energy use, origin locations, recipient locations and parcel eligibility for drone service. KPI include delivery time, flight distance, energy use, CO2 emissions, number of served parcels, service accessibility and operational constraints.

BS 1.4. Pharmaceutical delivery in urban areas

Scenario BS 1.4 concerns deliveries of medicines and pharmaceuticals in urban areas. It includes relations between wholesalers, pharmacies, hospitals and potentially individual recipients. In the current report, this scenario is treated as a future research proposal, i.e. as a valuable direction for further research that will not be developed in subsequent project reports.

The pharmaceutical scenario is important from a research perspective due to the nature of the cargo, quality requirements, regulatory constraints, required reliability and the importance of service accessibility for users. Pharmaceutical deliveries may include both institutional supply to pharmacies and hospitals and deliveries to patients.

Due to separate data requirements, the need to include specific service conditions and potential legal constraints, the scenario is not planned for full parameterisation in the current WP2 simulation studies. It remains part of the E-Laas scenario catalogue as a possible extension of the methodology.

AS 1.4.1. Modal split change in institutional pharmaceutical deliveries

Scenario AS 1.4.1 assumes a change in the structure of transport modes used for deliveries from wholesalers to pharmacies and hospitals. This variant refers primarily to institutional transport, where reliability, timeliness and compliance with cargo-handling requirements are important.

A possible modal split change may include a higher share of electric vehicles or autonomous delivery vehicles. The purpose of the scenario would be to assess the effect of such a change on time, energy, emissions, cost and delivery reliability.

In the current project, the scenario remains a proposal for further research. Its development would require separate data on pharmaceutical demand, locations of wholesalers, pharmacies and hospitals, delivery frequency, temperature requirements and regulatory constraints.

AS 1.4.2. Pharmacy-to-home delivery

Scenario AS 1.4.2 concerns a shift from individual patient trips to pharmacies towards a model of medicine delivery from pharmacies to individual recipients. This variant may have social importance, particularly for older people, people with limited mobility or residents of areas with weaker service accessibility.

The scenario would make it possible to analyse whether home deliveries can reduce the number of individual trips to pharmacies, reduce energy use and improve service accessibility. At the same time, it would require consideration of delivery cost, product eligibility rules, quality requirements and operator responsibility.

Within the current project scope, the scenario is not developed as an active simulation variant. It is retained as a potential direction for future research because it requires separate data and regulatory and organisational assumptions.

BS 1.5. B2B urban freight deliveries

Scenario BS 1.5 concerns urban freight deliveries between businesses, excluding individual consumers. It includes deliveries to companies, schools, hospitals, restaurants, construction sites and other points of collective consumption. In this report, the scenario is treated as a future research proposal.

B2B deliveries differ from deliveries to individual recipients in terms of larger cargo mass and volume, different delivery frequency, greater importance of time windows and a different vehicle structure. They also require a separate demand model, because B2B flows result from economic activity and facility functions rather than directly from household consumer behaviour.

The B2B scenario is valuable from a research perspective, but it is not developed in the current WP2 reports. Its inclusion in the scenario catalogue indicates the possibility of further extending the E-Laas methodology to larger and more complex urban freight flows.

AS 1.5.1. Alternative low-emission modes in B2B deliveries

Scenario AS 1.5.1 assumes partial electrification or a change in the structure of transport modes in B2B deliveries. This variant may include the use of electric trucks, electric delivery vehicles and improved consolidation of transport.

The purpose of the scenario would be to assess whether changes in fleet structure and delivery organisation can reduce fuel use, CO_2 emissions and operating costs while maintaining reliable service for business recipients. Analysis of consolidation, zoning and last-mile organisation would be particularly important.

In the current project, the scenario remains outside the active scope of simulation studies. Full development would require data on B2B volumes, cargo types, locations of institutional recipients, delivery frequency, time constraints and operator fleet structure. However, the scenario may provide a valuable basis for further research on urban business logistics.

7. Main input data required for scenario development

The scenarios described in the previous sections require a structured set of input data that allows them to be represented later in the microsimulation model. This section presents the data logic, selected parameter values and the way in which report scenarios were linked to simulation input tables. The full dataset (WP0) includes detailed spatial data, demand tables, vehicle characteristics, energy and emission parameters, and scenario-specific structures. Report D0.3 presents only the most important values and relations needed to understand the scenario assumptions and their implementation.

7.1. Scenario implementation in simulation input tables

Each scenario identified in D0.3 was represented in the simulation data using a technical scenario identifier. This identifier links the scenario description with the relevant demand source, demand multiplier, vehicle structure variant and, for parcel scenarios, the delivery channel variant. These links are presented in Table 3.

Table 3. Mapping between report scenarios and simulation input variants

Report scenario	Technical scenario ID	Scenario group	Demand multiplier	Vehicle structure variant	Channel variant
BS 1.1	FOOD_BS_1_1	food_delivery	1,00	FOOD_V0_BASE	not_applicable
AS 1.1.1	FOOD_AS_1_1_1	food_delivery	1,00	FOOD_V1_LOW_EMISSION_MODERATE	not_applicable
AS 1.1.2	FOOD_AS_1_1_2	food_delivery	1,25	FOOD_V2_LOW_EMISSION_HIGH	not_applicable
AS 1.1.3	FOOD_AS_1_1_3	food_delivery	1,25	FOOD_V2_ZERO_EMISSION	not_applicable
BS 1.2	FB_BS_1_2	foodbox_delivery	1,00	FOODBOX_V0_BASE	not_applicable
AS 1.2.1	FB_AS_1_2_1	foodbox_delivery	1,00	FOODBOX_V1_ELECTRIC_MIX	not_applicable
AS 1.2.2	FB_AS_1_2_2	foodbox_delivery	1,25	FOODBOX_V2_ELECTRIC_VANS	not_applicable
AS 1.2.3	FB_AS_1_2_3	foodbox_delivery	1,25	FOODBOX_V2_ZERO_EMISSION	not_applicable
BS 1.3	PKG_BS	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_BASE
AS 1.3.1	PKG_AS_1_3_1	parcel_delivery	1,00	PKG_V1_LOW_EMISSION_MODERATE	PKG_CH_BASE
AS 1.3.2	PKG_AS_1_3_2	parcel_delivery	1,00	PKG_V2_LOW_EMISSION_HIGH	PKG_CH_BASE
AS 1.3.3	PKG_AS_1_3_3	parcel_delivery	1,00	PKG_V3_ZERO_EMISSION	PKG_CH_BASE
AS 1.3.4	PKG_AS_1_3_4	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_BASE_WITH_DRONES
AS 1.3.5	PKG_AS_1_3_5	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_ONLY_PLS
AS 1.3.6	PKG_AS_1_3_6	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_MAJOR_PLS
AS 1.3.7	PKG_AS_1_3_7	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_EQUAL_PLS
AS 1.3.8	PKG_AS_1_3_8	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_MINOR_PLS
AS 1.3.9	PKG_AS_1_3_9	parcel_delivery	1,00	PKG_V0_BASE	PKG_CH_ONLY_DIRECT
AS 1.3.10	PKG_AS_1_3_10	parcel_delivery	1,00	PKG_V0_DRONES_ONLY	PKG_CH_ONLY_DIRECT_WITH_DRONES

As shown in Table 3, scenario changes are introduced in different ways depending on the scenario group. In ready-made food delivery and boxed meal delivery, alternative scenarios mainly change the demand multiplier and vehicle structure. In parcel scenarios, demand remains common, while the main differences concern vehicle structure, delivery channel split and the way transport relations are served.

7.2. Spatial and network input data

The spatial layer includes origins, destinations, intermediate logistics points and the transport network used for routing. Table 4 presents the main spatial layers used to parameterise the scenarios. These data show that the number of source objects is not always the same as the number of objects active in a scenario. For example, the restaurant layer contains 410 points, while the active demand table for ready-made food delivery uses 257 restaurants. Similarly, the boxed meal scenarios actively use 224 residential buildings and 51 office buildings. This distinction is important because the model should not automatically treat every source object as an active demand point.

Table 4. Main spatial input layers used in scenario development

Dataset sheet	Records	Object type	Scenario role
SRC_Nodes	593	network nodes	routing graph and coordinate transformation
SRC_Links	6 884	network links	routing graph with length, speed and mode permissions
SRC_Restaurants	410	restaurant POI	candidate origins; 257 restaurants used in food delivery demand
SRC_Apartments	1 897	residential buildings	recipients for boxed meals and parcel demand
SRC_Offices	51	office buildings	additional recipients for boxed meal delivery
SRC_Parcel_lockers	105	parcel lockers	intermediate nodes for parcel scenarios

7.3. Demand input data and generation rules

Demand is represented differently across scenario groups. Ready-made food delivery uses demand assigned to restaurants and a time profile with periods of increased intensity. Boxed meal delivery uses demand assigned to residential and office buildings. Parcel scenarios use one common residential parcel demand, which is then divided between delivery channels. This logic is presented in Table 5.

Table 5. Demand representation in active scenario groups

Scenario group	Spatial demand units	Demand level from dataset	Generation rule	Temporal or operational modifier
BS/AS 1.1 food delivery	257 active restaurants	183,50 orders/day in base scenarios; 229,37 orders/day in increased-demand scenarios	Poisson(lambda_r_stable_sim * hourly_factor)	food time profile with lunch and dinner peaks
BS/AS 1.2 boxed meals	224 active apartment buildings + 51 offices	172,42 deliveries/day in base scenarios; 215,53 deliveries/day in increased-demand scenarios	Poisson(sim_deliveries_expected_day)	home delivery at 5:30, 6:30, 7:30; office delivery at 9:30, 11:00, 12:30
BS/AS 1.3 parcels	1 897 apartment buildings + 105 parcel lockers	2 741,44 expected packages/day	Poisson(sim_lambda_packages_day), followed by package type and channel assignment	channel split and package eligibility rules

As shown in Table 5, scenarios BS/AS 1.1 and BS/AS 1.2 include increased-demand variants with a demand multiplier of 1.25. In parcel scenarios, the demand multiplier remains 1.00, while service channels and vehicle structures change. This is important for interpretation, because food-related scenarios may differ in both demand and service technology, whereas parcel scenarios are compared mainly through delivery channel organisation.

The time profile for ready-made food delivery accounts for periods of increased demand, especially lunch and dinner. Boxed meal deliveries are more planned and assigned to fixed time groups. In parcel scenarios, the key elements are the rules for assigning parcels to channels and parcel eligibility for parcel locker or drone delivery.

7.4. Vehicle structure variants for food and boxed meal scenarios

Vehicle structure is one of the main scenario variables. In the input data, it is expressed as the share of individual vehicles or propulsion sources in a given variant. Table 6 presents the aggregated structure by propulsion source for ready-made food and boxed meal delivery scenarios. Table 6 shows that alternative scenarios are not based only on a descriptive assumption of greater environmental friendliness. The change in vehicle structure is explicitly defined in the data. In ready-made food delivery, the share of combustion modes decreases from 32.0% in BS 1.1 to 0.0% in AS 1.1.3. In boxed meal delivery, the change is even stronger: the share of combustion, CNG and LPG vehicles decreases from 73.0% in BS 1.2 to 0.0% in AS 1.2.3.

However, zero-emission scenarios should be interpreted as locally zero-emission or zero-emission from the perspective of vehicle operation. If emissions associated with electricity or hydrogen production are included in further analysis, environmental results should be recalculated using appropriate emission factors.

Table 6. Aggregated vehicle structure by energy source for food and boxed meal scenarios

Scenario	Vehicle structure variant	Combustion/CNG/LPG	Electric	Hydrogen	Manual/no-power
BS 1.1	FOOD_V0_BASE	32,00%	48,00%	0,00%	20,00%
AS 1.1.1	FOOD_V1_LOW_EMISSION_MODERATE	18,00%	62,00%	0,00%	20,00%
AS 1.1.2	FOOD_V2_LOW_EMISSION_HIGH	9,00%	71,00%	0,00%	20,00%
AS 1.1.3	FOOD_V2_ZERO_EMISSION	0,00%	75,00%	0,00%	25,00%
BS 1.2	FOODBOX_V0_BASE	73,00%	27,00%	0,00%	0,00%
AS 1.2.1	FOODBOX_V1_ELECTRIC_MIX	33,00%	67,00%	0,00%	0,00%
AS 1.2.2	FOODBOX_V2_ELECTRIC_VANS	11,50%	87,50%	1,00%	0,00%
AS 1.2.3	FOODBOX_V2_ZERO_EMISSION	0,00%	98,00%	2,00%	0,00%

7.5. Relation-specific vehicle structures for parcel scenarios

Parcel scenarios require a more detailed representation than food delivery scenarios. In their case, vehicle structure is not defined by one value for the whole scenario, but separately for the following relations: hub-to-home, hub-to-parcel-locker, parcel-locker-to-home by client and parcel-locker-to-home by drone. This logic is shown in Table 7. Parcel scenarios should therefore not be interpreted only through the name of the variant. For example, AS 1.3.3 assumes a zero-emission operator structure on hub-to-home and hub-to-parcel-locker relations, but the customer pick-up leg from a parcel locker may still include combustion cars. This means that the system result depends not only on the operator fleet, but also on recipient behaviour.

Table 7. Relation-specific vehicle structures in selected parcel scenarios

Scenario	Relation			
	hub-to-home	hub-to-parcel-locker	parcel-locker-to-home by client	parcel-locker-to-home by drone
BS 1.3	75% combustion/CNG, 25% electric	72% combustion/CNG, 28% electric	70% combustion, 20% electric, 10% manual	inactive
AS 1.3.1	39% combustion/CNG, 61% electric	36% combustion/CNG, 64% electric	50% combustion, 38% electric, 12% manual	inactive
AS 1.3.2	14% combustion, 85% electric, 1% H2	10% combustion, 89% electric, 1% H2	25% combustion, 60% electric, 15% manual	inactive

AS 1.3.3	99% electric, 1% H2	99% electric, 1% H2	25% combustion, 60% electric, 15% manual	inactive
AS 1.3.4	75% combustion/CNG, 25% electric	72% combustion/CNG, 28% electric	inactive	40 small drones + 20 large drones
AS 1.3.5-AS 1.3.9	same as BS 1.3, with changed channel split	same as BS 1.3, with changed channel split	same as BS 1.3, if parcel locker channel is active	inactive
AS 1.3.10	40 small drones + 20 large drones	inactive	inactive	inactive

Table 7 also shows that drone scenarios are not a simple percentage substitution of road vehicles by drones. In AS 1.3.4, drones are assigned to the parcel-locker-to-home by drone relation, while the hub-to-home and hub-to-parcel-locker relations remain served by road vehicles. In AS 1.3.10, drones serve the hub-to-home relation directly, and the parcel locker channel is inactive.

7.6. Parcel channel split and package eligibility

Parcel scenarios use one common parcel demand, but differ in the split between direct home delivery and parcel locker delivery. Table 8 presents the delivery channel variants and their operational interpretation. The PUDO channel is not developed in this report, and the scenarios are interpreted only through the home delivery and parcel locker delivery channels.

Table 8. Parcel channel variants and operational interpretation

Scenario	Channel variant	Declared home share	Declared parcel locker share	Last leg from parcel locker	Pick-up during other trips	Eligibility -sensitive home share*	Eligibility -sensitive parcel locker share*
BS 1.3	PKG_CH_BASE	35%	65%	client's vehicle	58%	41,5%	58,5%
AS 1.3.1	PKG_CH_BASE	35%	65%	client's vehicle	58%	41,5%	58,5%
AS 1.3.2	PKG_CH_BASE	35%	65%	client's vehicle	58%	41,5%	58,5%
AS 1.3.3	PKG_CH_BASE	35%	65%	client's vehicle	58%	41,5%	58,5%
AS 1.3.4	PKG_CH_BASE_WITH_DRONES	35%	65%	drones	0%	41,5%	58,5%
AS 1.3.5	PKG_CH_ONLY_PLS	0%	100%	client's vehicle	58%	10,0%	90,0%
AS 1.3.6	PKG_CH_MAJOR_PLS	25%	75%	client's vehicle	58%	32,5%	67,5%
AS 1.3.7	PKG_CH_EQUAL_PLS	50%	50%	client's vehicle	58%	55,0%	45,0%
AS 1.3.8	PKG_CH_MINOR_PLS	75%	25%	client's vehicle	58%	77,5%	22,5%
AS 1.3.9	PKG_CH_ONLY_DIRECT	100%	0%	none	0%	100,0%	0,0%
AS 1.3.10	PKG_CH_ONLY_DIRECT_WITH_DRONES	100%	0%	none	0%	100,0%	0,0%

* Eligibility-sensitive shares are calculated assuming that package eligibility is independent from declared channel choice and that non-eligible parcel-locker packages are redirected to home delivery. These values support interpretation and do not replace the assignment rules implemented in the simulation dataset.

Table 8 is important because it prevents a misleading interpretation of scenarios with a high parcel locker share. A declared 100% share of parcel locker delivery does not automatically mean that 100% of all parcels can physically be placed in lockers. Some parcels may be too heavy or too large and therefore need to be redirected to direct delivery. This assumption is developed in Table 9, which presents package types and their eligibility for parcel lockers.

Table 9. Package type distribution and parcel locker eligibility

Package type	Share	Mass range [kg]	Volume range [m3]	Parcel locker eligible	Operational meaning
P1	25%	0,1-0,5	0,001-0,005	yes	small packages
P2	45%	0,5-2,0	0,005-0,020	yes	standard small/medium packages
P3	20%	2,0-5,0	0,020-0,050	yes	larger but still locker-compatible packages
P4	10%	5,0-50,0	0,050-0,150	no	heavy or oversized packages requiring direct handling

As shown in Table 9, 90% of parcels are potentially eligible for parcel locker handling, while 10% should be treated as non-eligible. This is particularly important when interpreting scenarios AS 1.3.4, AS 1.3.5 and AS 1.3.10, because both parcel lockers and drones have mass, volume and handling constraints.

7.7. Vehicle parameters used for energy and capacity calculations

Dataset M0 contains detailed technical parameters of transport modes, including maximum speed, volume capacity, payload, number of items carried and fuel or energy consumption. Table 10 presents selected vehicles that are most important for scenario interpretation. The full vehicle list remains in the dataset.

Table 10. Selected vehicle parameters used in scenario parameterisation

Vehicle	Max speed [km/h]	Capacity [m3]	Capacity [kg]	Capacity [pcs]	Loaded consumption
van_diesel	90	6,00	1 000	100	11 l/100 km
van_gasoline	90	6,00	1 000	100	9 l/100 km
van_electric	90	6,00	1 000	100	30 kWh/100 km
truck_6pallet_diesel	80	14,50	1 500	300	15 l/100 km
truck_6pallet_electric	80	14,50	1 500	300	100 kWh/100 km
car_electric	130	0,50	300	20	20 kWh/100 km
scooter_electric	45	0,08	25	5	5 kWh/100 km
bicycle_electric	25	0,06	15	3	1 kWh/100 km
cargo_drone_small	60	0,03	5	3	2 kWh/100 km
cargo_drone_large	60	0,15	15	3	8 kWh/100 km

Table 10 shows that scenario effects do not depend only on propulsion type. Capacity, load mass, number of transported items and operational constraints are also important. For example, a heavier vehicle may have higher energy use, but also larger capacity and fewer trips. Drones, in turn, have low energy use per unit of distance, but limited payload and volume capacity, which limits their use to a subset of parcels.

7.8. Energy and emission conversion assumptions

To compare vehicles using different energy carriers, energy and emission conversion factors are required. Table 11 presents selected values used in the dataset. These values should be treated as modelling assumptions rather than a full life-cycle environmental balance.

Table 11. Selected energy and emission conversion factors included in the dataset

Input unit	Output unit	Value used in dataset	Scope or assumption	Interpretation note
1 kWh	kg CO2	0,618	electricity, Poland	dataset value; sensitivity value: 0,553 kg CO2/kWh
1 l gasoline	kg CO2	2,31	direct combustion	tank-to-wheel CO2
1 l diesel	kg CO2	2,68	direct combustion	tank-to-wheel CO2
1 kg CNG	kg CO2	2,70059	direct combustion approximation	value depends on gas composition
1 l LPG	kg CO2	1,66	direct combustion	conservative value in the dataset
1 kg H2	kg CO2	0,00	local vehicle emission only	upstream hydrogen production excluded
1 l gasoline	kWh	8,88	energy content	used for energy-equivalent calculations
1 l diesel	kWh	10,00	energy content	used for energy-equivalent calculations
1 kg H2	kWh	33,33	hydrogen LHV	used for energy-equivalent calculations

Table 11 indicates that further analysis should clearly distinguish local emissions from full energy-cycle emissions. A value of 0 for hydrogen means no local vehicle emissions, but does not include emissions related to hydrogen production. Similarly, electricity requires an emission factor for the electricity generation mix.

8. Potential KPI for further analysis

The simulation studies of the developed scenarios make it possible to calculate different groups of performance indicators. Their selection should depend on the scenario type and the decision problem. A single universal KPI set is not sufficient, because the scenarios differ in demand structure, transport relations and process participants.

8.1. KPI calculation layers

In the simulation studies, KPI should be calculated at several levels. The proposed calculation levels are presented in Table 12. It is particularly important to distinguish the operator, recipient and drone layers. This is most relevant in parcel scenarios. A scenario with a higher parcel locker share may reduce the operator's distance, but at the same time generate additional recipient trips. Without separating these layers, scenario assessment could be misleading.

Table 12. KPI logic by calculation layer

KPI layer	Main question	Example indicators	Relevant scenario groups
Operator layer	How much transport work is performed by logistics operators?	operator distance, operator energy, fuel use, vehicle utilisation, served orders/parcels	all scenario groups
Recipient layer	Does the scenario transfer transport activity to recipients?	recipient distance, recipient energy, recipient CO2, share of pick-up during other trips	parcel locker scenarios
Drone layer	What is the operational effect of drone delivery?	flight distance, drone energy, drone utilisation, non-eligible parcels	AS 1.3.4 and AS 1.3.10
Service layer	Is demand served with acceptable quality?	delivery time, punctuality, served/unserved demand, accessibility	all scenario groups
System layer	What is the total effect of the scenario?	total energy, total CO2, energy per order, CO2 per order, total distance	all scenario groups

8.2. KPI groups by active scenario groups

KPI should be assigned not only to the type of logistics service, but also to the way in which a given scenario group changes the system. Therefore, Table 13 presents active scenario groups

planned for further simulation analysis. The table does not include pharmaceutical and B2B scenarios, as they have been retained as future research proposals. Table 13 organises KPI by active analytical groups rather than by the entire scenario catalogue. This approach is more useful for further simulation because it groups scenarios according to the mechanism of change: demand growth, fleet electrification, delivery channel change or drone use.
In particular, parcel scenarios were divided into three separate analytical groups. The first concerns the transformation of the operator fleet, the second changes in the share of home and parcel locker deliveries, and the third drone-based variants. This avoids mixing effects that arise from different change mechanisms within one assessment.

Table 13. Recommended KPI groups for active simulation scenario groups

Active scenario group	Included scenarios	Main analytical focus	Primary KPI	Secondary KPI	Required data source
Ready-made food delivery - demand and vehicle structure variants	BS 1.1, AS 1.1.1, AS 1.1.2, AS 1.1.3	influence of demand increase and modal shift on on-demand food delivery	delivery time, served orders, unserved orders, energy per order, CO2 per order	distance by vehicle type, vehicle utilisation, share of low-/zero-emission deliveries	SIM_FOOD_DEMAND, SIM_FOOD_TIME_PROFILE, SIM_FOOD_DISTANCE_MODAL, SIM_VEHICLE_STRUCTURE, Vehicles_clean
Boxed meal delivery - scheduled delivery variants	BS 1.2, AS 1.2.1, AS 1.2.2, AS 1.2.3	influence of demand increase and fleet electrification on planned deliveries to homes and offices	punctuality, served deliveries, delayed deliveries, route distance, energy per delivery, CO2 per delivery	load utilisation, vehicle utilisation, number of routes, delivery window compliance	SIM_FOODBOX_DEMAND, SIM_FOODBOX_TIME_PROFILE, SIM_VEHICLE_STRUCTURE, Vehicles_clean, SRC_Apartments, SRC_Offices
Parcel delivery - operator fleet transition	BS 1.3, AS 1.3.1, AS 1.3.2, AS 1.3.3	influence of low-emission and zero-emission operator fleet on parcel delivery with unchanged channel split	operator distance, operator energy, operator CO2, energy per parcel, CO2 per parcel	recipient distance, recipient CO2, vehicle utilisation, channel-specific distance	SIM_PACKAGE_DEMAND, SIM_PACKAGE_CHANNEL_SPLIT, SIM_PACKAGE_TYPE_DIST, SIM_VEHICLE_STRUCTURE, Vehicles_clean
Parcel delivery - channel split variants	BS 1.3, AS 1.3.5, AS 1.3.6, AS 1.3.7, AS 1.3.8, AS 1.3.9	influence of home/parcel-locker split on operator work and recipient-side transport activity	operator distance, recipient distance, total energy, total CO2, energy per parcel	parcel locker share, direct home share, pick-up during other trips, non-eligible package share	SIM_PACKAGE_DEMAND, SIM_PACKAGE_CHANNEL_SPLIT, SIM_PACKAGE_TYPE_DIST, SIM_VEHICLE_STRUCTURE, SRC_Parcel_lockers, SRC_Apartments
Parcel delivery - drone-based variants	AS 1.3.4, AS 1.3.10	feasibility and energy effects of drone delivery from parcel lockers or directly from hub to home	drone flight distance, drone energy, drone-served parcel share, non-eligible parcel share	road distance reduction, drone utilisation, unserved parcel share, payload/volume limitation	SIM_PACKAGE_DEMAND, SIM_PACKAGE_CHANNEL_SPLIT, SIM_PACKAGE_TYPE_DIST, SIM_VEHICLE_STRUCTURE, Vehicles_clean, SRC_Parcel_lockers
Cross-scenario system comparison	BS/AS 1.1, BS/AS 1.2, BS/AS 1.3	comparison of active scenario groups at system level	total energy, total CO2, energy per order/parcel, CO2 per order/parcel, served demand share	operator/recipient/drone energy split, distance split, sensitivity to demand and channel assumptions	all active simulation input tables and output event logs

8.3. Recommended normalisation of KPI

Simulation totals are often insufficient for comparing scenarios with different demand levels. Therefore, final simulation results should be normalised. The proposed normalised indicators are presented in Table 14. For scenarios BS/AS 1.1 and BS/AS 1.2, normalisation per order or delivery is most important. For parcel scenarios, normalisation is required both per parcel and per transport relation, because the same parcel may generate operator, recipient or drone movement.

Table 14. Suggested normalised KPI for final simulation results

Indicator	Formula logic	Interpretation
Energy per order	total energy / served orders	basic energy efficiency of the scenario
CO2 per order	total CO2 / served orders	environmental efficiency of the scenario
Operator distance per parcel	operator distance / served parcels	transport work performed by courier/logistics operators
Recipient distance per parcel	recipient distance / parcel locker parcels	transport work transferred to recipients
Drone energy per drone-served parcel	drone energy / drone-served parcels	efficiency of drone-based delivery
Served demand share	served demand / generated demand	operational feasibility under demand pressure
Non-eligible package share	non-eligible packages / generated packages	limitation of parcel locker or drone scenarios
Delay share	delayed deliveries / served deliveries	service quality, especially for boxed meals

8.4. Interpretation rules for scenario comparison

Scenario comparison should account for differences in demand, channel structure and service logic. In particular, scenarios with different demand multipliers should not be assessed only on the basis of total energy use or total CO2 emissions. A scenario with higher demand may have higher total consumption while also achieving better unit efficiency.

For parcel scenarios, assessment should not be limited to the operator perspective. As shown in Tables 7 and 8, some transport activity may be shifted to recipients or drones. Therefore, parcel locker scenarios should be assessed at system level, including operator distance, recipient distance and energy used in the final leg.

Zero-emission scenarios also require careful interpretation. Table 6 shows the change in vehicle structure, but this does not automatically mean zero system-level emissions. If emissions from electricity generation are included in the analysis, the conversion factors in Table 11 should be applied.

Drone scenarios should be assessed not only by energy use, but also by operational feasibility. Payload, volume, range and launch point availability constraints may limit the number of parcels that can realistically be served by drones. In this context, the data in Table 9 and the vehicle parameters in Table 10 are particularly important.

9. Conclusions

Report D0.3 defines a structured catalogue of scenarios for the reference case. The active scenarios cover three main groups: ready-made food delivery, boxed meal delivery and parcel delivery. Pharmaceutical and B2B scenarios remain in the catalogue as future research proposals, but they are not planned for detailed implementation in subsequent WP2 stages.

The presented scenario structure is consistent with the logic of the simulation dataset. As shown in Table 3, report scenarios are linked to technical identifiers, demand multipliers, vehicle structure variants and delivery channel variants. This means that the scenario description is not only narrative, but can be directly represented in the microsimulation model.

The spatial and demand data presented in Tables 4 and 5 show that the scenarios are based on different object types and different demand generation rules. Ready-made food delivery uses active restaurants and a demand time profile, boxed meal delivery is based on residential and office buildings, and parcel scenarios use common residential parcel demand divided between service channels.

A key methodological element is the relation-specific definition of vehicle structures in parcel scenarios. As shown in Table 7, the hub-to-home, hub-to-parcel-locker, parcel-locker-to-home by client and parcel-locker-to-home by drone relations are treated separately. This approach makes it possible to analyse not only the operator fleet, but also recipient and drone activity. This is important because a scenario that is favourable from the operator's perspective is not necessarily favourable at the system level.

The report also identifies the main interpretative limitations. Tables 8 and 9 show that the declared share of the parcel locker channel must be considered together with parcel eligibility. Some parcels, especially type P4, may require direct service because of mass or volume. This means that a high share of parcel lockers or drones should not be interpreted as the full technical ability to serve all parcels in that channel.

The selected vehicle parameters presented in Table 10 and the conversion factors in Table 11 provide the basis for further energy and emission calculations. However, it should be remembered that environmental results depend on the adopted emission scope. A local or tank-to-wheel variant may lead to different conclusions than a well-to-wheel or life-cycle variant.

Further simulation studies should use the multi-level KPI structure presented in Tables 12-14. Indicators should be calculated at the operator, recipient, drone and system levels. For comparisons between scenarios, normalisation of results per order, parcel, transport relation or served demand is particularly important.

10. References