E-Laas

Energy optimal urban Logistics As A Service

Deliverable report

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1. Summary

Report D2.2 was prepared as part of WP2, "Emulated analysis of energy optimal urban logistics flows". Within the structure of this WP, it serves as a link between the preparation of research assumptions, the identification of stakeholder needs and the subsequent modelling, simulation and assessment of urban logistics scenarios. The main objective of D2.2 was to transform the results of surveys, expert consultations, secondary data analysis and the state-of-the-art review into synthetic knowledge about the needs, preferences and constraints of different stakeholder groups involved in urban logistics.

Particular importance was attached to identifying the perspectives of individual recipients, couriers and drivers, logistics operators, and cities and municipalities. Each of these groups participates in the same delivery system, but evaluates it according to different criteria. Recipients focus primarily on the convenience, flexibility, accessibility and predictability of the service. Couriers pay attention to operational conditions, the availability of stopping places, service time, time pressure and problems occurring in the last stage of delivery. Logistics operators analyse the system from the perspective of costs, fleet efficiency, route organisation, delivery reliability, vehicle structure and the feasibility of implementing low- and zero-emission solutions. Cities and municipalities treat urban logistics as an element of managing public space, traffic, infrastructure, environmental impacts and residents' quality of life.

Within WP2, reports D2.1, D2.2 and D2.3 form a coherent sequence of work. D2.1, "Assumptions for questionnaire and simulation research", serves as the starting point, as it defines the methodological basis for survey and simulation research. It specifies which stakeholder groups should be included in the analysis, which thematic areas should be examined, what data are required for further modelling, and how research results can be used in simulation scenarios. D2.1 therefore establishes the research framework for the entire process: it defines the scope of questions, the logic of data acquisition and the relationship between empirical research and modelling.

On this basis, the work under D2.2 was carried out. Its role was to empirically fill the assumptions prepared in D2.1. While D2.1 answers the question of what should be studied and how, D2.2 shows which needs, preferences, behaviours and barriers actually occur among stakeholders of the urban logistics system. The report therefore moves from general research assumptions to structured knowledge about user behaviour, operational constraints, service expectations, infrastructure barriers and the acceptance of alternative delivery models.

The significance of D2.2 also lies in the fact that it transforms survey and qualitative data into a knowledge base useful for further modelling work. For this purpose, different data sources were collected, coded, aggregated and assigned to the relevant stakeholder groups. As a result, the findings of the report can be used not only as a description of preferences, but also as a source of assumptions for simulation models conducted at the micro and macro scale.

The scenario logic used in further project work is defined in report D0.3, "Identified scenarios of logistics systems, Inventory of reference cases with description". D0.3 organises the scenario catalogue for the reference case RC1 - GZM Metropolis and distinguishes three active scenario groups intended for further analysis in WP2: ready-made food delivery, boxed meal delivery, and parcel delivery with home and parcel locker channels. Pharmaceutical delivery and B2B urban freight deliveries are retained in the scenario catalogue as future research proposals, but

they are not treated as the main active scenario groups for the subsequent WP2 simulation analyses.

The most important link between D2.2 and D2.3 concerns the report D2.3, "Simulation model with indicators of the energy assessment of distribution systems in the relation between the logistics centre and the customer's door for conducting research. Comparative analysis of distribution systems scenarios". D2.3 includes a simulation model with indicators for the energy assessment of distribution systems and a comparative analysis of scenarios. For this reason, it cannot be based solely on abstract or technical assumptions concerning vehicles, routes and distances. It requires the inclusion of knowledge about real user behaviour, courier constraints, operators' capabilities, and the spatial and regulatory conditions of cities. This knowledge is provided by D2.2.

D2.2 feeds into D2.3 primarily at the level of model and scenario parameters. In ready-made food delivery scenarios, stakeholder preferences and operational data support the definition of demand-responsive delivery processes, modal split, the role of low-emission transport modes, delivery time and the ability to serve increased demand. In boxed meal delivery scenarios, the results are relevant for modelling planned and repetitive deliveries to homes and offices, including time windows, punctuality, vehicle structure, delivery route organisation and the feasibility of electric or zero-emission delivery variants. In parcel delivery scenarios, the preferences of individual recipients can be translated into the share of home deliveries, the share of parcel locker deliveries, the acceptable walking time to a parcel locker, the probability of choosing a given delivery channel, and the effect of parcel locker location on user behaviour.

The results concerning parcel lockers indicate that the attractiveness of this solution depends not only on the mere availability of the device, but also on actual walking time, spatial accessibility and the connection of the pick-up point with residents' daily mobility. This information is directly useful for modelling parcel delivery scenarios in which one common parcel demand is divided between home delivery and parcel locker delivery channels. It is also relevant for assessing whether a higher share of parcel locker use reduces operator transport work or partly transfers transport activity to recipients.

Data concerning couriers and drivers make it possible to make the operational parameters of the model more realistic. This applies, among other things, to delivery service time, time spent searching for a stopping place, the number of delivery points, the number of parcels, the length of the working day, parking problems, failed deliveries and the impact of weather conditions on system efficiency. As a result, the simulation model can include not only vehicle movement between points, but also elements of the delivery process that strongly affect time, costs, energy consumption and service quality.

The perspective of logistics operators allows the results of D2.2 to be translated into parameters concerning the fleet, costs and implementation constraints. For D2.3, information on the structure of vehicles used, readiness to change the fleet, economic barriers, operational feasibility and the potential for introducing low- and zero-emission vehicles is particularly important. Without this knowledge, the scenarios analysed in D2.3 could be too theoretical. D2.2 makes it possible to determine which changes have application potential and which may encounter cost, organisational, technological or infrastructure constraints.

The results concerning cities and municipalities complement the modelling with a spatial and regulatory dimension. They indicate which constraints should be considered when interpreting scenarios, including the availability of parking and loading spaces, the rules for using street space, the location of parcel lockers, the possibility of implementing micro-hubs, the level of cooperation with operators and potential regulations concerning deliveries. Within the D0.3 scenario structure, these elements function mainly as feasibility conditions and interpretation factors for the assessment of urban logistics solutions.

The most important links between D2.2 and D2.3 include the following groups of parameters:

- delivery form and delivery channel - recipients' preferences regarding home delivery, parcel locker delivery or other pick-up options influence the choice of delivery channel and the share of individual service models in parcel delivery scenarios;
- spatial accessibility of pick-up points - acceptable walking distance, the location of parcel lockers and the possibility of collecting a parcel during daily activities influence the attractiveness of parcel locker delivery and user behaviour;
- time preferences and service quality - expectations concerning punctuality, the length of delivery time windows, tolerance of delays and service predictability influence delivery time parameters and operational requirements, especially in ready-made food and boxed meal delivery scenarios;
- conditions of delivery performance by couriers - problems with finding a stopping place, service time, the number of delivery points, failed deliveries and weather-related disruptions influence operational times, stopping parameters and route efficiency;
- constraints of logistics operators - fleet structure, costs, readiness to change vehicles, operational feasibility and the potential use of low- and zero-emission modes influence modal split, vehicle structure, route organisation and the practical feasibility of implementing scenarios;
- perspective of cities and municipalities - availability of street space, delivery regulations, infrastructure location, loading and unloading conditions, and local policy priorities influence the feasibility and interpretation of scenarios under urban conditions;
- recipient-side activity in parcel locker scenarios - the mode of travel to parcel lockers, the possibility of collecting parcels during other trips and the distance to pick-up points influence the system-level energy and emission assessment, because part of the transport activity may be shifted from operators to recipients.

D2.2 is also an important contribution to milestone M2, "Decision on the appropriateness of Sustainable Urban Logistics Policies (SULP) emulate in WP2 and select the most important inhibitors to reach E-Laas objectives". The results of the report make it possible to identify which urban logistics policies are of the greatest practical importance and which barriers may limit the achievement of the project objectives. This applies primarily to the availability of parking and loading spaces, the location and accessibility of parcel lockers, operators' readiness to change their fleets, transformation costs, cooperation between cities and operators, and users' acceptance of alternative delivery models.

The relationship between the reports can be described as a coherent sequence of work forming the analytical core of the project. D0.3 defines the catalogue of scenarios and their role in further analyses. D2.1 defines the methodological assumptions and data needs. D2.2 provides empirical knowledge about the needs, preferences and constraints of stakeholders. D2.3 uses this knowledge to build, parameterise and assess simulation scenarios. Each of these reports has a

distinct function, but their fundamental value becomes apparent when they are considered together.
Thanks to this sequence, it is possible to translate the results of social and operational research into scenario variables used in modelling. This ensures consistency between the identification of user needs, the analysis of delivery operating conditions, the definition of active scenario groups and the energy assessment of the urban logistics system.

2. Introduction

Contemporary urban logistics is becoming one of the key areas of urban development management, as it directly affects residents' quality of life, the functioning of services, transport efficiency and the level of environmental impact. The growth of the e-commerce sector, the development of food and everyday goods delivery services, the increasing importance of parcel lockers and the growing number of vehicles serving last-mile deliveries mean that urban deliveries are competing ever more strongly for limited street space. At the same time, cities are seeking to reduce emissions, decrease congestion, improve safety and make more rational use of transport infrastructure. In this context, urban logistics is no longer solely an operational issue for logistics operators, but is becoming an element of urban policy, spatial planning and energy transition.
The E-Laas project responds to the need to develop solutions that will make it possible to better integrate user needs, operator capabilities, courier working conditions and the objectives of local administration. Its premise is to view urban logistics as a service system in which energy efficiency depends not only on the type of vehicle, but also on the organisation of deliveries, the location of pick-up points, demand structure, infrastructure availability, spatial management methods and recipient behaviour. This means that it is necessary to move away from a one-dimensional assessment of deliveries and towards a systemic approach that takes into account technical as well as social, organisational and spatial parameters.
The analyses conducted show that the needs of urban logistics stakeholders are diverse and not always fully aligned. Recipients expect convenience, flexibility and delivery predictability. Couriers need realistic conditions for the efficient operation of routes, in particular access to stopping places, reduced time losses and better organisation of the delivery process. Logistics operators focus on cost efficiency, fleet reliability, operational stability and limiting the risks associated with the low-emission transition. Cities and municipalities view logistics from the perspective of public space management, safety, emissions, parking and the impact of deliveries on urban traffic. This diversity of perspectives means that effective solutions must be designed as a compromise between the expectations of different groups, rather than as a simple response to the needs of only one of them.
An important element of the project is the link between the results of survey research and qualitative analyses and simulation scenarios. User preferences, operational constraints faced by couriers, barriers identified by operators and the position of local administration should be translated into specific model variables. This applies, among other things, to modal split, demand level, choice of pick-up points, delivery time windows, service time, location of parking spaces, consolidation points and the possibility of using low-emission vehicles. As a result, the scenarios considered can serve not only to assess technological variants, but also to

verify which solutions are operationally feasible, socially acceptable and consistent with the objectives of urban policy.

This study synthesises the most important conclusions resulting from the analyses carried out within the project. Particular attention is paid to the relationship between stakeholder needs and scenario parameters, as this relationship determines the practical usefulness of the results for further stages of modelling and implementation. The aim is not to identify one universal model of urban logistics, but to define the conditions under which different solutions can jointly create a more efficient, energy-saving and acceptable urban delivery system.

3. Purpose and scope of the report

The purpose of this report is to present synthetic knowledge on the needs, preferences and constraints of the key stakeholder groups involved in urban distribution systems. The report focuses on identifying the factors that influence the possibility of implementing energy-efficient and sustainable urban logistics solutions, with particular emphasis on last-mile deliveries. Its task is to organise the results of survey research, expert consultations, secondary data analysis and the review of the current state of knowledge in such a way that they can be used in further project work.

The scope of the report covers four main stakeholder groups: individual recipients, drivers and couriers, logistics operators, and local government units. For each of these groups, different needs, expectations and barriers are analysed. The report serves as a bridge between the research and simulation assumptions and the further modelling and assessment of scenarios planned in the subsequent stages of the project. This means that its objective is not only to describe the research results, but also to indicate which information can be translated into simulation model parameters.

The scope of the report also includes the identification of implementation barriers and potential conflicts between stakeholders. This is important because the energy efficiency of urban logistics depends not only on technology, vehicles and routes, but also on user behaviour, courier working conditions, operators' decisions, and the regulatory and infrastructural capabilities of cities.

4. Stakeholder groups

4.1. The significance of stakeholder identification

A logistics system can be defined as a deliberately organised, structured and interrelated set of elements whose primary function is to ensure the efficient flow of material streams and the related information flows within a given economic system. It includes supply, production, transport and warehousing subsystems, as well as the relationships between different market actors, such as manufacturing companies, carriers, suppliers and recipients. In this sense, a logistics system is a tool for organising and optimising flow processes, influencing both the operational efficiency of individual entities and the effective functioning of the economy as a whole.

In the case of urban logistics, this complexity is particularly visible. Goods flows take place in an environment that is highly constrained in spatial terms, affected by congestion and subject to increasing environmental requirements. At the same time, urban logistics must respond to the dynamically changing needs of residents, businesses, logistics operators, public administration and infrastructure providers. This means that it is not merely a transport problem, but a multidimensional socio-technical system in which the decisions of one group of participants affect the operating conditions of the others.

The identification of logistics system stakeholders makes it possible to determine who uses the system, who influences its functioning, who bears the costs of its organisation and who experiences its effects. This is particularly important in the E-Laas project, whose aim is to develop solutions supporting the energy efficiency of urban logistics. In order for the model being developed to respond to real market needs, it is necessary to identify the expectations, constraints, preferences and potential barriers faced by different user groups.

Stakeholder identification is not limited to describing the participants in the urban logistics market, but also performs an analytical and design function. It makes it possible to recognise the needs, expectations, constraints and potential conflicts between the different user groups of the system. This knowledge is essential in the subsequent stages of the project, as it allows functionalities to be properly designed, scenarios to be defined, survey results to be correctly interpreted and the potential for practical implementation of the proposed solutions to be assessed. Without proper stakeholder identification, there is a risk of developing a model that is technically correct but not adapted to real decision-making processes, operational conditions and user preferences.

It is particularly important that the needs of individual stakeholder groups may differ and sometimes even conflict. Individual customers may expect fast, inexpensive and flexible home deliveries, while cities aim to reduce the number of delivery vehicles, emissions, noise and the occupation of street space. Logistics operators focus on cost efficiency and operational reliability, whereas drivers and couriers directly experience time pressure, parking problems, constraints resulting from traffic organisation and difficulties related to servicing dense urban areas. Infrastructure and technology providers, in turn, are interested in the scalability, interoperability and economic viability of the solutions implemented.

In this sense, identifying stakeholder needs makes it possible not only to recognise their expectations, but also to indicate areas of conflict and search for compromise solutions. Such solutions may include, for example, delivery consolidation, the development of micro-hubs, the use of parcel lockers and pick-up points, planning deliveries outside peak hours, the implementation of low-emission vehicles, the sharing of logistics infrastructure, or better management and use of available data.

Urban logistics stakeholders can be grouped into several main categories:

- users and individual recipients;
- drivers and couriers;
- logistics operators;
- local government units.

Each of these groups has a different role in the system, different needs and a different impact on the possibility of implementing energy-efficient logistics solutions.

4.2. Identified stakeholders

4.2.1. Users and individual recipients

Recipients of logistics services represent the demand side of the urban logistics system. They are residents and consumers who use parcel delivery services, e-commerce deliveries, grocery deliveries, ready-meal deliveries and deliveries of other goods. Their behaviour and preferences directly influence the number, frequency, location and temporal structure of deliveries.

From the perspective of this group, delivery reliability, service cost, delivery time, flexibility of time windows, availability of different pick-up options and the convenience of using solutions such as parcel lockers or pick-up points are of key importance. The acceptance of deliveries carried out by low-emission vehicles, off-peak deliveries, or solutions requiring the recipient to travel to a pick-up point may also become increasingly important.

This group is extremely important from the perspective of organising first-mile/last-mile delivery systems, because recipients' preferences define the limits of acceptability for new delivery models. Even energy-efficient solutions may not be successfully implemented if they are perceived as less convenient, more expensive or less reliable. Therefore, identifying the needs of individual recipients makes it possible to determine which services have the greatest potential for social and market acceptance.

4.2.2. Drivers and couriers

The next stakeholder group relates to the operational level of the urban logistics system. Drivers and couriers carry out the physical flow of goods within the city and directly experience the constraints resulting from traffic organisation, the availability of parking spaces, time pressure, the dispersion of delivery points, customer requirements and infrastructure conditions.

Their perspective is particularly important because it demonstrates the practical feasibility of the proposed solutions. A model of energy-efficient urban logistics cannot be limited solely to route optimisation or emission reduction in theoretical terms. It must take into account the real working conditions of couriers, such as the possibility of parking and unloading, access to restricted traffic zones, the service time of a single delivery, work ergonomics, safety, and the availability of charging or transhipment infrastructure.

Drivers and couriers can provide knowledge about implementation barriers that are not always visible at the level of aggregated data. Their experience can help assess whether the proposed solutions are practical, whether they do not excessively increase operational burdens, and whether they can genuinely contribute to improving the energy efficiency of the entire system.

4.2.3. Logistics operators

Logistics operators include delivery organisers, freight forwarders, carriers and entities managing vehicle fleets. They are among the most important stakeholders in urban logistics systems, as they make decisions regarding the organisation of logistics processes, fleet selection, route planning, shipment consolidation, service standards and investments in technology.

Their basic needs concern maintaining high service reliability, reducing operating costs, optimising the use of vehicles and drivers, shortening delivery times, meeting regulatory

requirements and remaining competitive. From the perspective of energy efficiency, the possibilities of reducing empty mileage, improving route planning, using zero- or low-emission vehicles and integrating with urban logistics infrastructure are also important.
Logistics operators are a group with a very significant influence on operational and strategic decision-making. Information obtained from logistics operators can support the assessment of delivery organisation variants, cost and energy consumption analysis, planning the use of low-emission fleets, selecting the location of transhipment points, and adapting services to customer expectations and city requirements.

4.2.4. Local government units

Local government units represent the public-administration side of the urban logistics system. They include cities, municipalities and city districts responsible for managing street space, traffic organisation, parking policy, loading and unloading areas, infrastructure development and local regulations concerning deliveries.
Their needs are related to reducing the negative impacts of urban logistics on public space, road safety, congestion, emissions and residents' quality of life. At the same time, they are responsible for creating conditions that allow deliveries to be carried out efficiently without excessive occupation of pavements, traffic lanes and parking spaces.
From the perspective of the E-Laas project, this stakeholder group is important because local authorities define many boundary conditions for scenario implementation. They may influence the location of parcel lockers and pick-up points, the designation of delivery spaces, access rules, clean transport zones, delivery time windows, charging infrastructure, micro-hubs and cooperation mechanisms with logistics operators.
Information obtained from local government units supports the interpretation of simulation scenarios and the formulation of sustainable urban logistics policy recommendations. It makes it possible to assess which solutions are feasible within urban governance practice and which require stronger cooperation between municipalities, operators and infrastructure providers.

4.3. Significance for the project

The identification and characterisation of stakeholders provide the basis for further work in the E-Laas project. They make it possible to translate the general objective of improving the energy efficiency of urban logistics into specific user requirements, model functionalities and service scenarios. As a result, it is possible to develop a solution that not only reduces energy consumption and the negative impacts of transport, but also responds to the real needs of recipients, operators, couriers, cities and infrastructure providers. The identified stakeholders of the urban logistics system are presented in Fig. 1.
Stakeholder identification also makes it possible to determine potential implementation barriers. These may relate to costs, user acceptance, regulatory constraints, data availability, lack of infrastructure, conflicting interests of market participants or operational difficulties. Early identification of these barriers increases the chances of designing practical solutions that can be applied in different urban conditions.
The ability to seek compromises between conflicting expectations is also of key importance. Particularly useful in this respect are tools that support dialogue between stakeholders, enable

the analysis of the effects of different delivery organisation variants, and allow them to be assessed in terms of costs, service quality, energy consumption, emissions and impact on urban space.

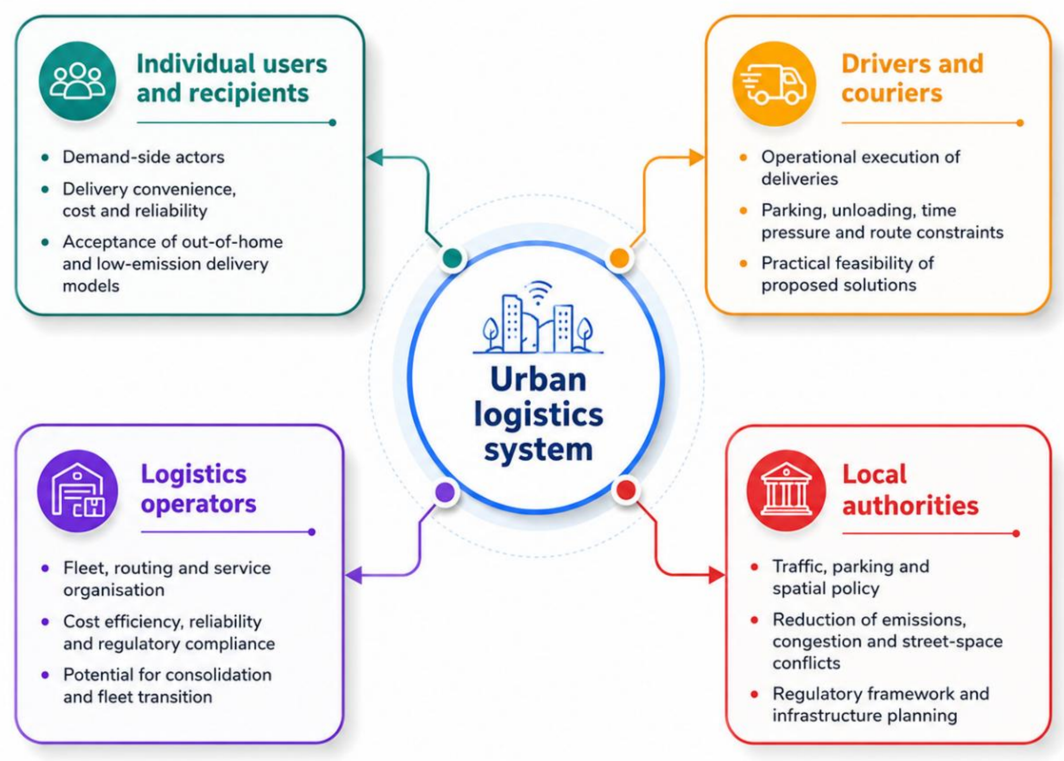

Fig. 1. Stakeholders of the urban logistics system

5. Research material and data sources

The research material analysed within the project was multi-source in nature and included both primary data, collected directly from urban logistics stakeholders, and secondary data, such as project documents, scientific literature, strategic documents and urban policies. This approach resulted from the complexity of the problem under analysis. Urban logistics cannot be described solely through transport parameters, such as distance, travel time or the number of vehicles. In the E-Laas project, energy consumption, emissions, the organisation of the delivery system, user behaviour, infrastructural constraints, urban regulations and acceptance of the implementation of low- and zero-emission solutions were also important.

For this reason, it was assumed that the basis for further analyses should be the combination of several categories of materials: survey research, expert consultations, secondary data analysis and state-of-the-art analysis. This approach is consistent with the logic of work described in D2.1, where it was indicated that three groups of data are crucial for WP2: spatial and transport data, survey data concerning the preferences, behaviours and constraints of system participants, and data and assumptions needed to build simulation models and subsequently assess KPIs.

5.1. Survey research

The main source of data was the survey research conducted among participants in the urban logistics system. Its purpose was to obtain information that cannot be acquired from administrative, spatial or transport data. This applies primarily to recipient preferences, delivery service time, operational problems, infrastructural constraints, acceptance of alternative delivery forms and attitudes towards low-emission solutions. The surveys covered four stakeholder groups: users/recipients of services, suppliers/couriers, representatives of local government units and logistics operators.

The survey questionnaires were prepared in a structure corresponding to the different groups of respondents. In the case of individual users, the questions concerned, among other things, preferred methods of parcel collection, delivery problems, the use of parcel lockers and pick-up points, acceptable walking time to a pick-up point, parcel sending, and the importance of pollutant emissions when choosing a delivery form.

Survey data perform several functions in the project. First, they enable the identification of the needs and preferences of potential users. Second, they make it possible to supplement the description of scenarios with behavioural and operational parameters. Third, they support the interpretation of modelling and simulation results, as they allow technical results to be related to the actual expectations of stakeholders. Fourth, they provide a basis for assessing the social acceptability of potential solutions, such as off-peak deliveries, delivery consolidation points, micro-hubs, parcel lockers or the use of low-emission vehicles.

5.2. Expert consultations and project workshops

The second category of source materials consisted of expert consultations conducted within the project. They included conversations and discussions with subject-matter experts, consortium partners, and representatives of the scientific community, public administration, logistics operators and market practitioners. These consultations complemented the survey research. Their purpose was not to replace empirical data, but to verify research assumptions, clarify interpretative issues and improve the understanding of the implementation context.

Project workshops and expert meetings held in the international project environment were of particular importance, including project events in Poland, Sweden and China. They made it possible to confront the assumptions of E-Laas with different urban, organisational and technological conditions. As a result, urban logistics could be examined not only from the perspective of the Polish reference case, the Górnośląsko-Zagłębiowska Metropolis, but also in a broader European and non-European context.

As indicated in report D2.1, workshops and expert consultations constituted an additional element for verifying assumptions and a source of context for interpreting the results of survey research. Their significance consisted primarily in identifying potential implementation constraints, assessing the usefulness of the scope of data collected through the surveys, and recognising the perspectives of different stakeholder groups involved in last-mile logistics.

Expert consultations were particularly important in relation to issues that are difficult to capture through surveys alone, such as the feasibility of proposed organisational changes, regulatory barriers, infrastructural constraints, operators' readiness to cooperate with cities, the availability of operational data, and the conditions for implementing low-emission solutions. They also made it possible to better understand potential conflicts between the expectations of individual stakeholders, for example between recipient convenience, operators' cost efficiency, couriers' working conditions and cities' environmental objectives.

5.3. Secondary data analysis

Another element of the research material was the analysis of secondary data. It covered spatial, transport, demographic, functional and infrastructural data that can be used to describe the study area, identify demand generators, locate sending and receiving points, and prepare assumptions for modelling. D2.1 indicated that relevant data include, among others, data on the transport network, transport zones, locations of senders and recipients, logistics infrastructure, types of transport modes, demographic and functional data, and sources of potential demand for deliveries.

In the project, data concerning the reference case - the GZM Metropolis - were of particular importance. GZM was adopted as the Polish reference case, enabling the analysis of urban logistics in a complex, polycentric metropolitan area. The data describing GZM include, among others, the spatial structure, transport network layout, transport zones, location of points of interest, distribution of residents, workplaces, service, retail, catering and logistics facilities, as well as potential generators of delivery demand.

The analysis of secondary data was linked to the methodology for describing reference cases and scenarios developed in D0.2. This report defines the structure of attributes needed to describe an urban logistics system, including attributes of the urban area, transport network, transport zones, sending and receiving points, means of transport, demand, operational, energy, emission and cost parameters, user behaviour, and KPI indicators.

Secondary data therefore served both a contextual and modelling function. On the one hand, they made it possible to describe the environment in which urban delivery processes operate. On the other hand, they provided the basis for preparing input data for macro- and microsimulation analyses. In this sense, secondary data were not treated as an independent source of answers to the research questions, but as an element of a broader data structure requiring supplementation with survey and expert information.

5.4. State-of-the-art analysis

Another important source of knowledge was the state-of-the-art analysis carried out within the project, the results of which were discussed in report D0.1. It included a review of scientific literature, research projects, reports and urban policies. Its aim was to position the project within the current state of knowledge on sustainable urban logistics, first-mile and last-mile deliveries, energy management, digitalisation and the social aspects of urban freight transport.

The analysis of literature and research projects made it possible to identify the main trends and research gaps relevant to the project. In particular, it indicated that urban logistics should be analysed as an integrated ecosystem comprising vehicles, infrastructure, logistics facilities, energy systems, users, service providers and public authorities. This is particularly important for distribution systems using low- and zero-emission vehicles, in which route planning, vehicle range, energy consumption, service reliability and infrastructure availability are strongly interconnected.

The review of research projects showed that many previous initiatives concerned micro-hubs, cargo bikes, electric vehicles, parcel systems, intelligent loading zones, urban policy guidelines, digital platforms and decision-support tools. At the same time, limitations related to the availability of detailed source data were identified, which justifies the need to combine public, spatial, transport, expert and dedicated empirical data.

The analysis of urban policies and strategic documents, in turn, made it possible to identify solutions applied or planned in cities, such as consolidation centres, micro-hubs, dedicated loading and unloading spaces, restricted access zones, low-emission vehicles, cargo bikes, charging infrastructure, rules for the location of parcel lockers, and mechanisms for cooperation between cities and logistics operators. This knowledge was important for interpreting stakeholder needs and for assessing which solutions may correspond to the real directions of urban policy development.

5.5. Relevance of an integrated approach to data sources

An integrated approach to data sources was one of the key elements of the methodology adopted in the project. This resulted from the fact that urban logistics is a multidimensional phenomenon, encompassing user behaviour, operational processes carried out by couriers, spatial conditions, infrastructural constraints, urban policy, and environmental and energy objectives. Different data sources considered individually do not make it possible to capture this complexity. Only the combination of multiple sources of information enables the development of synthetic knowledge about the needs of potential users and the conditions for implementing urban logistics services in line with the assumptions of energy efficiency.

Fig. 2 presents the successive stages of work, from data acquisition to the formulation of key results useful for the subsequent stages of the project. The diagram includes data sources, data preparation, data analysis and key results. This structure emphasises that knowledge about stakeholder needs is not the result of a single survey, but the outcome of an organised process in which different types of data are collected, coded, aggregated, analysed and interpreted in relation to specific stakeholder groups.

The first stage covers data sources. As mentioned earlier, the analysed data sources included survey research, the results of the state-of-the-art analysis, the results of expert consultations and secondary data.

The second stage presented in the figure concerns data preparation. It includes the anonymisation of responses, data quality control, variable coding, response aggregation and the assignment of responses to the relevant stakeholder groups. This stage was essential for the reliability of further analyses. Response anonymisation ensured the security of respondents' data and made it possible to conduct analyses without identifying individual persons or institutions. Data quality control made it possible to verify the completeness and consistency of responses, which is particularly important in the case of large survey datasets and open-ended questions.

Variable coding made it possible to transform diverse responses into structured analytical material. The project included categorical, ordinal, binary, numerical and textual variables. Coding open-ended responses was of particular importance, especially in the case of municipalities and logistics operators, where respondents often described problems, barriers or possible solutions in their own words. Thanks to coding, it was possible to group similar responses into thematic categories, such as parking problems, blocking of pavements, lack of charging infrastructure, need for financial support, lack of cooperation with operators or lack of implemented measures. Response aggregation then made it possible to compare results between groups and create synthetic measures, such as the number of indications, percentage share, average rating or response structure. The final element of this stage was the assignment of responses to stakeholder groups, which enabled segmentation and comparative analyses.

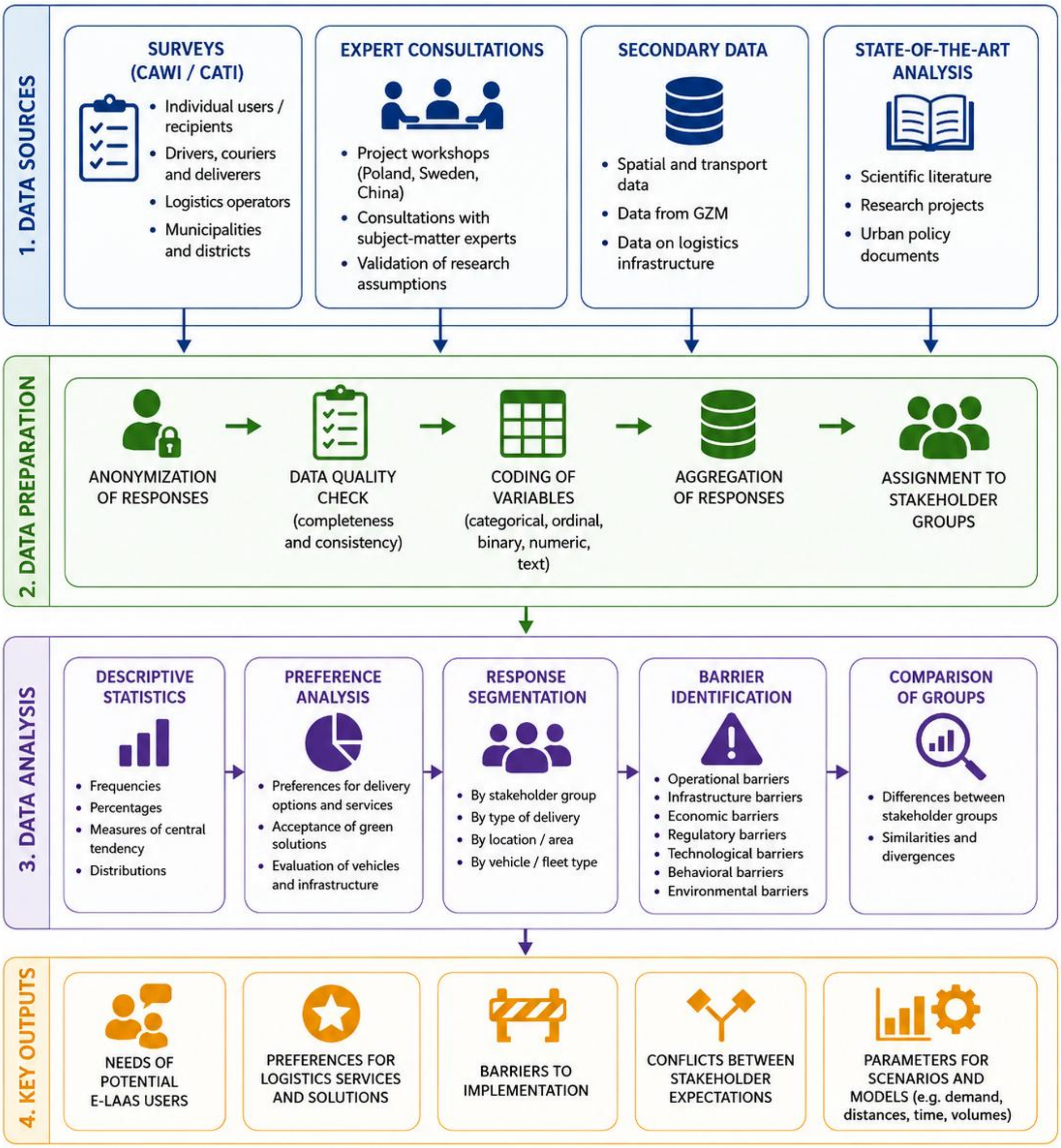

Fig. 2. Workflow for synthesising knowledge on the needs of potential E-Laas users

The third stage covers data analysis. The figure indicates five main types of analysis: descriptive statistics, preference analysis, response segmentation, barrier identification and group comparison. Descriptive statistics provided the basis for the quantitative description of the collected data. It included counts, percentage shares, measures of central tendency and response distributions. This made it possible to determine the basic characteristics of the analysed groups, such as the number of respondents by delivery type, the structure of transport modes used, the share of drive types, the frequency of operational problems or the assessment of the impact of urban infrastructure.

Preference analysis made it possible to identify which solutions are accepted or expected by different stakeholder groups. In the case of individual users, this concerned, among other things, preferred forms of delivery, parcel lockers, courier deliveries and the importance of time flexibility. In the case of couriers, it covered the assessment of working conditions, preferences regarding parking infrastructure, working time, route workload and the way deliveries are handled. In the case of logistics operators, preference analysis concerned, among other things, potential readiness to change the fleet, the assessment of urban infrastructure, and the importance of parking spaces, chargers, micro-hubs and consolidation centres.

Response segmentation enabled the analysis of results by stakeholder group, delivery type, location, area of operation, vehicle type or fleet type. This is particularly important because the needs of the urban logistics system are not homogeneous. Users collecting parcels from parcel lockers have different requirements, couriers delivering food have different ones, operators handling B2B deliveries have different ones, and local authorities responsible for the organisation of space and traffic have still different ones. Segmentation therefore made it possible to avoid excessive generalisation of results and to indicate which needs are common and which are specific to a given group.

Barrier identification was one of the most important elements of the analysis from the perspective of implementing the project results. These barriers varied in nature: operational, infrastructural, economic, regulatory, technological, behavioural and environmental. Examples of operational barriers include couriers' problems with finding a stopping place, the time-consuming nature of deliveries, recipient absence or time pressure. Infrastructural barriers include a shortage of parking spaces, the lack of chargers or the mismatch between urban space and delivery service needs. Economic barriers relate to the costs of fleet replacement, the costs of operating electric vehicles or the need for financial support. Regulatory barriers are connected with access to restricted traffic zones, clean transport zones or delivery rules during specific hours. Technological barriers concern, among other things, the range of electric vehicles, the availability of suitable vehicles or data integration. Behavioural barriers relate to user habits, willingness to use new forms of delivery and acceptance of change. Environmental barriers include the impact of weather, temperature, seasonality and atmospheric conditions on delivery productivity.

The final element of data analysis was group comparison. It made it possible to identify both differences and similarities between stakeholders. Such a comparison is particularly important because the urban logistics system must be designed as a multilateral solution. Users expect convenience, flexibility and reliability. Couriers need efficient work organisation, available stopping places and reduced time losses. Logistics operators focus on costs, fleet efficiency, regulations and infrastructure. Cities and municipalities view urban logistics through the lens of public space, safety, emissions, congestion and residents' quality of life. Comparing these perspectives makes it possible to identify areas of alignment, as well as potential conflicts of interest.

The fourth stage presented in the figure covers the key results of the analytical process. The first of these is the identification of the needs of potential users. This includes the needs of service recipients, drivers and couriers, logistics operators and local government units. The second result is the identification of preferences regarding services and logistics solutions, including preferences concerning delivery forms, infrastructure, vehicles, route organisation and possible changes in the service model. The third result is the identification of implementation barriers, without which the design of new services could remain too theoretical and detached from practical constraints. The fourth result is the indication of conflicts between stakeholder expectations, for example between recipient convenience and courier route efficiency, between operators' needs and urban space constraints, or between a city's climate objectives and the costs of fleet transformation. The fifth result is the acquisition of parameters for scenarios and models, such as demand, distances, time, number of deliveries, volumes, fleet structure and operational constraints.

The significance of the integrated approach therefore lies in its ability to move from dispersed data to synthetic, multidimensional knowledge. Consequently, the adopted methodology makes it possible to combine scientific, empirical, operational and policy perspectives, which allows for the development of solutions that are not merely theoretical constructs, but correspond to the real operating conditions of urban logistics. This applies both to technical and spatial conditions, as well as to user needs, operator constraints, courier experience and the possibilities for intervention by local authorities.

The integrated approach also strengthens the usefulness of the results for the subsequent stages of the project. The collected and structured research material provides a basis for analysing user needs and preferences, parameterising scenarios, building simulation models, assessing energy and environmental KPI indicators, and preparing recommendations for sustainable and energy-efficient urban logistics. In practice, this means that the results of the analyses can be used not only to describe the current state of the system, but also to design variants of future solutions, test their effects and assess their feasibility.

6. Methodology

The survey research methodology was developed in such a way as to enable the identification of the needs, preferences, constraints and barriers affecting the main stakeholder groups in urban logistics. The starting point was the assumption that the energy efficiency of urban logistics cannot be assessed solely on the basis of technical or transport parameters. It is also necessary to identify user behaviour, the practices of logistics operators, the experiences of couriers and drivers, and the perspective of local government units.

The adopted methodology is consistent with the logic of the project, in which the results of empirical research are intended to support the subsequent stages of work: the analysis of user preferences, scenario parameterisation, the development of simulation models, the assessment of KPI indicators, and the preparation of recommendations for sustainable and energy-efficient urban logistics. The justification for this approach also results from the state-of-the-art analysis, which showed that contemporary urban logistics should be analysed as an integrated system comprising vehicles, infrastructure, logistics facilities, energy systems, users, operators and public authorities.

6.1. Method of data collection

Primary data were collected through surveys addressed to different stakeholders of the urban logistics system. The questionnaires were prepared separately for the main categories of respondents, so that the scope of questions corresponded to their role in the urban delivery system. The following research groups were distinguished:

- drivers, couriers and suppliers carrying out different types of urban deliveries;
- representatives of cities and municipalities;
- users and recipients of delivery services;
- logistics operators.

In addition, seven delivery categories were identified, including, among others:

- ready-made food deliveries;
- boxed meal deliveries;
- grocery deliveries;
- parcel deliveries to parcel lockers and pick-up points;
- parcel deliveries to individual customers;
- B2B deliveries;
- deliveries of medicines and pharmaceuticals.

The study was quantitative in nature, but it also included qualitative elements. The vast majority of questions were closed-ended, single-choice or multiple-choice questions, ordinal questions, and value-range questions. Open-ended questions were used as a supplement, especially in the surveys addressed to local government units and logistics operators. This made it possible to obtain both quantitative data and descriptive information on problems, barriers, expected solutions and implementation experience.

The scope of the surveys was adapted to the specificity of each group. For drivers, couriers and suppliers, the questions covered, among other things, the characteristics of the delivery process, the type of goods transported, the area of operation, transport modes used, drive type, vehicle ownership model, a typical working day, number of kilometres travelled, number of delivery addresses, loading and unloading times, time spent searching for a stopping place, and the assessment of operational barriers. The questions addressed to individual users concerned, among other things, the preferred method of parcel collection, delivery problems, use of parcel lockers and pick-up points, acceptable walking time to a parcel locker, frequency of collecting and sending parcels, and the importance of pollutant emissions when choosing a delivery service.

In the case of cities, diagnostic and expert questions were used. They concerned problems observed in urban space, such as blocking pavements, parking in unauthorised places, excessive street load, reduced safety or traffic obstruction. The questions also covered possible measures to improve urban logistics, including dedicated parking spaces, chargers for electric vehicles, transhipment centres, electric bicycles, subsidies or tax reliefs for environmentally friendly operators, delivery time windows, night deliveries, and entry restrictions or bans.

In the case of logistics operators, the questionnaire covered, among other things, the area of operation, the structure of goods handled, fleet structure, vehicle ownership model, the share of vehicles by drive type, the possibility of using environmentally friendly vehicles, barriers to the implementation of electric vehicles, the impact of urban infrastructure on the delivery process, readiness to use micro-hubs and consolidation centres, and the potential impact of clean transport zones on operational activity.

6.2. Character of the sample

The research sample was purposive and stratified in nature. This means that respondents were assigned to predefined research groups corresponding to the main types of stakeholders and types of urban logistics processes. The objective was not to obtain a single, homogeneous sample representative of the entire urban logistics market, but to collect diverse empirical material enabling the comparison of perspectives of different system participants.
This approach is justified by the nature of the project. Urban logistics comprises many different processes, and individual stakeholder groups possess different types of knowledge. Individual recipients provide information on preferences and acceptance of solutions; drivers and couriers have knowledge of operational conditions and delivery-related problems; operators provide knowledge on process organisation and implementation barriers; while local government units provide knowledge on spatial, regulatory and infrastructural constraints.
The survey was designed to use CATI and CAWI methods. As a result of the survey research, a total of 2,427 responses were collected. Details are presented in Table 1.
The variation in the size of individual groups should be taken into account when interpreting the results. For groups with a large number of responses, it is possible to make broader use of descriptive statistics and comparisons between respondent categories. For smaller groups, such as B2B deliveries or grocery deliveries, the results should be treated with caution, primarily as exploratory and supplementary material. In such cases, the identification of characteristic problems and barriers is more important than the formulation of statistical generalisations.

Table 1. Number of completed surveys

Surveyed group	Number of completed surveys
On-demand ready-made food delivery to individual recipients	240
Boxed meal delivery to individual recipients	80
Grocery delivery to individual customers	30
Parcel deliveries to parcel lockers and pick-up points	240
Parcel deliveries to individual customers	240
B2B goods deliveries	10
Urban delivery of medicines and pharmaceuticals	242
Survey for municipalities/districts	244
Survey for users	863
Survey for logistics operators	238
Total	**2427**

6.3. Anonymisation of survey data

The survey data were processed in a way that enabled aggregate analysis without identifying individual respondents. The questionnaires did not provide for the collection of the names and surnames of natural persons, and the essential part of the data described the characteristics of the delivery process, preferences, behaviours, type of activity, area of operation or location in general terms.

The results database included location variables, such as town/city, municipality or postal code. These data are needed for spatial analyses and for assigning responses to area types; however, in the reports they are presented only in aggregated form. This means that the results are presented at the level of respondent groups, area types, delivery categories or value ranges, and not in a way that would allow a specific person, enterprise or place of business activity to be identified.

Anonymisation primarily included the removal or omission of data enabling direct identification of the respondent, aggregation of responses to the level of research groups, coding of textual responses into analytical categories, limiting the presentation of individual observations, and cautious use of open-ended responses.

From the perspective of the report, it is important that anonymisation does not eliminate the analytical value of the data. It preserves the possibility of comparing stakeholder groups, analysing preferences, identifying barriers and determining typical problems of urban logistics, while at the same time reducing the risk of disclosing individual-level information.

6.4. Coding of variables

The survey variables were structured in a way that enabled both quantitative and qualitative analysis. The results database included different types of variables: nominal, ordinal, binary, numerical, interval and textual. The coding method was adapted to the nature of the question and the subsequent method of analysis.

Nominal variables included, among others, the respondent group, type of goods, type of area of operation, preferred parcel collection method, drive type, vehicle ownership model, type of applications used, vehicle charging location or preferred vehicle ownership model. These variables were analysed using frequency distributions and percentage shares.

Multiple-choice variables were coded as sets of binary variables. This applied, among others, to areas of operation, transport modes used, types of drive, types of infrastructure, delivery-related problems, possible measures taken by municipalities and barriers to the implementation of electric vehicles. In such cases, each partial response was represented as a separate variable taking the value of 1 if a given category was indicated and 0 if it was not indicated.

Ordinal variables included responses expressed on frequency, intensity or assessment scales. Examples include scales such as “always - very often - often - rarely - very rarely”, acceptance scales, difficulty scales, scales assessing the impact of infrastructure on the delivery process, and ratings on a 0-10 or 1-10 scale. Variables of this type enable the analysis of medians, modes, shares of positive and negative responses, and comparisons of assessments between stakeholder groups.

Interval variables were used where providing an exact value could have been difficult for respondents or could have reduced the quality of responses. This applied, among others, to the number of kilometres travelled per day, number of working hours, loading time, waiting time, travel time, unloading time, time spent searching for a parking space, vehicle service time and distance to a parcel locker. Interval responses were analysed by category frequencies and, where necessary, could be converted into interval midpoints for the purposes of comparative analyses or modelling.

Numerical variables included, among others, the number of delivery addresses, number of parcels, number of parcels sent per month, share of parcels by size, share of vehicles by drive type, percentage of accepted orders or the declared impact of seasonality on the number of orders. Descriptive statistics were used to analyse such variables, including the mean, median, quartiles, minimum, maximum and identification of outliers.

Textual responses, especially in open-ended questions, required qualitative coding. Coding consisted of assigning statements to thematic categories, such as parking problems, lack of charging infrastructure, cost constraints, insufficient number of loading and unloading spaces, difficulties with access to the city centre, time pressure, weather conditions, lack of acceptance of the costs of ecological deliveries, regulatory constraints, problems with the location of parcel lockers or insufficient cooperation between operators and administration.

6.5. Data preparation and quality control

Before the actual analysis began, the data required structuring and quality control. This process included checking the completeness of records, identifying missing data, standardising category names, verifying binary variables, checking percentage variables and organising textual responses.

In the first stage, the structure of the database was checked: the number of records, the number of variables, column names and the distribution of responses by respondent group. Next, variables specific to particular types of questionnaires were identified. Since different groups of respondents answered different sets of questions, some missing data were structural rather than random. This means that a missing response in a given column does not always indicate that the respondent skipped a question, but may result from the fact that the question was not intended for that respondent's group.

In the next stage, response categories recorded in a non-uniform way were standardised. This applied in particular to text fields and variables in which respondents could add their own answers. For example, responses differing only in spelling, capitalisation or linguistic form should be reduced to a common analytical category. In the case of numerical variables, the range of values was checked, atypical observations were identified and the consistency of percentage responses was verified.

Data quality control was particularly important due to the complex structure of the questionnaire and the different respondent groups. Its objective was not to mechanically remove all incomplete records, but to retain as many responses as possible while ensuring the correctness of analyses for individual questions. Therefore, the sample size could differ between analyses of individual variables.

6.6. Method of analysis

The analysis of survey results was designed as a multi-stage process. It included descriptive statistics, preference analysis, response segmentation and barrier identification. This structure of analysis made it possible to combine the quantitative and qualitative dimensions and to relate the results to the needs of the project.

The first stage of the analysis consisted of descriptive statistics. For nominal and binary variables, response counts and percentage shares were calculated. This made it possible to determine the structure of respondents, the types of transport modes used, the types of goods transported, the most frequently indicated problems, the dominant forms of parcel collection and the frequency with which specific barriers were indicated. For numerical and ordinal variables, measures of central tendency and dispersion were analysed, in particular the mean, median, mode, quartiles and response distributions across intervals.

The second stage was preference analysis. With regard to individual users, it covered preferred methods of parcel collection, willingness to use parcel lockers and pick-up points, acceptable walking time or distance to a parcel locker, the way parcels are collected, and the importance of environmental aspects. With regard to drivers and couriers, the analysis covered willingness to change vehicles, assessment of the usefulness of electric vehicles, acceptance of working outside peak hours, parking problems and the impact of weather conditions. With regard to operators, the analysis covered readiness to change the fleet, barriers to electromobility, assessment of the impact of urban infrastructure and the difficulty of implementing micro-hubs, consolidation centres or shared services.

The third stage was response segmentation. Segmentation consisted of analysing the results across dimensions corresponding to the main stakeholder groups, delivery types, types of urban areas, means of transport and selected respondent characteristics. In the case of individual users, responses could be segmented, among others, by place of residence, age, mobility patterns and the types of deliveries they use. In the case of couriers and suppliers, segmentation could include delivery type, area of operation, vehicle type, drive type, length of the working day or frequency of parking problems. In the case of operators, it was possible to compare responses according to fleet structure, type of goods handled and area of operation.

The fourth stage was barrier identification. Barriers were analysed on the basis of both closed-ended and open-ended responses. Several main categories of barriers were distinguished: operational, infrastructural, economic, technological, regulatory, behavioural and environmental. Operational barriers included, among others, delivery time, time pressure, parking problems, loading and unloading time, and the absence of the recipient at the address. Infrastructural barriers concerned the availability of parking spaces, chargers, transhipment points, parcel lockers and micro-hubs. Economic barriers included the costs of the fleet, energy, labour and implementation of new solutions. Technological barriers concerned limitations of electric vehicles, range, charging and reliability. Regulatory barriers referred to clean transport zones, entry restrictions, delivery time windows and rules for using urban space. Behavioural barriers concerned user habits, preferences for door-to-door deliveries, limited willingness to bear higher costs and acceptance of alternative delivery forms.

7. Results

7.1. User needs

Thanks to the results of the survey research, it was possible to identify the needs of recipients of services provided within the urban logistics system, with particular emphasis on customers using courier deliveries, parcel lockers, pick-up points and selected direct delivery services, such as food deliveries, grocery deliveries and boxed meal deliveries. The analysis concerned the group of individual users, among whom 863 responses were collected. The scope of the survey for recipients included both socio-demographic data and questions describing transport behaviour and logistics preferences. Respondents indicated, among other things, their place of residence, age, means of transport used, types of deliveries they use, preferred parcel collection method, delivery-related problems, average number of parcels collected per week, structure of parcel sizes, walking time to a parcel locker, method of collecting parcels from a parcel locker or pick-up point, and the importance of low-emission vehicles.

It is particularly important that the survey results made it possible not only to describe current user preferences, but also to indicate requirements for future urban logistics solutions. This applies primarily to the spatial accessibility of pick-up points, time flexibility of deliveries, service reliability, integration of deliveries with residents' daily mobility, and the potential acceptance of low-emission solutions.

The first area of analysis concerned the preferred form of parcel collection. The results indicate the dominance of courier deliveries carried out directly to the place of residence. As shown in Fig. 3, 62,1% of respondents indicated courier delivery as their preferred parcel collection method. The second most frequently selected form was a parcel locker, indicated by 36,7% of respondents. Other pick-up points were of marginal importance, with only 1,2% of respondents indicating them as their preferred method.

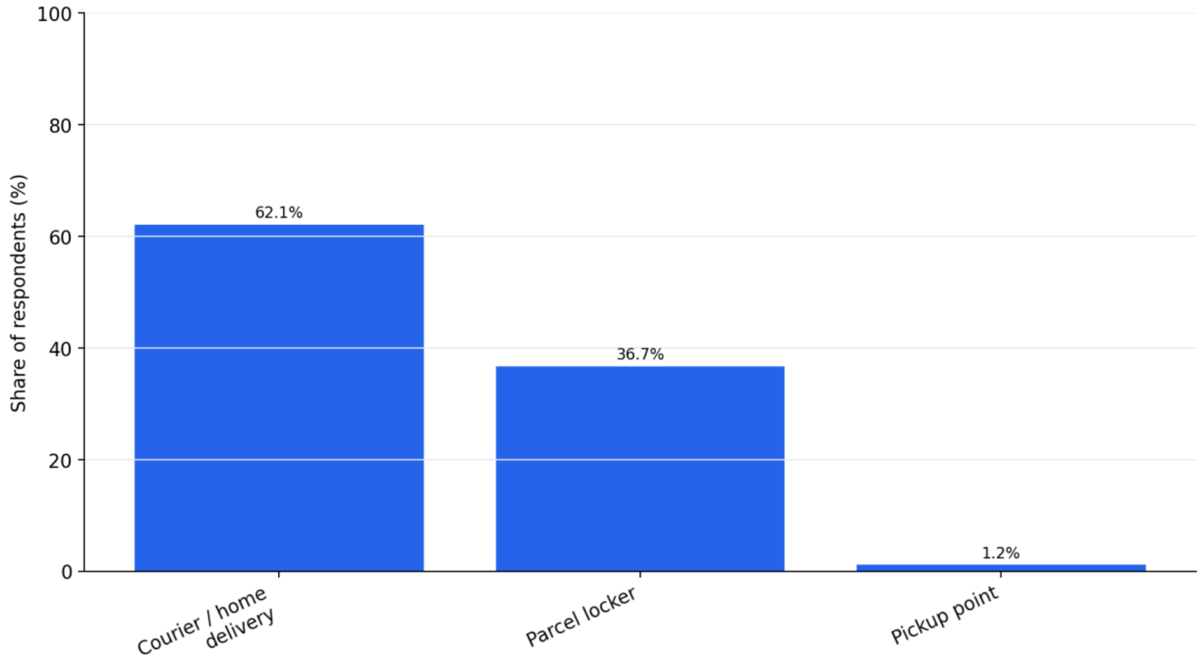

Fig. 3. Preferred parcel delivery method

These results show that, despite the very high popularity of parcel lockers in Poland, home delivery remains the basic and most comfortable form of parcel collection for most users. This can be interpreted as the effect of the high convenience of direct delivery, where the user does not have to undertake any additional activity to collect the parcel. At the same time, the share of parcel lockers at nearly 37% is very high and confirms that out-of-home solutions have become a fully established element of the urban distribution system, rather than merely a supplement to traditional courier delivery. From the perspective of service design, this means that both channels should be treated as complementary. Home courier delivery responds to the need for convenience and minimisation of customer effort, while parcel lockers and pick-up points respond to the need for time flexibility, independence from being at home, and the possibility of collecting a parcel during other activities.

In addition, the analysis of the preferred delivery method by place of residence shows that the choice between courier delivery and parcel locker delivery is not spatially homogeneous. As can be inferred from Fig. 4, the highest share of preferences for couriers occurs among residents of housing estates located close to the city centre, at 66,5%. A high share of courier delivery is also visible in suburban areas, at 62,8%, and in housing estates on the outskirts of cities, at 57,7%. In city centres, courier deliveries are preferred by 53,8% of respondents.

A somewhat different profile is visible among rural residents. In this group, 42,9% of respondents prefer courier delivery, while 53,6% prefer parcel lockers. However, this result should be interpreted with caution, as the group of rural residents in the sample was small and consisted of 28 people. Nevertheless, the result is interesting because it may indicate that where courier delivery is less predictable or less convenient from an organisational perspective, a parcel locker may be perceived as a more stable pick-up point.

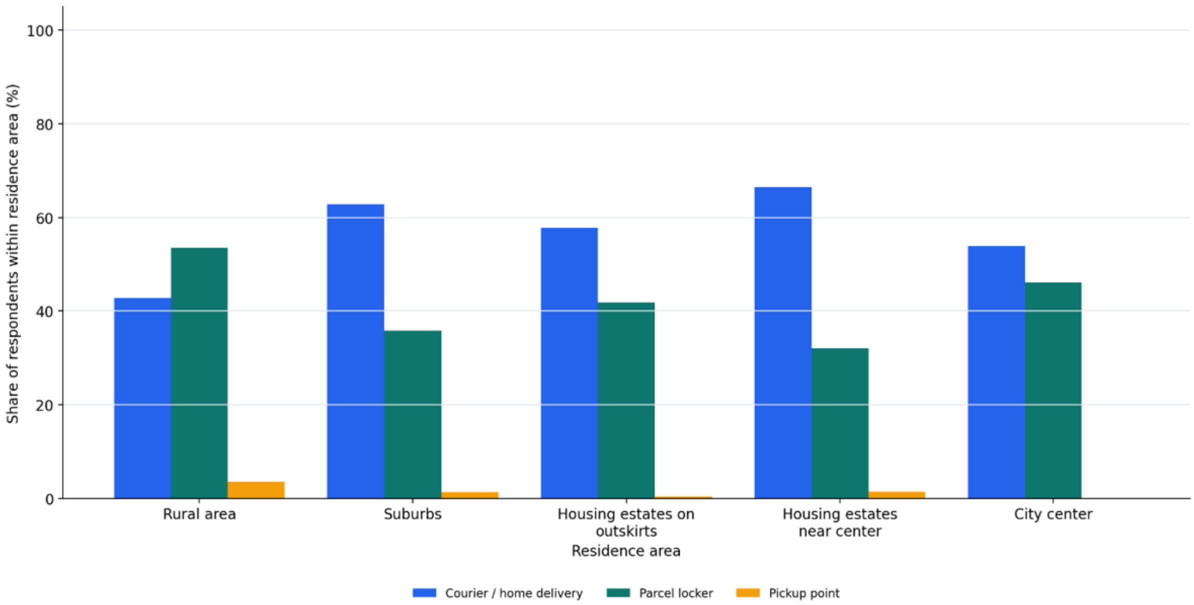

Fig. 4. Preferred parcel delivery method by type of customer residence area

From a spatial perspective, a parcel locker is therefore particularly attractive where it fits into residents' daily routes or where it reduces the uncertainty associated with waiting for a courier. In cities and housing estates close to the centre, the high availability of courier services and the greater density of operator service may be more important, which supports the dominant role of home delivery.

As can be seen in Fig. 5, respondents' age clearly differentiates preferences regarding the parcel collection method. In the youngest group, i.e. among people under 18 years of age, 63,6% of respondents prefer a parcel locker and 36,4% prefer a courier. In the 18-25 age group, the share of preferences for parcel lockers is 51,1%, while for couriers it is 46,6%. This means that in the two youngest groups, the parcel locker is at least an equivalent, and in practice often the dominant, form of collection.

In subsequent age groups, a gradual increase in the importance of courier delivery is visible. In the 26-35 age group, 58,9% of respondents prefer a courier; in the 36-50 age group, 64,8%; and in the 51+ age group, as many as 68,6%. At the same time, the share of preferences for parcel lockers decreases accordingly.

This structure of results indicates the generational nature of logistics preferences. Younger users more often accept the out-of-home collection model because it is consistent with their flexible daily rhythm and greater readiness to manage parcel collection independently. Older groups more often prefer courier delivery, which may be associated with the greater importance of convenience, attachment to the traditional door-to-door service model and a lower willingness to make an additional trip to collect a parcel.

Therefore, the design of last-mile services should take age segmentation into account. Solutions based on parcel lockers, pick-up points and mobile applications may be particularly effective among younger groups, while for older users it remains crucial to maintain high-quality home delivery, especially in terms of delivery time information, the possibility of contacting the courier and delivery reliability.

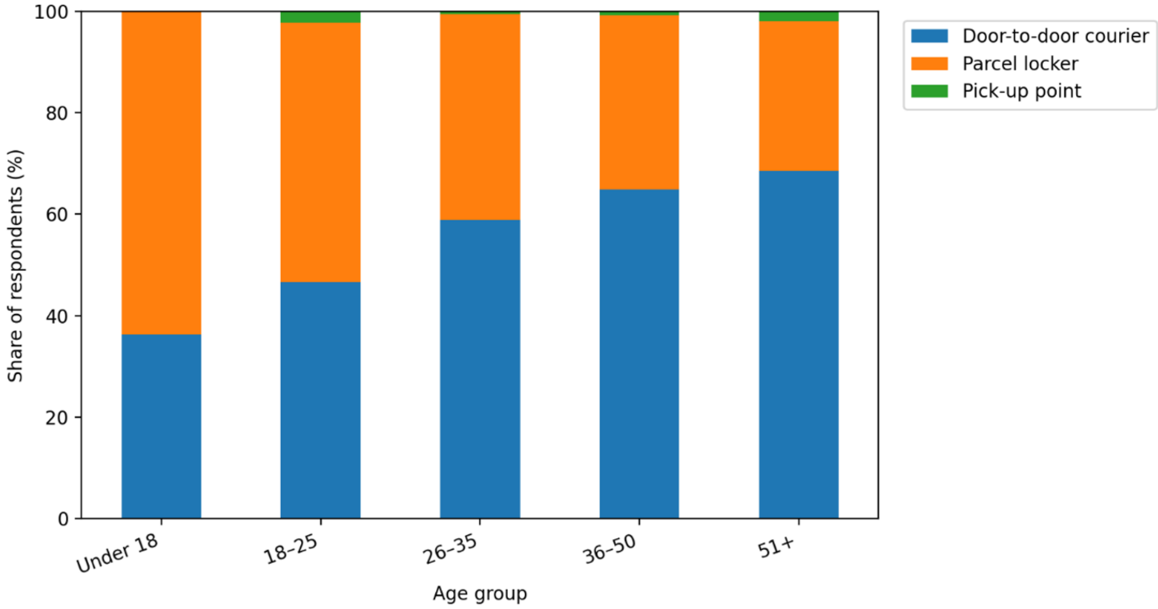

Fig. 5. Preferred parcel delivery method by age of respondents

As can be inferred from Fig. 6, the average number of parcels collected in the analysed group is approximately 1.4 parcels per week, with a median of 1 parcel per week. The largest share of respondents, i.e. 63,4%, declare collecting an average of one parcel per week. Another 24,0% collect an average of two parcels per week. The share of people collecting three or more parcels per week is significantly lower.

For most individual users, parcel collection is a regular but not highly intensive activity. It is not an everyday behaviour, but it is frequent enough for last-mile delivery infrastructure to become an important element of residents' daily functioning. Collecting one or two parcels per week means that the user has repeated contact with the logistics system, and the quality of this interaction may influence the overall assessment of urban services, logistics operators and the convenience of living in a given location.

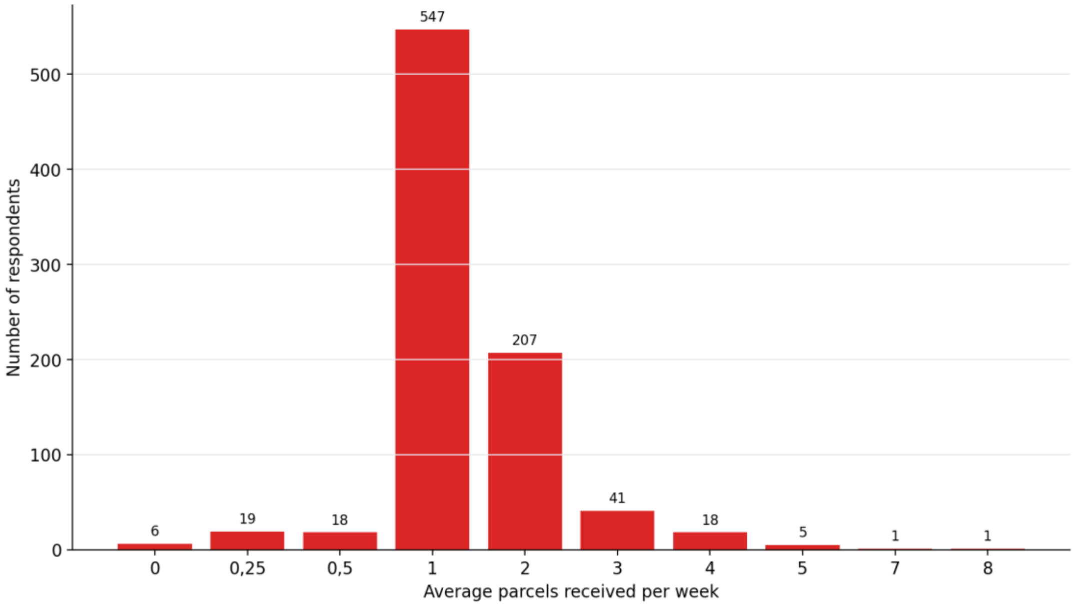

Fig. 6. Number of respondents by average weekly parcel received

The average number of collected parcels varies depending on place of residence, as shown in Fig. 7, although the differences are not very large. The highest average was recorded among residents of housing estates close to the city centre, at 1,51 parcels per week. In city centres, the average was 1.36; in housing estates on the outskirts, 1,33; in rural areas, 1,28; and in suburban areas, 1,24 parcels per week.

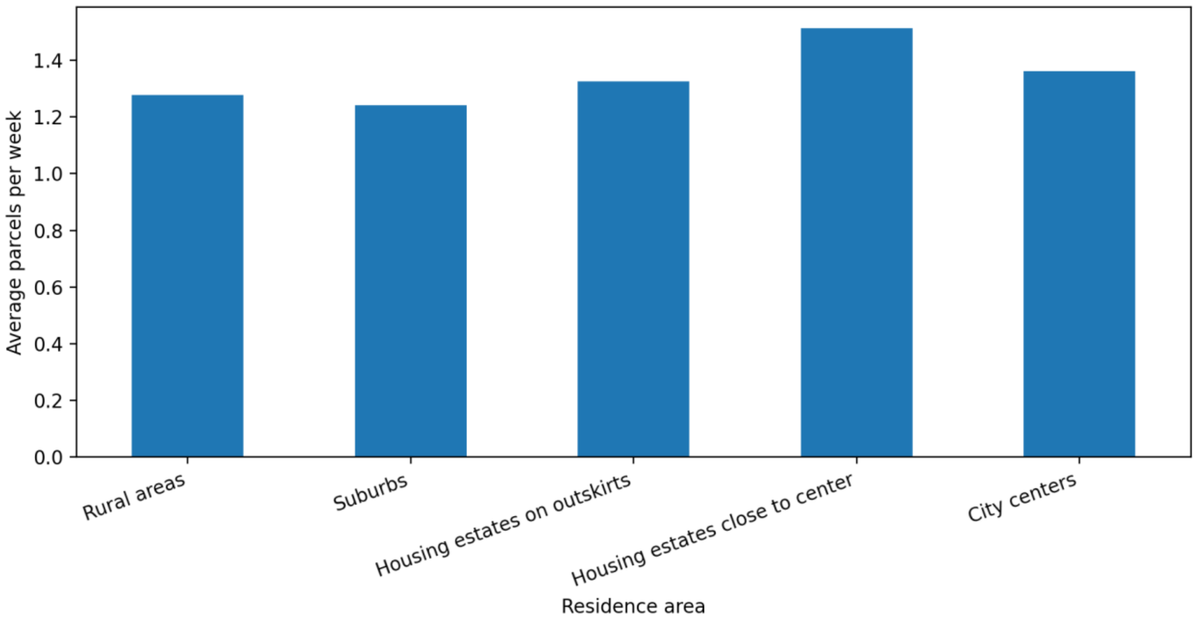

Fig. 7. Average number of parcels collected per week by residence area

The highest level of parcel collection in housing estates close to the centre can be interpreted as the effect of a combination of several factors: higher population density, more intensive use of e-commerce, good availability of courier and parcel locker services, and residents' daily mobility. These are areas where delivery systems should be particularly efficient because they generate relatively high and regular demand for parcel services.

Lower values in rural and suburban areas do not mean a lack of logistics needs, but indicate a different model of using services. In such locations, the availability of pick-up points, the possibility of combining parcel collection with commuting or shopping, and delivery reliability in more dispersed settlement patterns may be more important.

The structure of parcel sizes collected, presented in Fig. 8, indicates the dominance of small and medium-sized parcels. The largest average share is held by M-size parcels, at 57,6%. The second category is S-size parcels, with an average share of 32,0%. L-size parcels account for an average of 8,7%, while the share of XL-size parcels is 2,2%. Larger and palletised shipments are of marginal importance in the individual user segment.

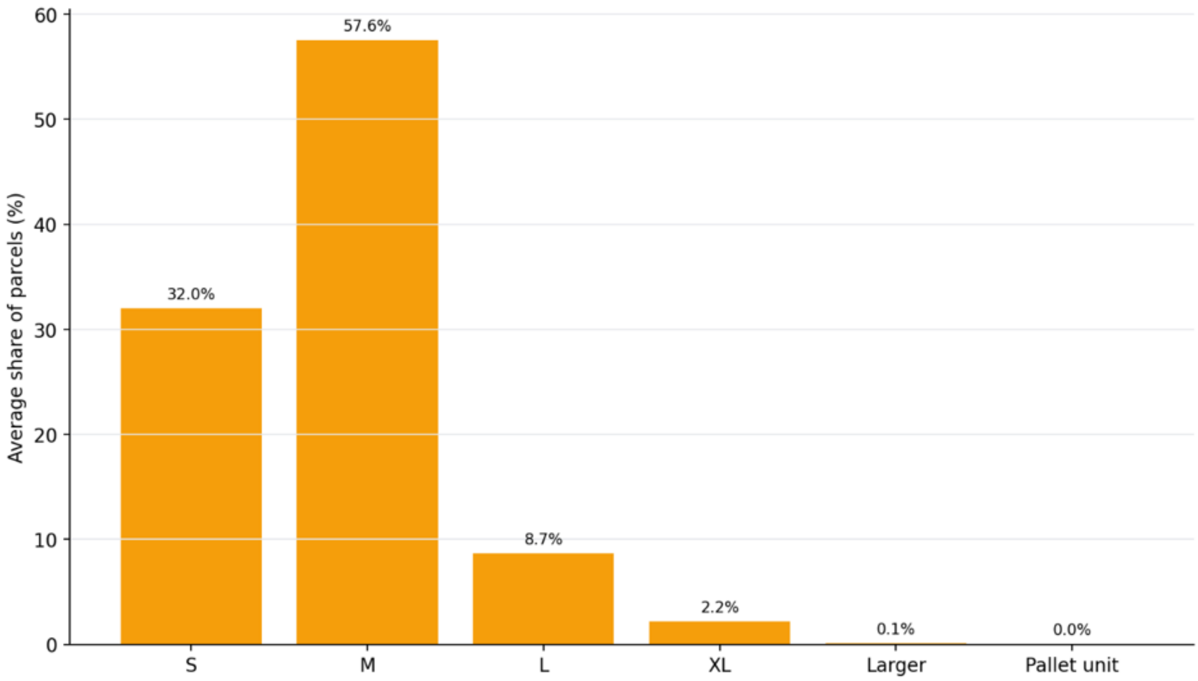

Fig. 8. Size structure of collected parcels

This result is highly important for the design of the logistics system. Since the vast majority of shipments are S or M format, last-mile infrastructure, including parcel lockers, distribution vehicles, micro-hubs and consolidation points, can be optimised primarily for handling small e-commerce parcels. At the same time, the low frequency of large shipments indicates that home courier delivery may retain particular importance for non-standard parcels, for which collection from a parcel locker would be inconvenient or impossible.

In practice, this leads to the conclusion that delivery channels should be differentiated. Small and medium-sized parcels can be efficiently handled by the network of parcel lockers and pick-up points, while larger parcels should remain the domain of courier deliveries, possibly with a precisely agreed delivery time window.

The results of the survey research show that collecting a parcel from a parcel locker or pick-up point is most often integrated with daily mobility, as shown in Fig. 9. A total of 46,9% of respondents declare that they collect a parcel on their way to or from work. Another 36,8% do so during other activities, such as shopping, walking, running errands or other daily trips. Only 16,2% of respondents declare that parcel collection requires a dedicated trip.

These results indicate that a parcel locker or pick-up point is most attractive when it does not generate a separate trip. If collection can be "embedded" into the user's existing route, the time and organisational cost of collection is low. In this model, the parcel locker becomes an element of everyday urban infrastructure, similarly to a shop, public transport stop or service point.

On the other hand, the need to make a dedicated trip to collect a parcel is a potential barrier to using a parcel locker. It may reduce the attractiveness of this delivery form, especially among older people, people with limited mobility, residents of areas with dispersed development, or users for whom the parcel locker is located outside their daily routes.

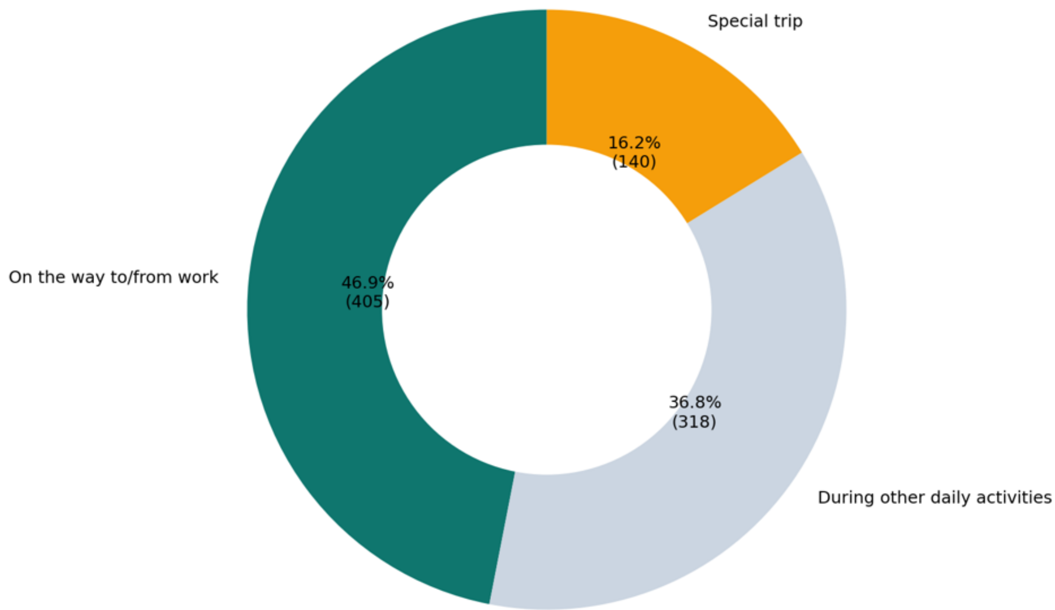

Fig. 9. Parcel locker pickup collection context

As shown in Fig. 10, place of residence clearly affects the way parcel collection is organised. In rural areas, 57,1% of respondents declare collecting parcels on the way to or from work, and in suburban areas this share is 54%. In housing estates on the outskirts, the value is 49,5%; in housing estates close to the centre, 43,4%; and in city centres, 38,5%. At the same time, in city centres and housing estates close to the centre, parcel collection during other activities is more common. In city centres, this method of collection is declared by 46,2% of respondents, and in housing estates close to the centre by 43,9%. In rural areas, this share is much lower and amounts to 17,9%.

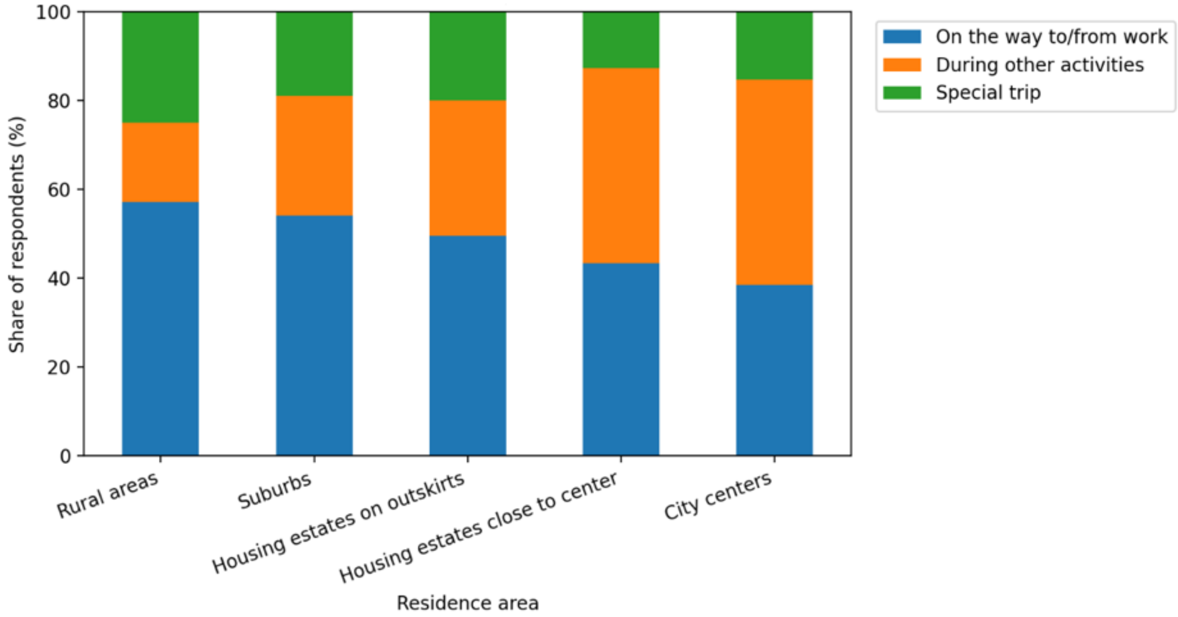

Fig. 10. Parcel locker pickup collection context by residence area

This means that the function of parcel lockers differs spatially. In rural and suburban areas, the parcel locker is often an element of the commuting route - the user collects the parcel while travelling to work, school, a shop or another important location. In central areas, the parcel locker is more often part of a dense network of urban activities and may be used more spontaneously, during many different activities.

Thus, the location of parcel lockers should be linked to the actual mobility patterns of residents. In city centres and housing estates close to the centre, pedestrian proximity and integration with local services are important. In suburban and rural areas, nodes of daily travel are more important: car parks, shops, stops, stations, schools, local centres and points located along main commuting routes.

As shown in Fig. 11, the most commonly used type of delivery is courier delivery to individual customers. It is used by 98,4% of respondents. Deliveries to parcel lockers and pick-up points rank second and are used by 83,9% of respondents. This means that the vast majority of users have experience with both parcel service channels.

Ready-made food deliveries are used by 40% of respondents. Grocery deliveries were indicated by 10,2%, and boxed meal deliveries by 5,1%. These results show that the core of the urban delivery market in the analysed group consists of courier and parcel deliveries, while food, grocery and boxed meal deliveries are supplementary in nature. However, this does not mean that they are insignificant. These segments require special organisation because they are more often sensitive to time, freshness, temperature, punctuality and short delivery windows.

The urban logistics system should therefore be designed in a multi-layered way. Standard e-commerce parcels require efficient, scalable handling and good accessibility of pick-up points. Food and boxed meal deliveries, in contrast, require greater punctuality and operational resilience over short time horizons.

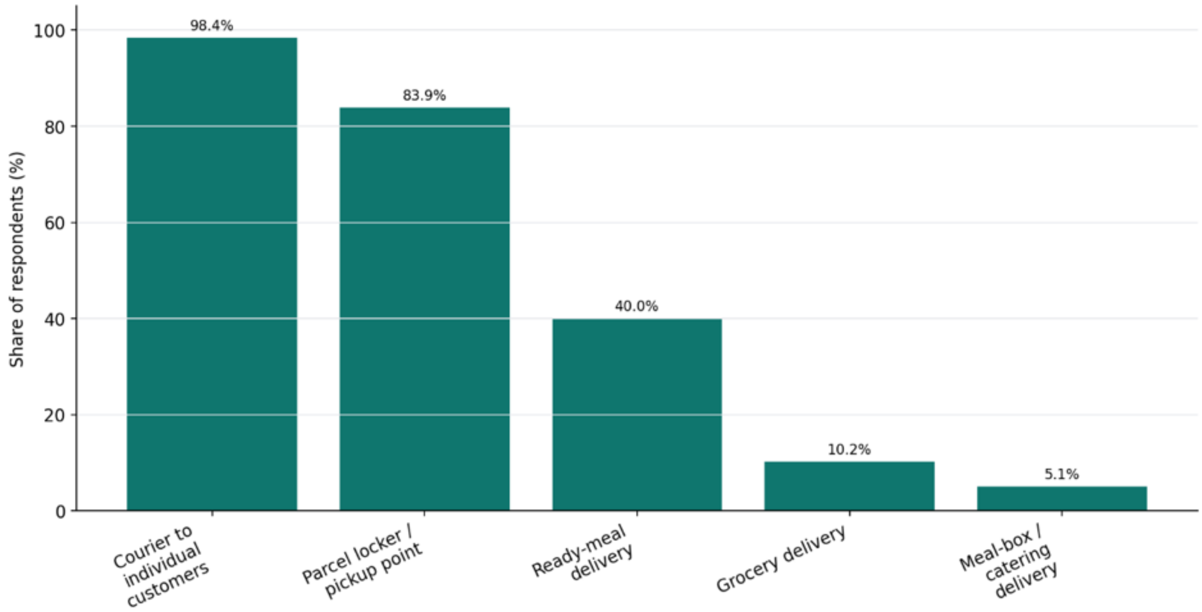

Fig. 11. Delivery types used by respondents

The analysis of the types of logistics services used by age, presented in Fig. 12, shows that the use of courier deliveries and parcel lockers is high in all groups. Courier deliveries to individual customers exceed 94% in every age group and reach 99,7% in the 36-50 age group. Deliveries to parcel lockers and pick-up points are also widespread, ranging from 81,2% in the 26-35 age group to 90,9% in the under-18 age group.

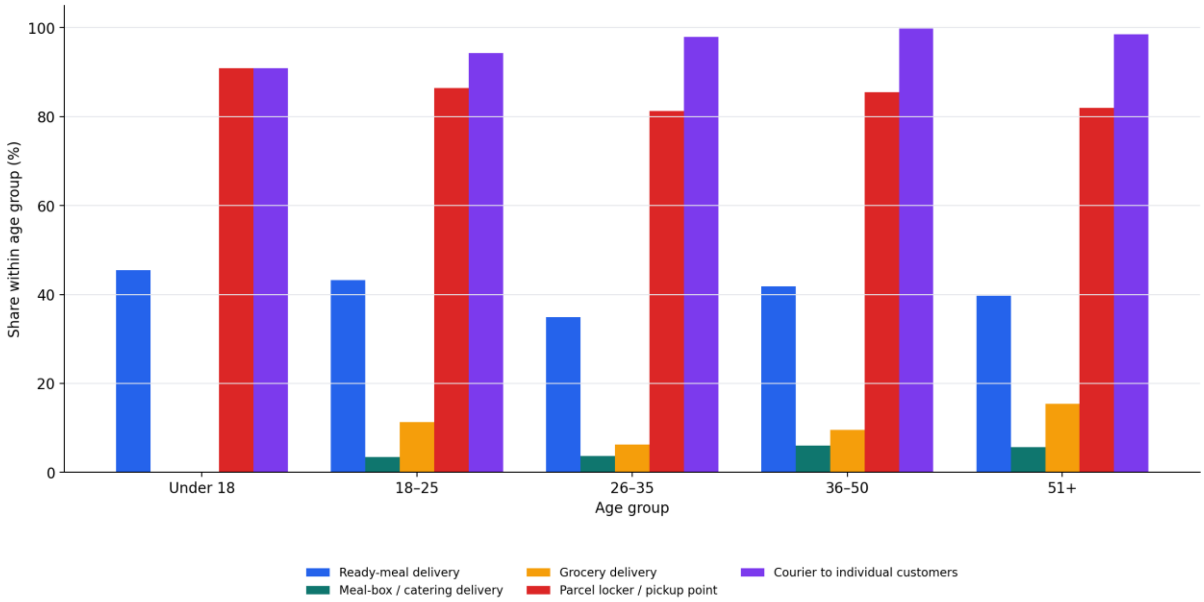

Fig. 12. Delivery type used by age of respondents

Greater differences are visible in the case of ready-made food deliveries, grocery deliveries and boxed meal deliveries. Ready-made food deliveries are used by 45,5% of people under 18, 43,2% of people aged 18-25, 34,9% in the 26-35 group, 41,8% in the 36-50 group and 39,7% in the 51+ group. The differences do not form a simple linear trend, but they show that this service has relatively broad use across different age groups.

Grocery deliveries are most often indicated by people aged 51 and over, at 15,5%, and by people aged 18-25, at 11,4%. This may mean that the motivations for using this service differ: in the older group they may result from convenience and the reduced need to physically transport groceries, while in the younger group they may result from familiarity with digital services and online shopping.

In addition, it is worth noting that place of residence particularly strongly differentiates the use of food deliveries and boxed meal deliveries, as shown in Fig. 13. Ready-made food deliveries are most often used in city centres, at 53,8%, and in suburban areas, at 48%, while the lowest share was recorded in rural areas, at 14,3%. This result is consistent with the nature of this market segment: food deliveries require sufficient demand density, restaurant availability, short travel times and cost-effective route organisation.

Boxed meal deliveries also occur most often in city centres, at 19,2%. In other locations, this share is much lower: 6,1% in suburban areas, 4,6% in housing estates close to the centre, 3,6% in rural areas and 2,3% in housing estates on the outskirts. Due to the small number of boxed meal users in the sample, this result should be treated as a directional signal rather than a basis for very detailed generalisations.

Parcel locker and courier deliveries, on the other hand, are widespread in all types of locations. Deliveries to parcel lockers and pick-up points are indicated by 92,9% of rural residents, 85,5% of residents of housing estates on the outskirts, 83,4% of residents of housing estates close to the centre, 82,7% of city centre residents and 81,8% of suburban residents. Courier deliveries also remain almost universal in every spatial group.

It can be noted that parcel services are universal in nature, whereas food-related services are much more dependent on spatial structure, building density and the availability of local supply.

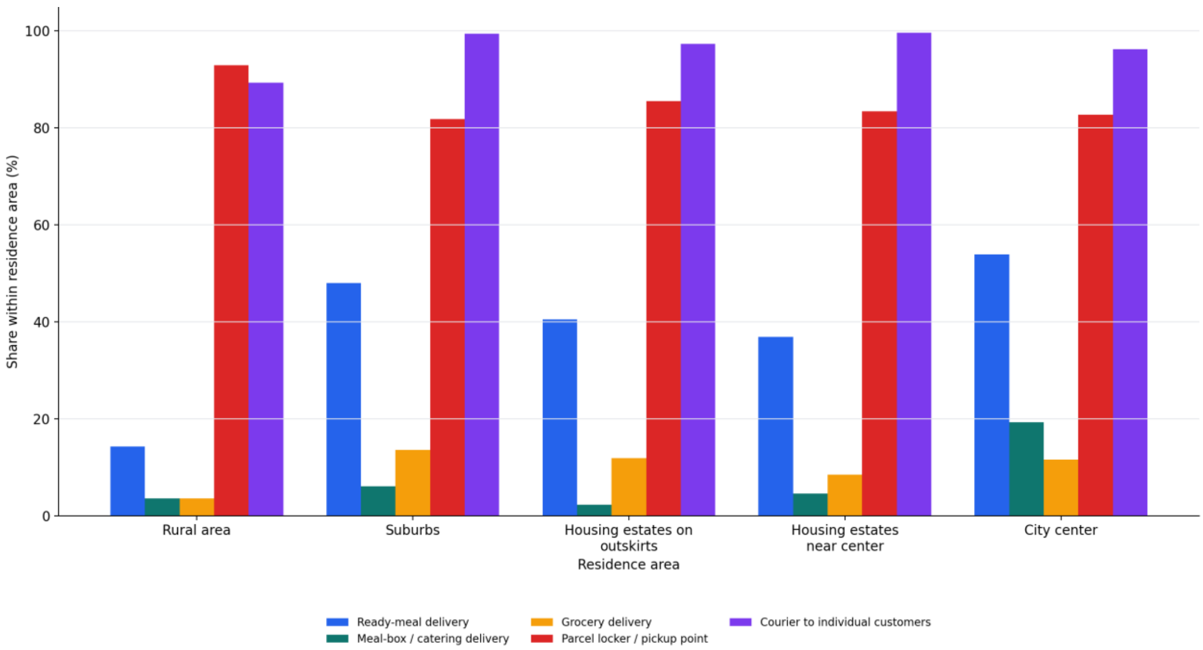

Fig. 13. Delivery type used by residence area

As follows from the analysis of Fig. 14, the availability of parcel lockers is one of the most important factors influencing the usefulness of out-of-home deliveries. In the analysed sample, 8,2% of respondents declare that they can reach the nearest parcel locker within up to 2 minutes, 18,3% within 2-5 minutes, and 44,4% within 5-10 minutes. In total, this means that 70,9% of respondents have a parcel locker within a maximum walking time of 10 minutes. For 29,1%, the walking time exceeds 10 minutes.

This result is positive from the perspective of the overall accessibility of parcel locker infrastructure, but at the same time it indicates a significant group of users for whom a parcel locker may be less convenient. The 10-minute threshold is of practical importance: if walking to a parcel locker exceeds this threshold, parcel collection increasingly ceases to be a natural, short walking activity and may require an additional trip or the use of a car.

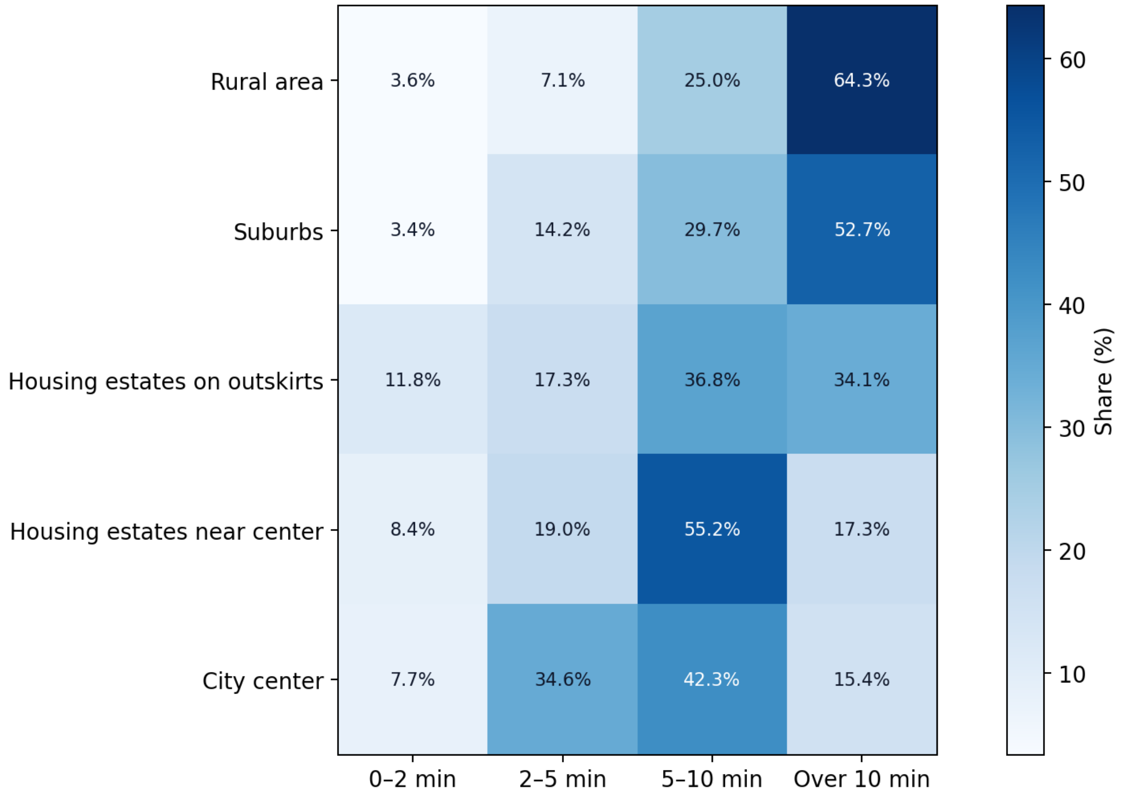

Fig. 14. Real walking time to nearest parcel locker by residence area

The greatest differences in parcel locker accessibility become visible when place of residence is taken into account, as shown in Fig. 15. In rural areas, as many as 64,3% of respondents declare a walking time to the nearest parcel locker of more than 10 minutes. In suburban areas, this share is 52,7%. By comparison, in housing estates close to the centre, a time of more than 10 minutes is indicated by 17,3%, and in city centres by 15,4% of respondents.

This means that the current accessibility of parcel lockers is clearly better in urban and more densely urbanised areas. In rural and suburban areas, a parcel locker more often requires a longer walk and, in practice, may more often be reached by car or used while running other errands. This result confirms the need to differentiate location standards depending on the type of area.

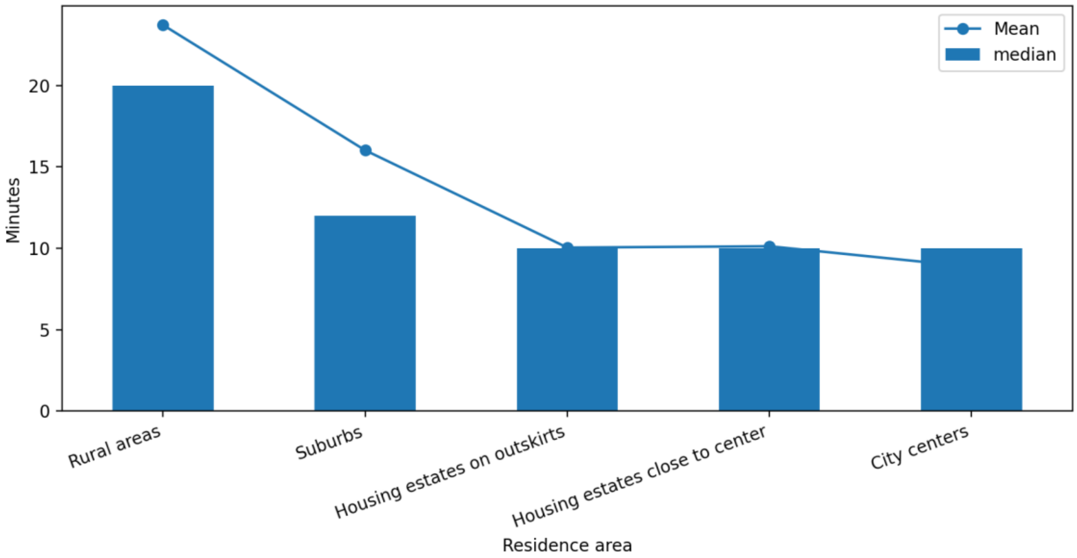

Fig. 15. Maximum acceptable walking time to nearest parcel locker by residence area

In city centres and housing estates close to the centre, very good pedestrian accessibility is justified. In suburban and rural areas, the objective should not be an even densification of the network across the entire area, but rather the placement of pick-up points in local activity centres, near shops, transport interchanges, car parks, schools, stations and daily commuting routes.

Next, the preferred delivery method was analysed depending on the actual walking time to a parcel locker, as shown in Fig. 16. Among people who have a parcel locker within 0-2 minutes, 63,4% prefer a parcel locker and 36,6% prefer a courier. In the group with a walking time of 2-5 minutes, 51,9% prefer a parcel locker and 46,2% prefer a courier. After the 5-minute threshold is exceeded, preferences begin to shift towards courier delivery. With a walking time of 5-10 minutes, 67,1% prefer a courier and 31,9% prefer a parcel locker. In the group with a walking time of more than 10 minutes, 71,7% prefer a courier, while 27,1% prefer a parcel locker.

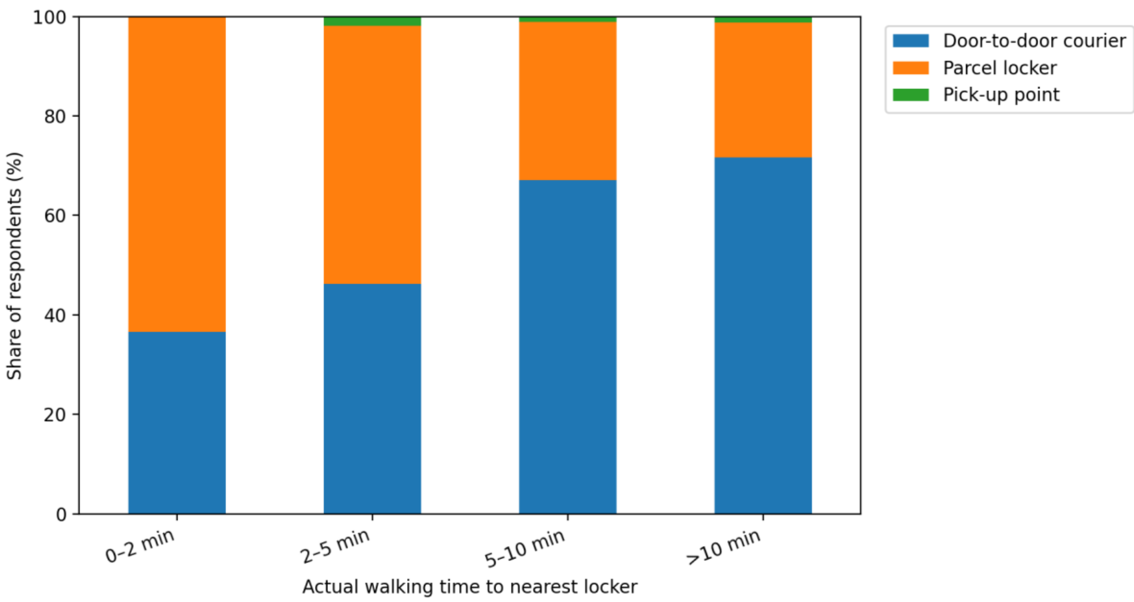

Fig. 16. Preferred delivery method by real walking time to nearest parcel locker

It can be noted that spatial accessibility is one of the key conditions for the attractiveness of parcel lockers. A parcel locker effectively competes with home delivery mainly when it is located very close to the user or on the user's daily route. When it requires a longer walk, its advantage of time flexibility may not be sufficient to compensate for the additional effort.

Therefore, location decisions regarding pick-up points should be made on the basis of data on users' actual routes, building density, pedestrian accessibility and links with public transport. The mere presence of a parcel locker in a given district does not guarantee its attractiveness if it is not located in an appropriate spatial relationship to residents.

In the survey, respondents assessed the frequency of using their own car, public transport and bicycle on a scale from 1 to 10. The results indicate that people who prefer parcel lockers have a slightly lower average intensity of car use than those who prefer couriers, as shown in Fig. 17. The average for users preferring courier delivery is 8,11, while for those preferring parcel lockers it is 7,77. The difference is not very large, but directionally it indicates that parcel lockers are not exclusively a solution for car users.

People who prefer parcel lockers also have a slightly higher average intensity of bicycle use - 5,01 compared with 4,55 for those preferring couriers. In the case of public transport, the differences are small, but the analysis indicates that the preference for parcel lockers is statistically associated with more frequent use of public transport and walking, although the strength of this effect is small.

The interpretation of these results leads to the conclusion that parcel lockers should be treated as an element of everyday mobility infrastructure. Their location should take into account not only walking distance from the place of residence, but also pedestrian and bicycle flows and public transport accessibility. The greatest potential lies in locations where a parcel locker is a natural stopping point during daily mobility.

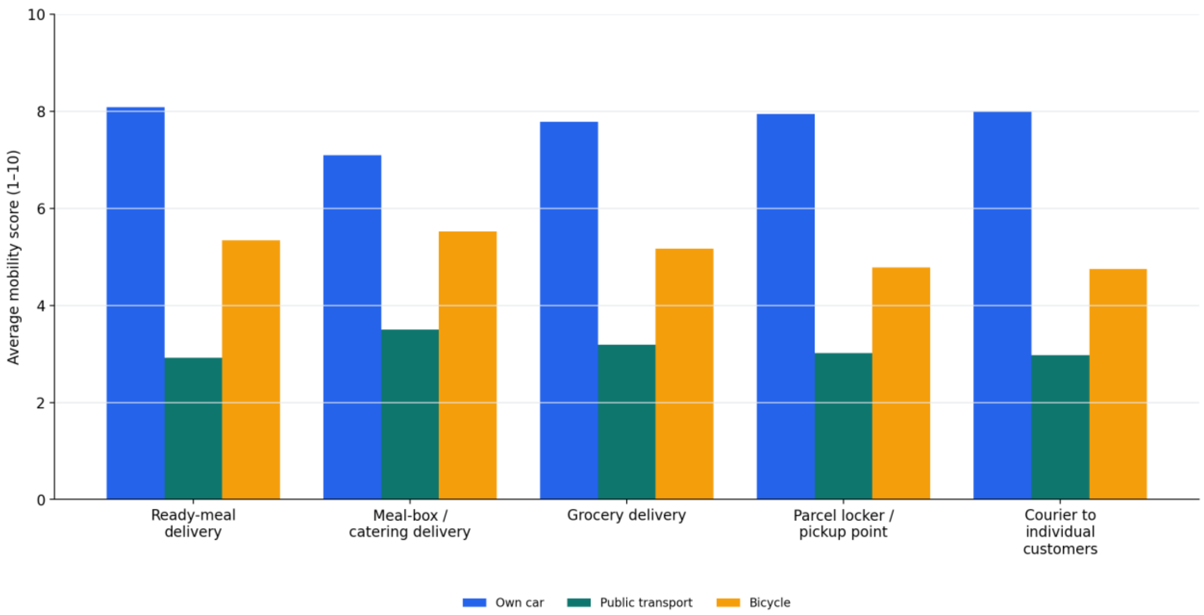

Fig. 17. Mobility intensity by delivery type used

Next, the most common problems experienced by customers in relation to delivery services were analysed, as shown in Fig. 18. The most important problem indicated by respondents is the lack of a precise delivery time window. This problem was indicated by 87,4% of respondents. Much less frequently indicated were: lack of delivery on the selected day, at 9,5%, and loss or damage of parcels, at 3,1%. Such a clear dominance of the delivery time window problem indicates that the main quality gap in courier deliveries is not the very possibility of delivering the parcel, but the lack of predictability of delivery time. For the customer, this means the need to wait at home, difficulty in planning the day, the risk of a failed delivery attempt and the need to later redirect the parcel.

This result explains the popularity of parcel lockers very well. A parcel locker is not always more convenient spatially, as it requires walking, but it gives the user control over the time of collection. In this way, it solves the key problem of courier delivery: time uncertainty.

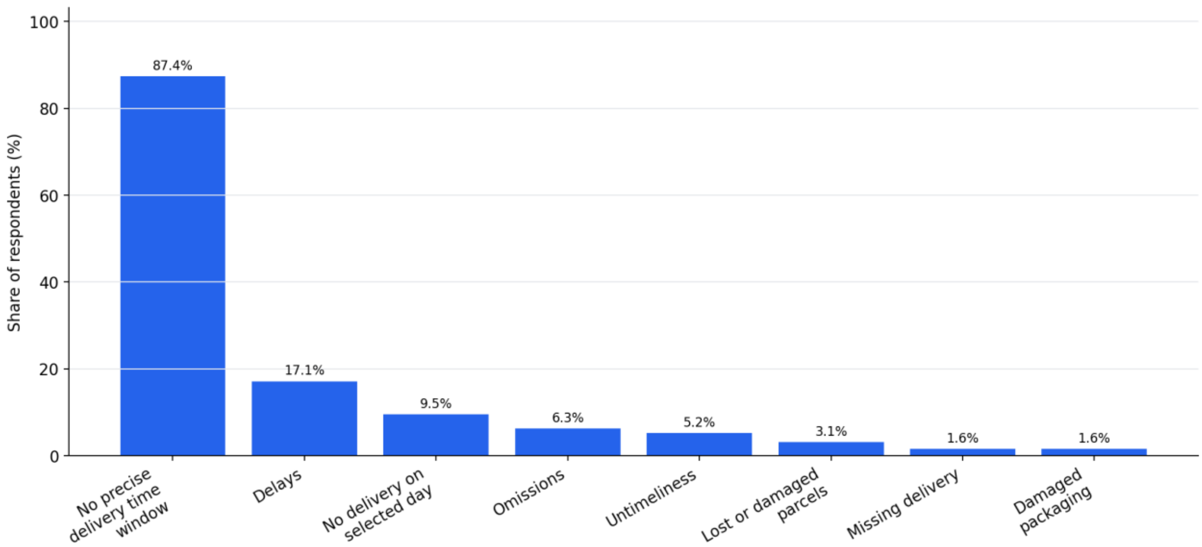

Fig. 18. Delivery problems reported by respondents

It is worth noting that the survey results show that the nature of problems differs depending on the type of delivery, as shown in Fig. 19. In the case of food deliveries, the most important problem is delays. Among users of ready-made food deliveries, delays were indicated by 20,3%. Lack of punctuality was indicated by 7,3%, missed deliveries by 3,8%, non-delivery by 1,7%, and damaged packaging by 1,2%.

In the case of boxed meal deliveries, the structure of problems is more specific. Among boxed meal users, delays were indicated by 18,2%, non-delivery by 9,1%, and damaged packaging by 11,4%. The data also show a high share of indications concerning missed deliveries. Due to the small number of boxed meal users, 44 people, these values should be interpreted with caution, but directionally they show that this segment is more operationally sensitive.

Food and boxed meal deliveries are services that are particularly time-sensitive. A delay in an e-commerce parcel delivery may be an inconvenience, but a delay in meal delivery may directly reduce the usefulness of the service. In the case of boxed meals, this is additionally compounded by the cyclical nature of deliveries, the expectation of morning delivery and the importance of product freshness.

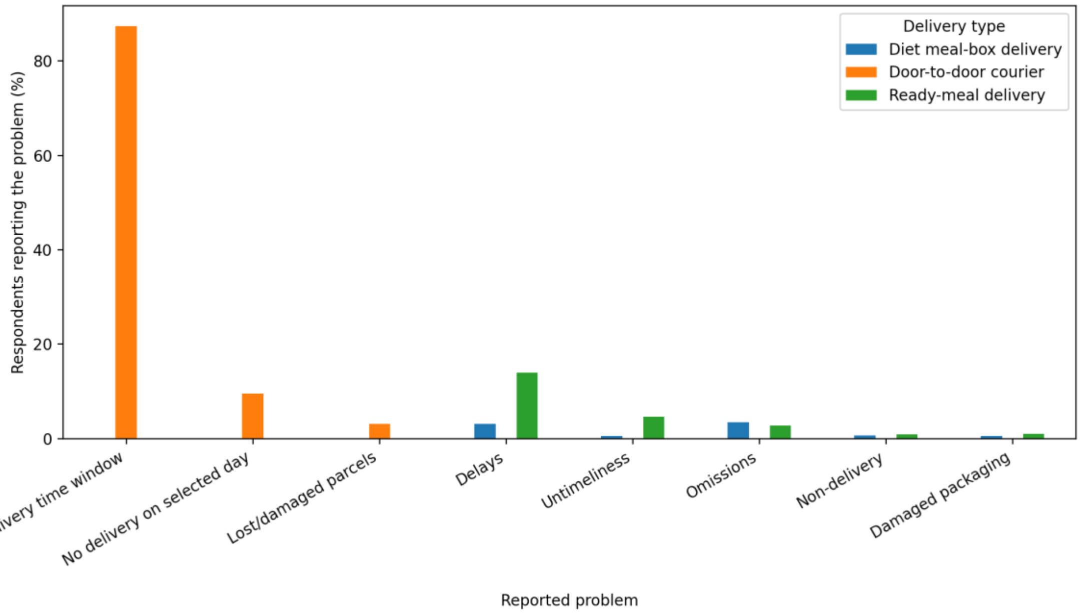

Fig. 19. Delivery problems by delivery type

As part of the survey research, respondents were also asked about the level of acceptance of deliveries carried out by low-emission vehicles, as shown in Fig. 20. When asked about the importance of pollution emissions related to parcel delivery and the choice of companies offering deliveries using environmentally friendly vehicles, 4,6% of respondents answered “yes”, while 95,4% answered “no”. This result suggests that, in the analysed group, the environmental criterion currently has little importance as a declared factor in the choice of delivery operator.

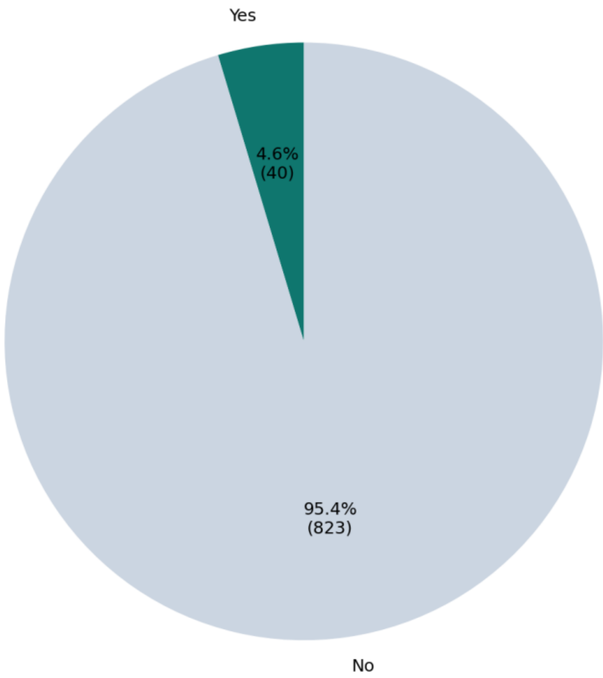

Fig. 20. Importance of low-emission vehicles for parcel recipients

This does not mean, however, that the environmental aspect is irrelevant to the design of the urban logistics system. At least two interpretations are possible. First, users may support low-emission solutions at a general level, but not treat them as the main criterion for individual selection of a courier company. Second, in practice, consumers often prioritise price, convenience, punctuality and availability first, and only later environmental criteria. Low-emission performance should therefore be treated rather as a systemic feature and an element of urban policy than as the main purchasing incentive for the user. The user may not choose an operator because of low-emission vehicles, but may use such a system if it does not worsen convenience, price, accessibility and reliability.

In summary, the survey results make it possible to distinguish several main needs of users of urban logistics services. First, collection convenience is crucial. Users still most often prefer home courier delivery, which shows the importance of minimising customer effort. At the same time, the very high share of parcel locker use indicates that convenience does not always mean door-to-door delivery. For many users, the possibility of independently choosing the collection time is more convenient.

Time flexibility is very important. The dominant problem of courier delivery is the lack of a precise delivery time window. This means that users expect greater predictability and control over delivery. This applies especially to home deliveries, where the lack of information about the delivery time generates the greatest inconvenience. It can also be noted that the spatial accessibility of pick-up points is important. A parcel locker is attractive primarily when it is located close to the place of residence or on the user's daily route. As walking time to the parcel locker increases, the tendency to choose this delivery form decreases.

The integration of deliveries with daily mobility is also of great importance. Most users collect parcels on the way to or from work or during other activities. This means that pick-up points should be designed as part of the system of everyday urban flows, rather than as isolated elements of logistics infrastructure.

Moreover, user needs vary by age and space. Younger respondents more often prefer parcel lockers, while older respondents more often choose courier delivery. Residents of areas located near city centres have better pedestrian accessibility to parcel lockers, whereas residents of rural and suburban areas more often have to integrate parcel collection with commuting.

7.2. Drivers' and couriers' perspective

The results of the survey conducted among drivers and couriers make it possible to describe the operational side of the urban delivery system. Unlike the part of the survey addressed to service recipients, this part of the study focused on the organisation of work, means of transport used, service intensity, process execution time and the impact of weather conditions.

The analysis covers 1082 responses assigned to seven delivery segments:

- ready-made food deliveries,
- boxed meal deliveries,
- grocery deliveries,
- parcel deliveries to individual customers,
- parcel lockers and pick-up points,
- B2B deliveries,

- pharmaceutical deliveries.

The sample structure presented in Fig. 21 indicates that the study primarily covered the segments of greatest importance for last-mile logistics. The most numerous groups were pharmaceutical deliveries, ready-made food deliveries, parcels to individual customers, and deliveries to parcel lockers and pick-up points. Boxed meal deliveries constituted a smaller, but still important, part of the sample. Grocery deliveries and B2B deliveries were represented by a much smaller number of responses.

This sample structure corresponds well to the logic of the project, as it includes both parcel deliveries and segments that are time- or temperature-sensitive. Traditional courier deliveries and deliveries to parcel lockers represent repetitive, mass urban distribution processes. Ready-made food deliveries, boxed meal deliveries and grocery deliveries refer to services that are more sensitive to time, freshness and the organisation of short delivery windows. Pharmaceutical deliveries introduce an additional aspect of quality and safety requirements.

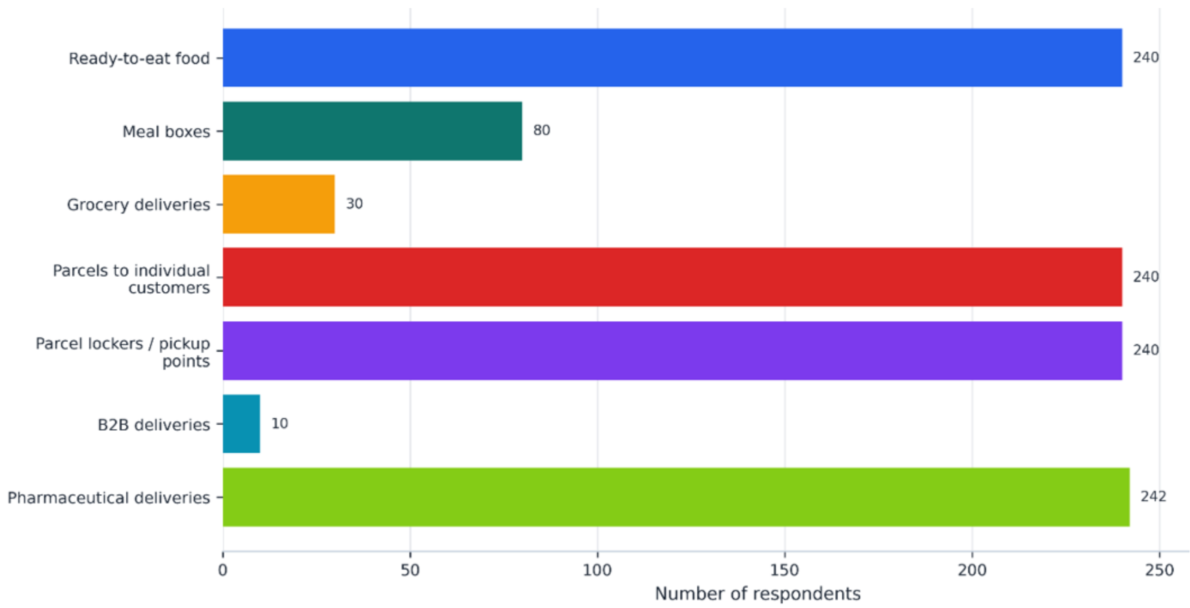

Fig. 21. Number of respondents by delivery type

The next chart presents the types of services performed in relation to the area of operation (Fig. 22). It can be observed that individual delivery types have different spatial profiles. Ready-made food deliveries and boxed meal deliveries are strongly associated with housing estates. In the case of ready-made food, 80,8% of respondents indicated service in housing estates, 45,0% in suburban areas and 38,8% in city centres. In boxed meal deliveries, the share of housing estates was even higher, at 92,5%, with 41,2% for suburban areas and 35,0% for city centres.

Grocery deliveries show a more suburban and housing-estate-oriented profile. Both suburban areas and housing estates were indicated by 73,3% of respondents, while city centres were indicated by 36,7%. This result may be related to the nature of grocery deliveries as services often provided to households located outside the strict city centre, where car transport and the handling of larger shopping baskets are more important.

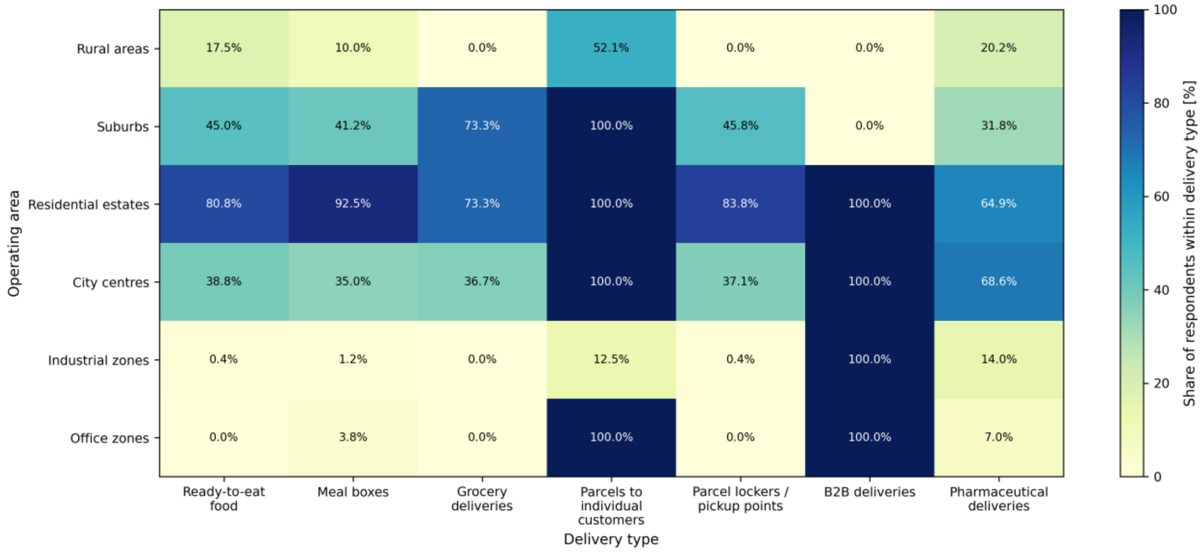

Fig. 22. Delivery types by operating area

Parcel deliveries to individual customers have the broadest spatial character. In this group, 100% of respondents indicated suburban areas, housing estates, city centres and office zones, and 52,1% also indicated rural areas. This means that traditional courier delivery has the most universal spatial coverage. Deliveries to parcel lockers and pick-up points are clearly concentrated in housing estates, at 83,8%, and to a lesser extent in suburban areas and city centres. Pharmaceutical deliveries are characterised by a high share of city centres, at 68,6%, and housing estates, at 64,9%, which indicates their importance both in central areas and in everyday service provision for residents.

These results confirm that the urban logistics system cannot be designed as a uniform scheme for all deliveries. Food-related and pharmaceutical segments require a different distribution of service points, different time windows and a different organisation of work than parcel distribution and parcel locker services.

The next chart presents the means of transport used (Fig. 23). Passenger cars clearly dominate the structure of means of transport. Passenger cars were indicated by 576 respondents, which corresponds to 53,2% of the entire sample, while delivery vehicles up to 3,5 t GVW were indicated by 536 respondents, i.e. 49,5%. Since the question allowed respondents to indicate more than one means of transport, the values do not add up to 100%. Heavier vehicles appear only marginally, with 10 indications, corresponding to 0,9% of the sample. Bicycles were indicated by 4 respondents, and motorcycles or scooters by 2 respondents.

These results show a very strong dependence of the analysed delivery processes on road vehicles. From the perspective of energy and environmental modelling, this is a key piece of information, as the potential for reducing energy consumption and emissions will depend primarily on changes in the passenger car and light delivery vehicle segments. At the same time, the low share of bicycles, cargo bikes and scooters indicates that alternative means of transport are not currently widespread in the analysed courier sample.

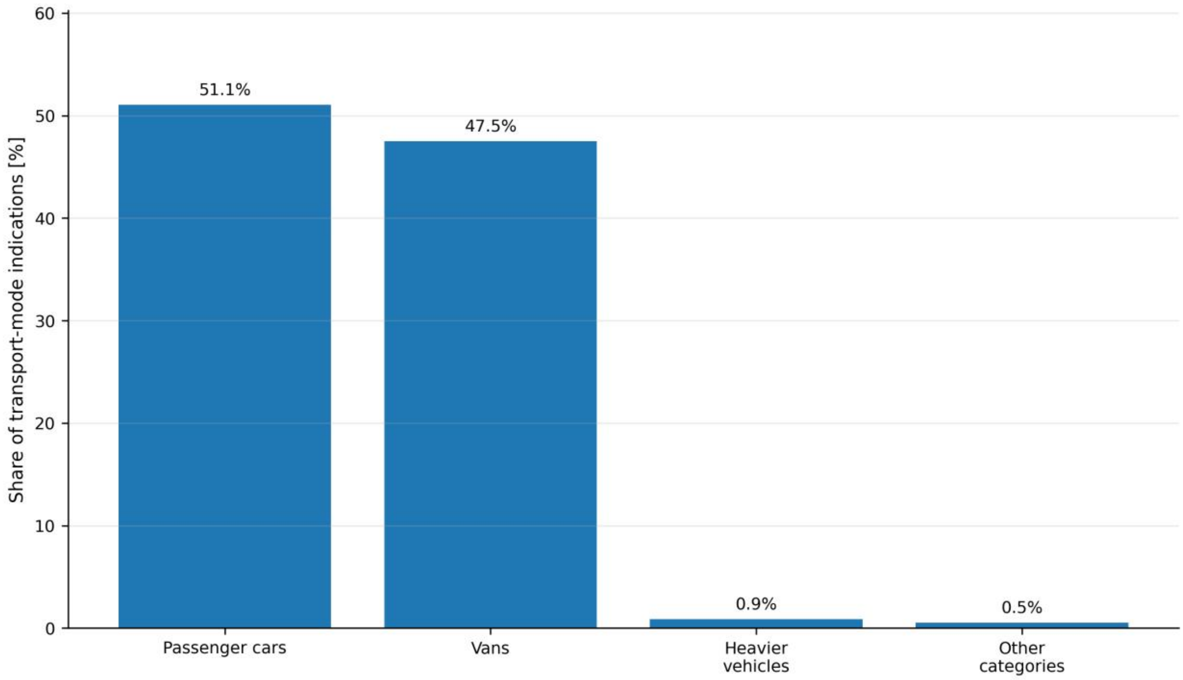

Fig. 23. Vehicle types used for service delivery

Next, the structure of vehicle drives used to carry out deliveries was analysed (Fig. 24). The drive structure indicates a strong presence of internal combustion vehicles. Among the indications concerning drive types, LPG appeared most frequently, with 431 indications, followed by petrol, with 543 indications. Diesel was indicated 169 times. Electric drive appeared in 76 indications, hybrid drive in 10, and plug-in hybrid in 7. It should be remembered that some respondents indicated more than one drive type, so the drive structure is a structure of indications rather than a mutually exclusive division of respondents. This result shows that the electrification of the courier fleet in the analysed sample remains limited. Electric vehicles are present, but they are not the dominant solution.

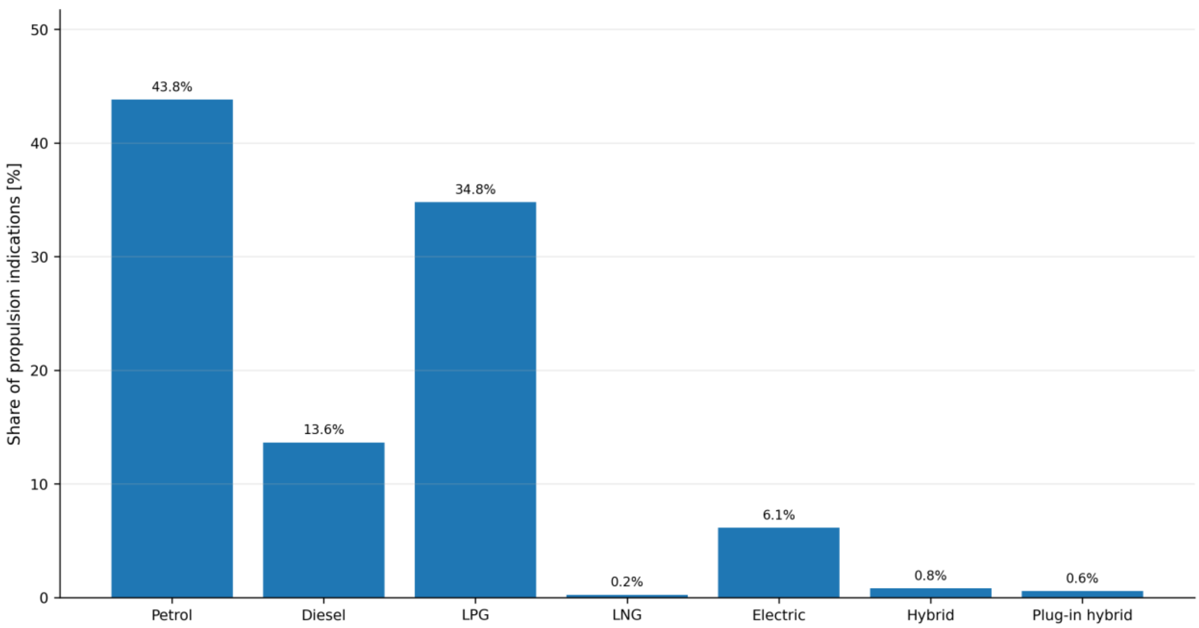

Fig. 24. Propulsion type of vehicles used for service delivery

In the next part of the survey, respondents answered questions concerning the length of the working day. According to the responses, couriers' working time is relatively long. The most numerous response categories were 6-10 hours per day and 10-12 hours per day (Fig. 25). These responses were indicated by 514 and 506 respondents, respectively, which means that almost the entire sample is concentrated in the two highest working-time intervals.

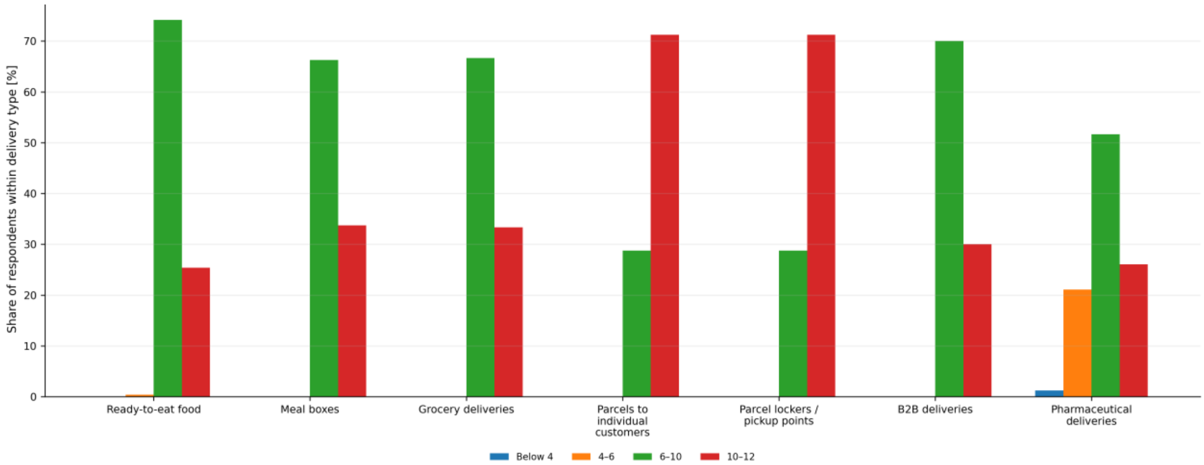

Fig. 25. Delivery working hours by delivery type

The average number of working hours differs between delivery types (Fig. 26). The longest average working day occurs in parcel deliveries to individual customers and in deliveries to parcel lockers and pick-up points - in both cases approximately 10,1 hours per day. B2B deliveries average approximately 9,6 hours, grocery deliveries approximately 9,0 hours, and boxed meal deliveries approximately 9,0 hours. Ready-made food deliveries are characterised by an average of approximately 8,8 hours, while pharmaceutical deliveries by approximately 8,1 hours.

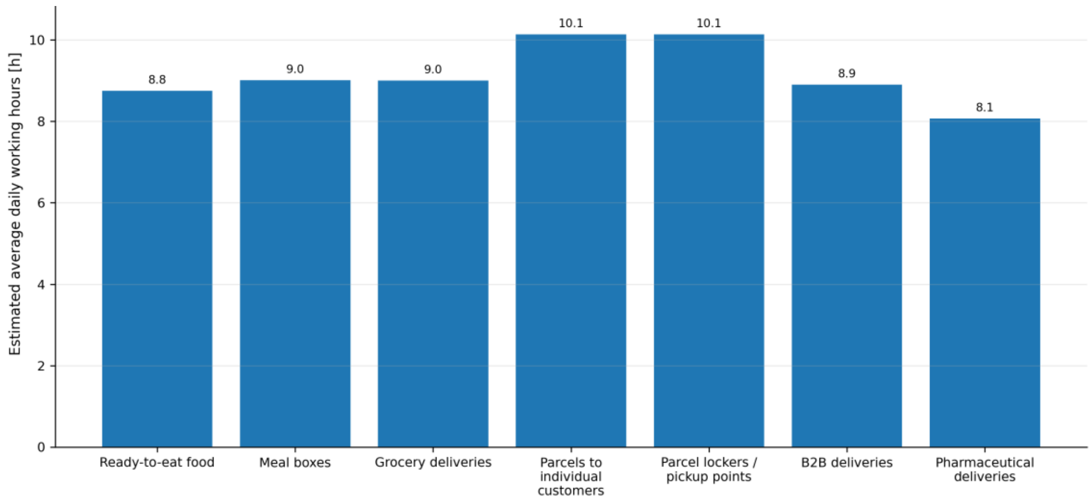

Fig. 26. Average daily working hours by delivery type

These results indicate that traditional parcel deliveries and parcel locker services are the most time-consuming work segments. This may be linked to the large number of service points, long distances travelled and the need to complete extensive routes. Pharmaceutical deliveries have a lower average length of the working day, but at the same time they are characterised by a high number of delivery addresses, which suggests a different rhythm of work organisation: shorter distances or more concentrated service areas combined with a high number of points.

As shown in Fig. 27, work regularity is very high. The most frequently indicated category was daily work for several hours, with 914 responses. Full-time daily work appeared in 54 responses, while occasional work, several days a month, appeared in 112 responses. This means that for the vast majority of respondents, courier work is permanent and repetitive, rather than only occasional.

Weekdays clearly dominate the structure of working days. Work on weekdays was indicated by 977 respondents, while weekend work was indicated by 233 respondents. This means that weekends are an important but supplementary element of work. Their importance may be greater in segments dependent on consumer demand, such as food deliveries, grocery deliveries or some parcel deliveries.

From the perspective of modelling the urban logistics system, these results are important because they indicate the dominance of repetitive work patterns. Route optimisation systems, the location of micro-hubs, demand for stopping places and charging infrastructure should therefore be designed primarily for a regular daily work rhythm, but with the possibility of handling increased demand at selected hours and on selected days.

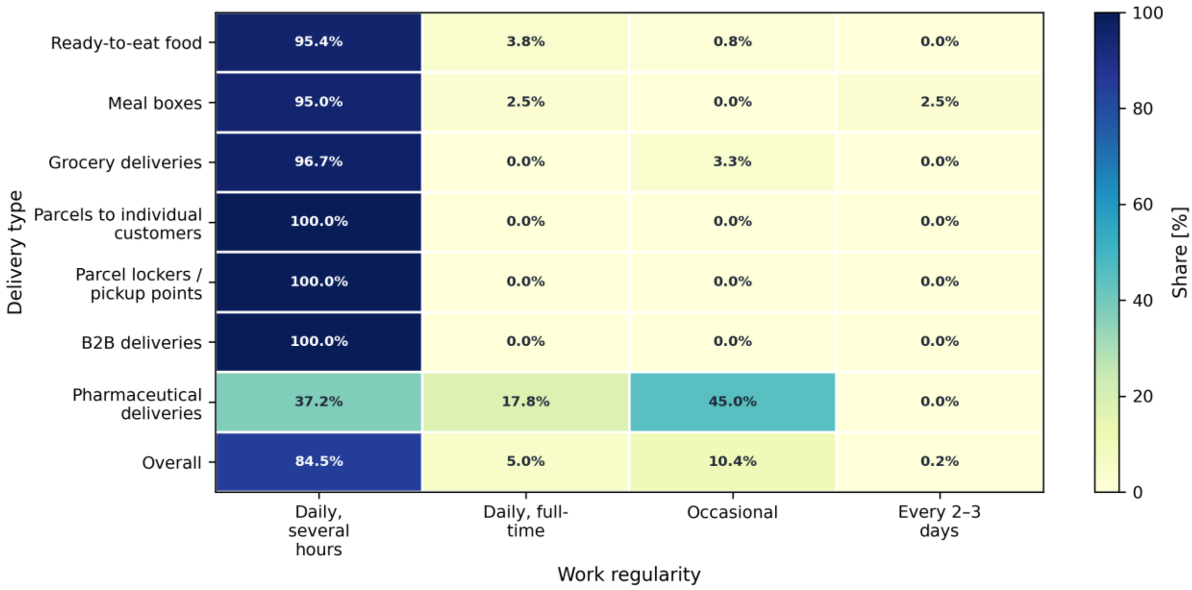

Fig. 27. Work regularity by delivery type

Next, daily mileage was analysed (Fig. 28). Daily mileage is one of the most important parameters describing the energy and operational load of the delivery system. In the whole sample, high mileage values appear most frequently. The category above 200 km per day was indicated by 498 respondents, 100-150 km by 237 respondents, and 150-200 km by 176 respondents. Lower mileage values, below 100 km, occur much less frequently.

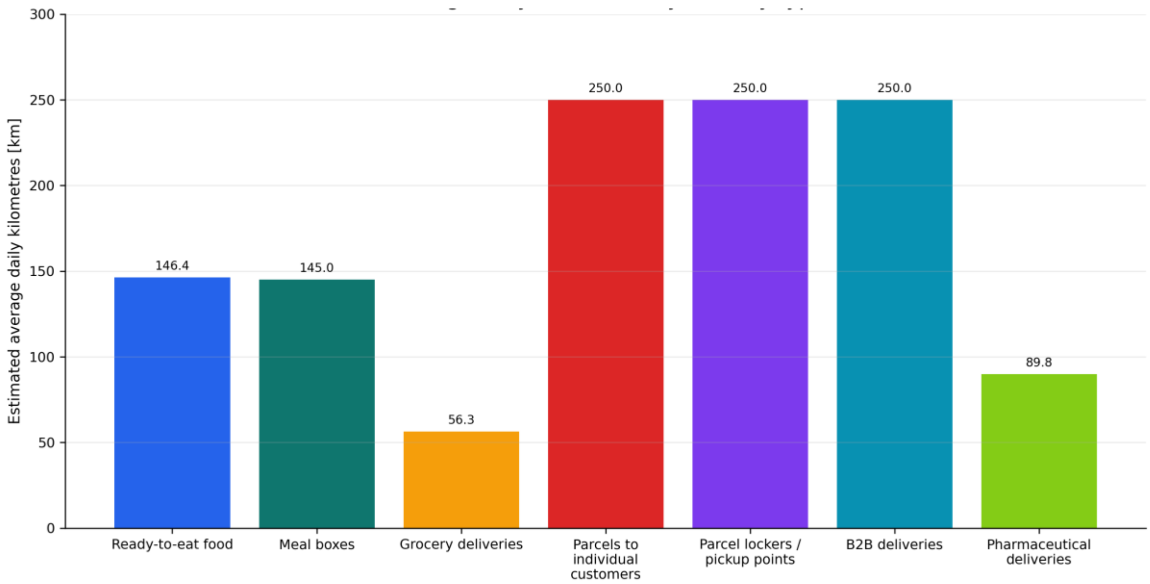

Fig. 28. Average daily kilometres by delivery type

Differences between segments are very clear. The highest estimated average mileage values concern parcels to individual customers, deliveries to parcel lockers and pick-up points, and B2B deliveries - approximately 225 km per day. Ready-made food deliveries and boxed meal deliveries reach an average of approximately 145-146 km per day. Grocery deliveries have a much lower average mileage, approximately 56 km, while pharmaceutical deliveries reach approximately 89 km.

These results show that individual segments generate very different requirements for vehicles and infrastructure. High mileage in the parcel segment means greater importance of vehicle range, fuel or energy costs, charging availability and the organisation of breaks. Lower mileage in grocery deliveries may support electrification, but only if appropriate vehicle capacity and efficient loading operations are ensured.

Figures 29 and 30 present the average daily number of loading addresses and the average number of loading operations.

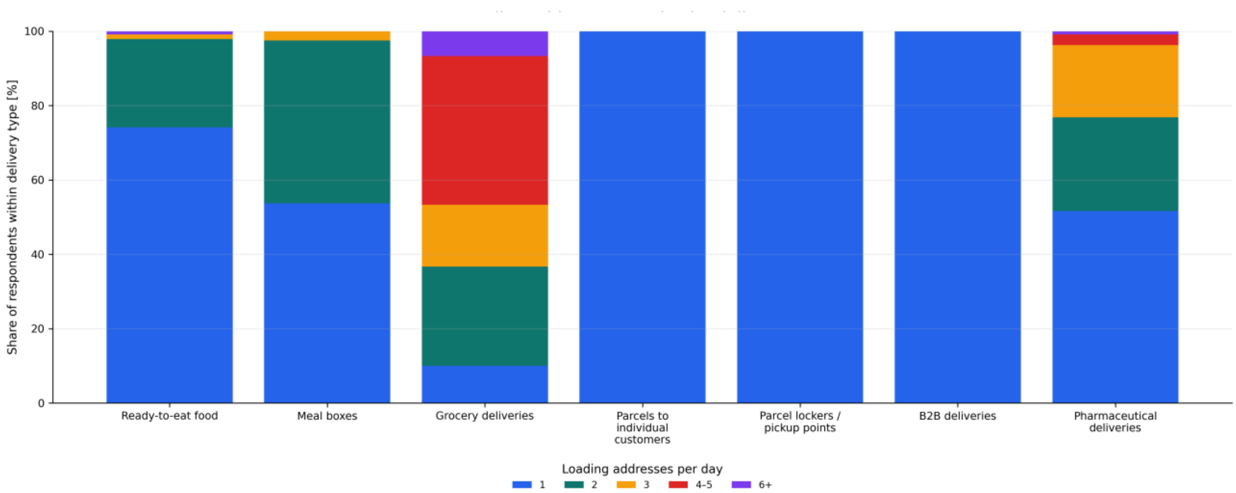

Fig. 29. Average loading addresses per day by delivery type

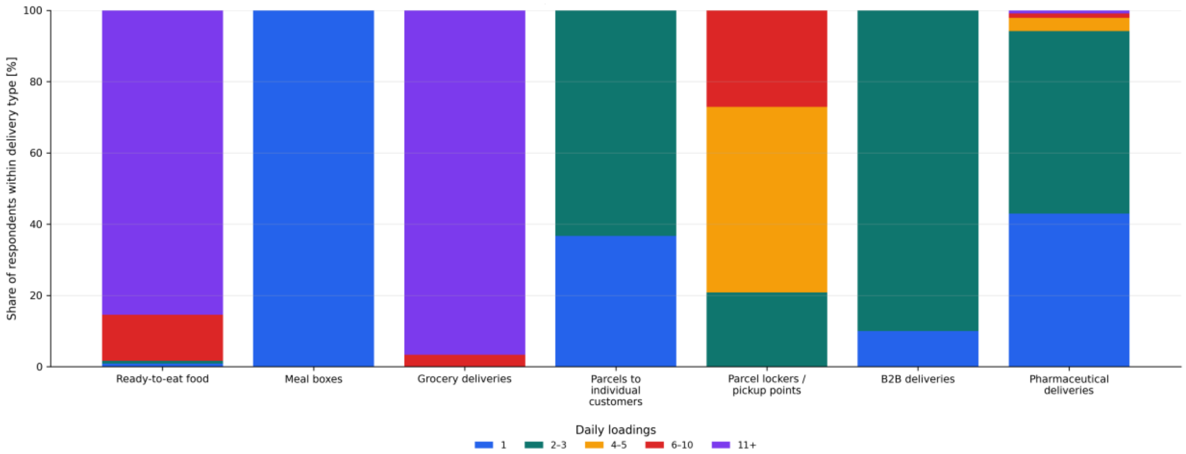

Fig. 30. Average daily loadings by delivery type

The average number of loading addresses in the whole sample is approximately 1,5 per day. One loading address was indicated most frequently, by 839 respondents. This means that most couriers start the process from one main loading point. The exceptions are grocery and pharmaceutical deliveries, where the average number of loading addresses is higher and amounts to approximately 3,4 and 2,3, respectively. In these segments, dispersed goods collection points or the handling of multiple source locations may be more important.
The average number of loading operations per day is approximately 7,9, but this value differs strongly between segments. The highest number of loading operations is declared by couriers delivering ready-made food, with an average of approximately 24,4, and groceries, with approximately 16,7. In boxed meal deliveries, parcel deliveries and B2B deliveries, the number of loading operations is much lower. This structure confirms the different nature of food-related deliveries, where the route consists of many short pick-up and delivery cycles.
Data concerning the number of delivery addresses and the average daily number of deliveries are presented in Fig. 31 and Fig. 32. The average number of delivery addresses is approximately 29,5 per day. The highest value occurs in pharmaceutical deliveries, with approximately 46,9 addresses per day, and parcel deliveries to individual customers, with approximately 35,2 addresses. Deliveries to parcel lockers and pick-up points have far fewer delivery addresses, approximately 10,9, but a significantly higher number of parcels on the route. The average number of parcels per day in the whole sample is approximately 56,7. The highest values are reached by parcel lockers and pick-up points, with approximately 94,5 parcels per day, and pharmaceutical deliveries, with approximately 66,6.
These results clearly show the difference between address intensity and shipment intensity. Deliveries to parcel lockers involve fewer points but more parcels per point. Pharmaceutical deliveries and parcel deliveries to individual customers involve more addresses, which increases the importance of stopping time, walking distance, parking and the micro-organisation of the final metres of delivery.

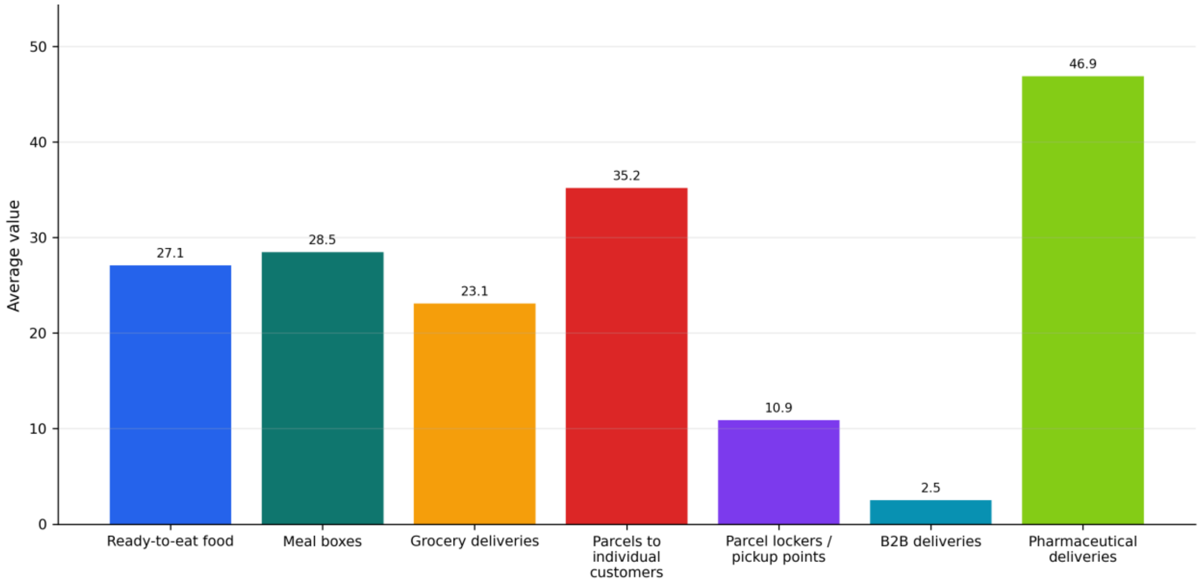

Fig. 31. Average delivery addresses per day by delivery type

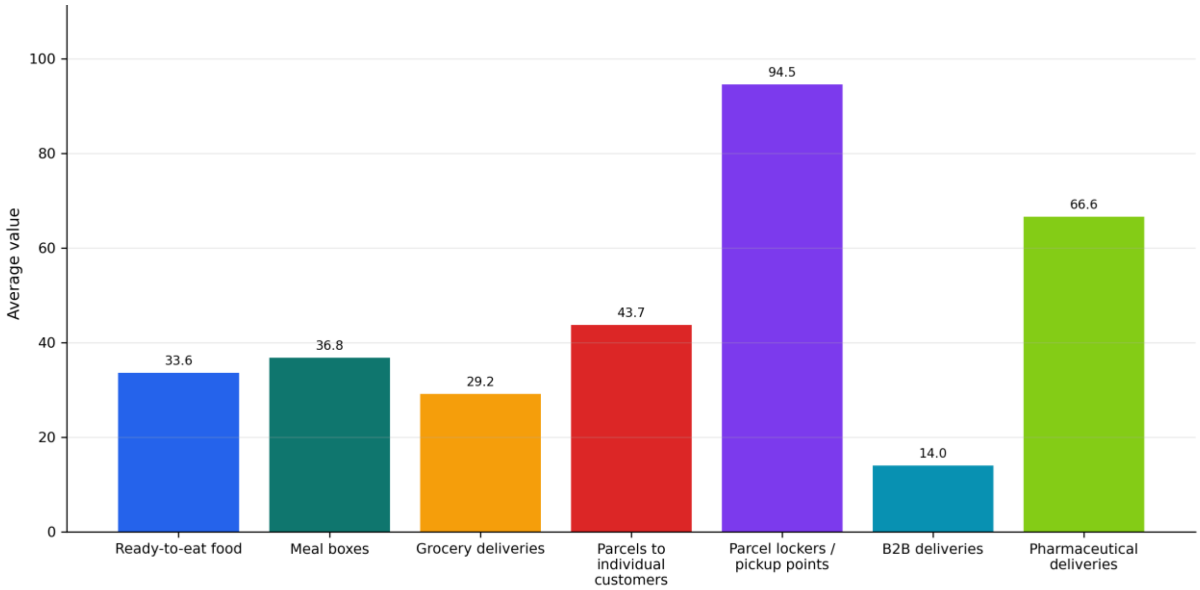

Fig. 32. Average daily deliveries by delivery type

The analysis of delivery process times (Fig. 33) shows that urban delivery consists of many elements which together create a significant operational burden. The average travel time from the loading point to the first delivery is approximately 12,4 minutes. The average loading time is approximately 25,1 minutes, and waiting for loading approximately 12,5 minutes. The average travel time between delivery points is approximately 14,7 minutes, while the average unloading or delivery time is approximately 13,0 minutes.

Two elements of the process deserve particular attention: idle time and vehicle servicing time. The average daily idle time is approximately 41,3 minutes, and the time allocated to current vehicle servicing, including refuelling or charging, is approximately 22,3 minutes. These values are important from the perspective of labour productivity, as they do not directly create value for the recipient, but are necessary or result from organisational constraints.

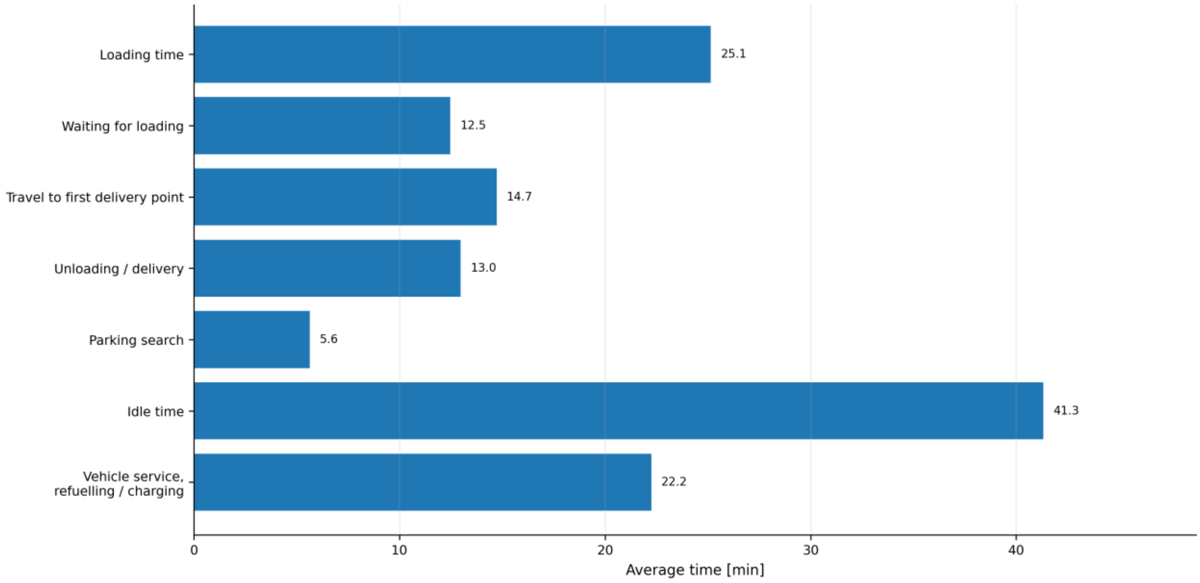

Fig. 33. Average daily process component times

The average time spent searching for a stopping place is approximately 5,6 minutes. The value itself may seem moderate, but in the context of many delivery points per day, even a few minutes at each problematic stop can significantly reduce route efficiency. In this sense, parking is not only a spatial problem, but also an element of time cost in last-mile logistics.

The problem of finding a parking space and stopping in unauthorised places is presented in Fig. 34. The problem of finding a stopping place during delivery is one of the most important operational problems indicated by couriers. The answer "often" was indicated by 404 respondents, and "very often" by 6 respondents. In total, this means that approximately 37,9% of respondents often or very often experience problems finding a stopping place. At the same time, 384 respondents indicated that the problem occurs very rarely, and 249 that it occurs rarely.

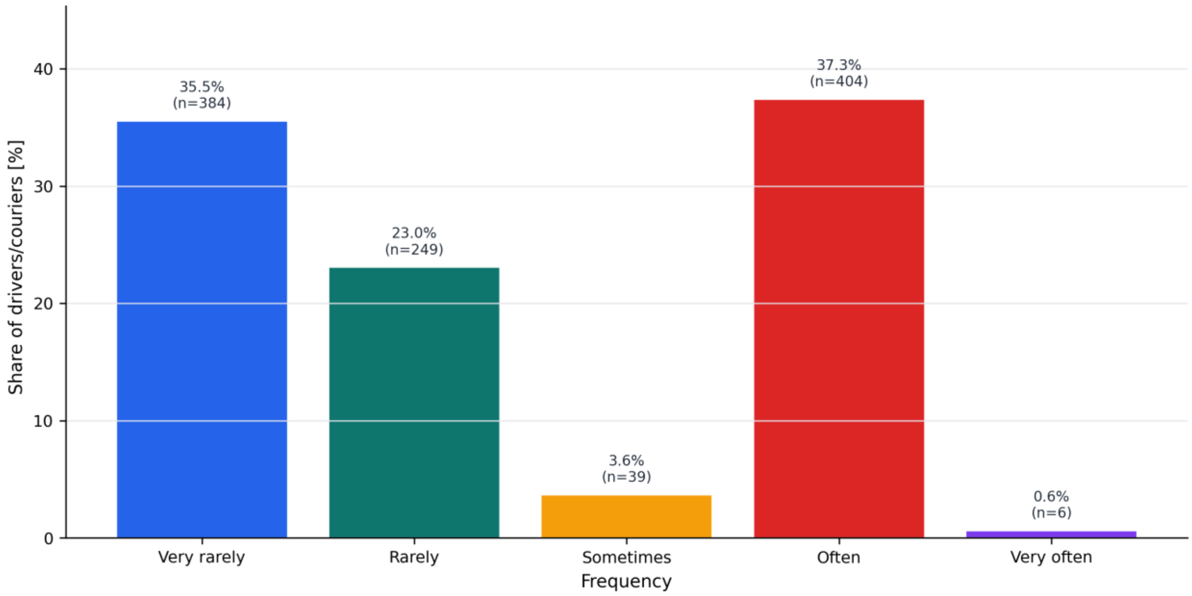

Fig. 34. Frequency of problems finding a parking/stopping place during deliveries

The frequency of stopping in an unauthorised place or on an active traffic lane is strongly linked to the difficulty of finding a stopping place. The answer "often" was indicated by 314 respondents, and "very often" by 13 respondents. The interdependence between the two variables is high. The ordinal correlation calculated on a five-point scale is approximately 0,65. This means that the more often a courier reports a problem with finding a stopping place, the more often they declare stopping in an unauthorised place or on an active traffic lane.
Fig. 35 clearly shows the pattern of responses along the diagonal. The largest concentrations occur for the combinations "very rarely - very rarely", "rarely - rarely" and "often - often". It can be inferred that illegal or suboptimal stops are not solely the result of individual driver decisions. To a large extent, they are a consequence of insufficient availability of legal stopping space near delivery points.

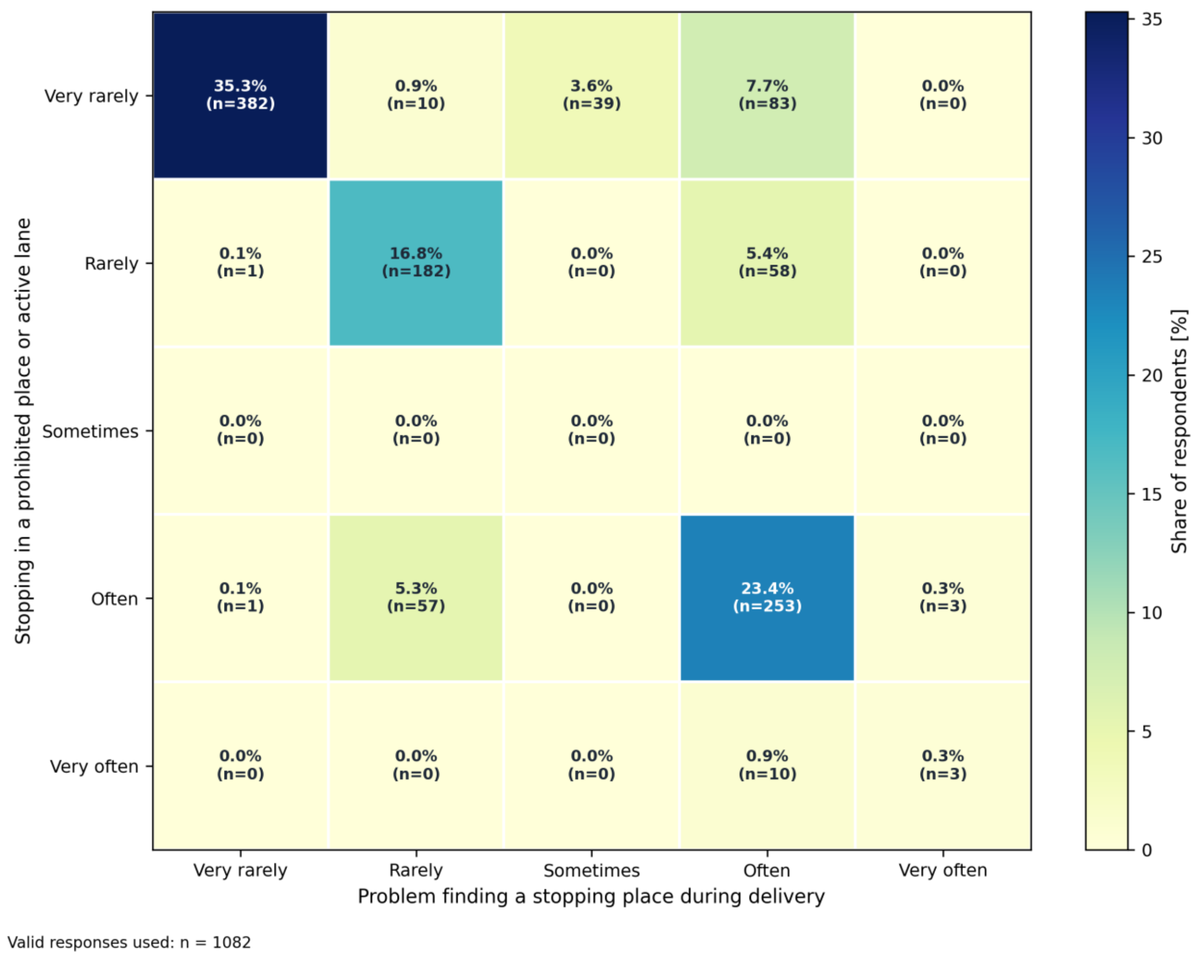

Fig. 35. Parking problem vs. prohibited stopping

In the open-ended question concerning the most annoying or burdensome element of the delivery process (Fig. 36), the problem of parking and finding a stopping place clearly dominates. After classifying textual responses into thematic categories, 439 responses referred directly to parking, stopping places or vehicle stopping. Other categories, such as road traffic, time pressure, problems with recipients, the application, weather or vehicle servicing, appeared much less frequently.

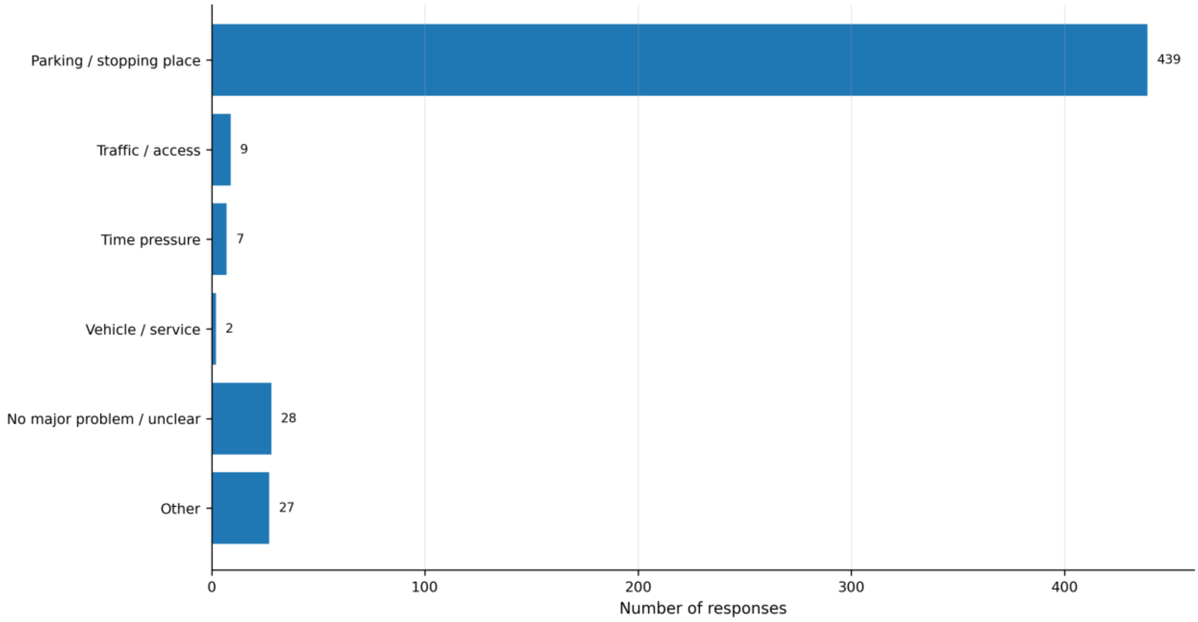

Fig. 36. Main operational problems reported by couriers

This result is consistent with the earlier quantitative analysis of difficulties in finding a stopping place and stopping in unauthorised places. It means that parking is not merely one of many equivalent problems, but the main bottleneck in couriers' daily work. It is an element that affects time, stress, the risk of a fine, traffic safety and relations with other users of urban space.

The general chart of operational problems should therefore be interpreted as a hierarchy of barriers in courier work. The chart by delivery type, in turn, shows whether the parking problem is universal or particularly visible in selected segments. In the data, the dominance of this category is so strong that it constitutes one of the central conclusions of the entire courier survey.

Next, the problem of recipient absence was analysed for the segment of parcels delivered to individual customers (Fig. 37). In this group, the number of valid responses was 240. The most frequently indicated answer was that recipient absence concerns approximately 20% of deliveries, with 115 responses. Another 78 responses indicated a level of 10%, and 47 responses indicated a level of 30%. This means that failed or potentially problematic delivery attempts are a permanent element of door-to-door deliveries.

In the case of recipient absence, the parcel is most often left at the door, with 106 responses. The second category is not leaving the parcel, with 77 responses, and the third is leaving it with a neighbour, with 57 responses (Fig. 38). These results show that practices for dealing with recipient absence are varied and may depend on the operator's regulations, the nature of the shipment, trust in the delivery location and the courier's individual decision. The problem of recipient absence is important because it generates uncertainty and additional operational cost. It may lead to repeated delivery attempts, parcel redirection, contact with the recipient or leaving the parcel in a place that is not always optimal from a security perspective. These results strengthen the argument for developing flexible pick-up points, precise time windows and communication tools between the recipient and the courier.

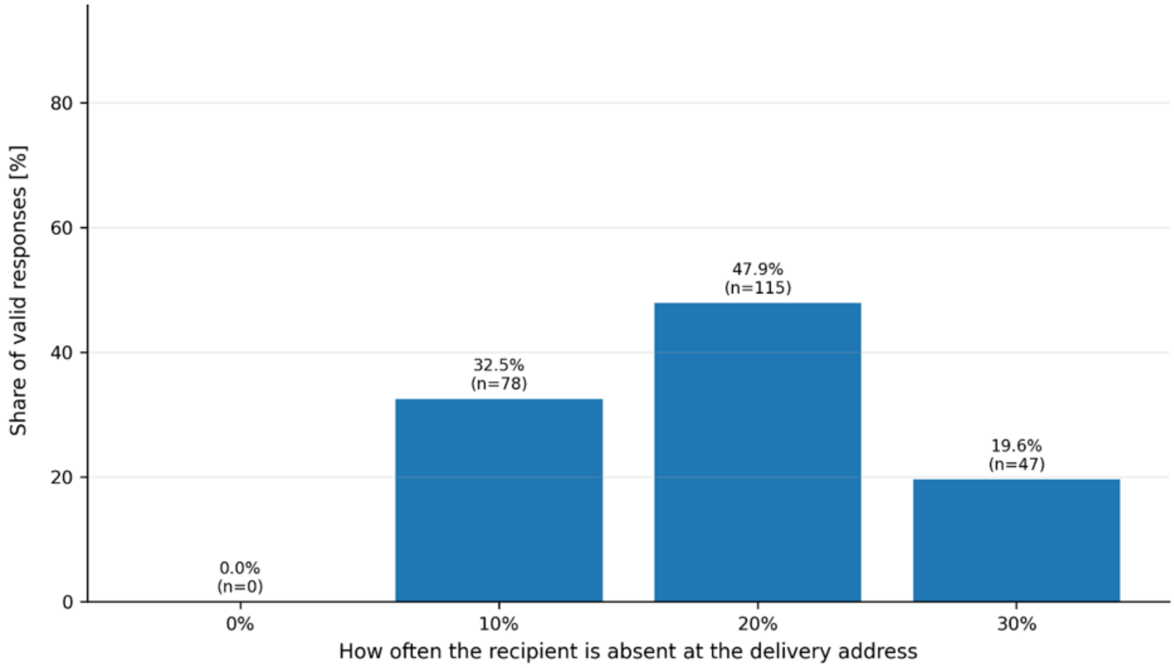

Fig. 37. Recipient absence frequency (parcels to individual customers)

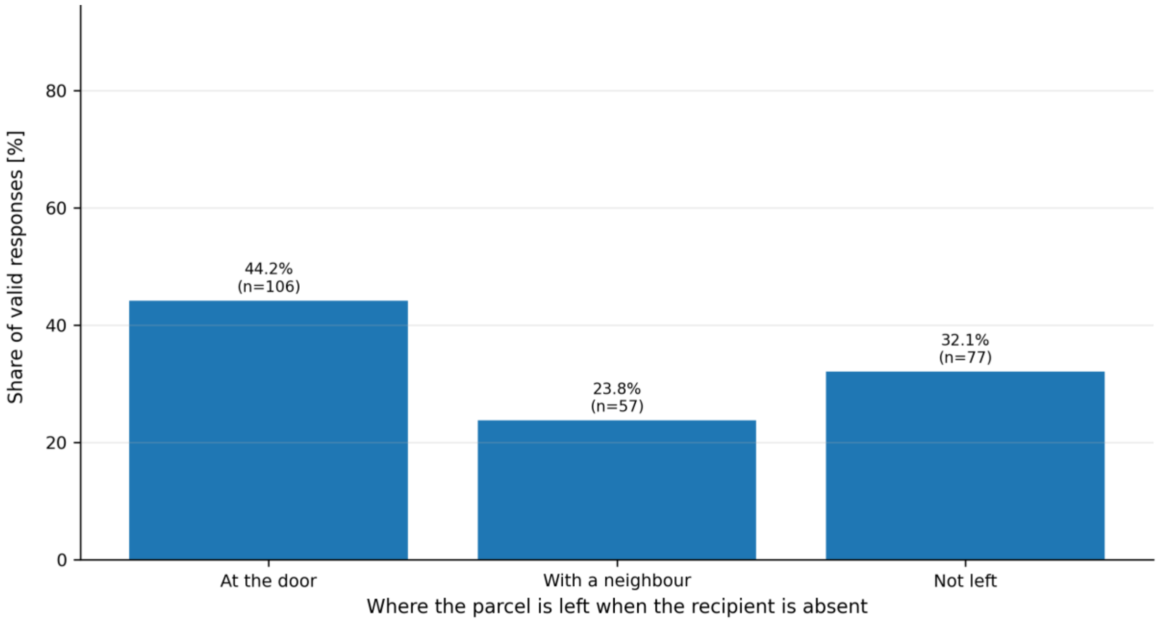

Fig. 38. Where parcels are left when the recipient is absent (parcels to individual customers)

The next step was to analyse the impact of weather on productivity. The impact of weather conditions on productivity is not uniform. Rain and snow most often do not reduce productivity or reduce it only slightly. In the case of rain, 540 respondents indicated no impact, 285 indicated a slight reduction of up to 20%, and 15 indicated a medium reduction of up to 50%. In the case of snow, no impact was indicated by 550 respondents, a slight reduction by 287, and a medium reduction by 3 respondents (Fig. 39).

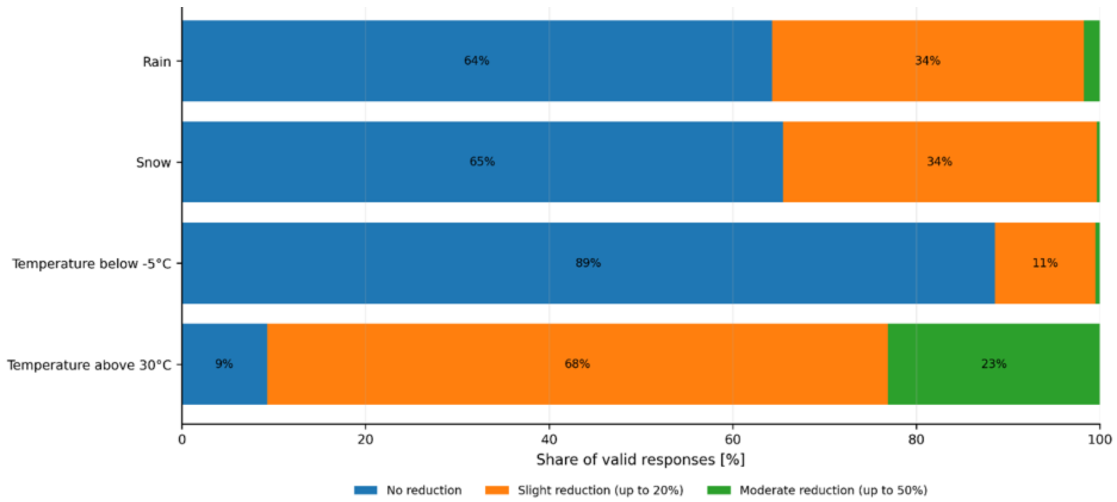

Fig. 39. Weather impact on courier productivity

Temperatures below -5°C are assessed as less problematic than high temperatures. No reduction in productivity at temperatures below -5°C was indicated by 744 respondents, and a slight reduction by 92. For temperatures above 30°C, the situation is reversed: 568 respondents indicated a slight reduction in productivity, 194 indicated a medium reduction, and only 78 indicated no impact. This means that high temperatures are a more significant operational barrier in this sample than frost.

The survey also included questions concerning the use of electric vehicles for deliveries. The questions on electric vehicles were completed by a very small group of respondents - 6 people. For this reason, the results should not be treated as representative of the entire sample. However, they are useful as a signal showing what problems may arise in the process of electrifying the courier fleet.

In the responses concerning the place of vehicle charging, the following variants appeared: no need for charging during the day, company base, and city or route. This means that some electric vehicle users do not treat daytime charging as necessary, but in other cases, charging on the route or at the company base remains an element of daily work organisation (Fig. 40).

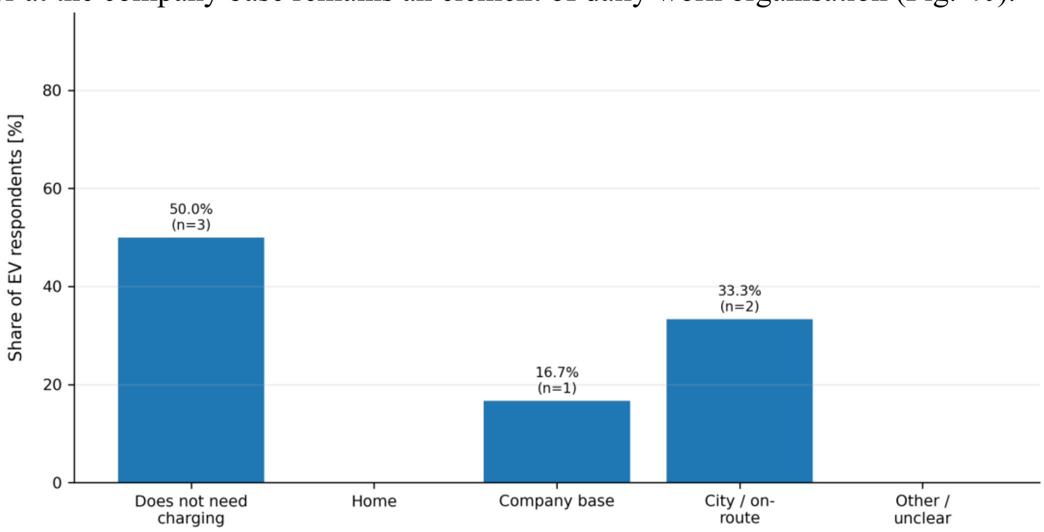

Fig. 40. Where EV couriers charge their vehicles during the day

Data on vehicle breakdowns show highly varied responses - from 0 to 10 working days lost per year (Fig. 41). With such a small number of responses, strong statistical conclusions cannot be formulated. However, it can be indicated that electric vehicle reliability, charging availability and the time needed for charging are potential barriers that should be taken into account in scenarios for the development of low-emission urban logistics.

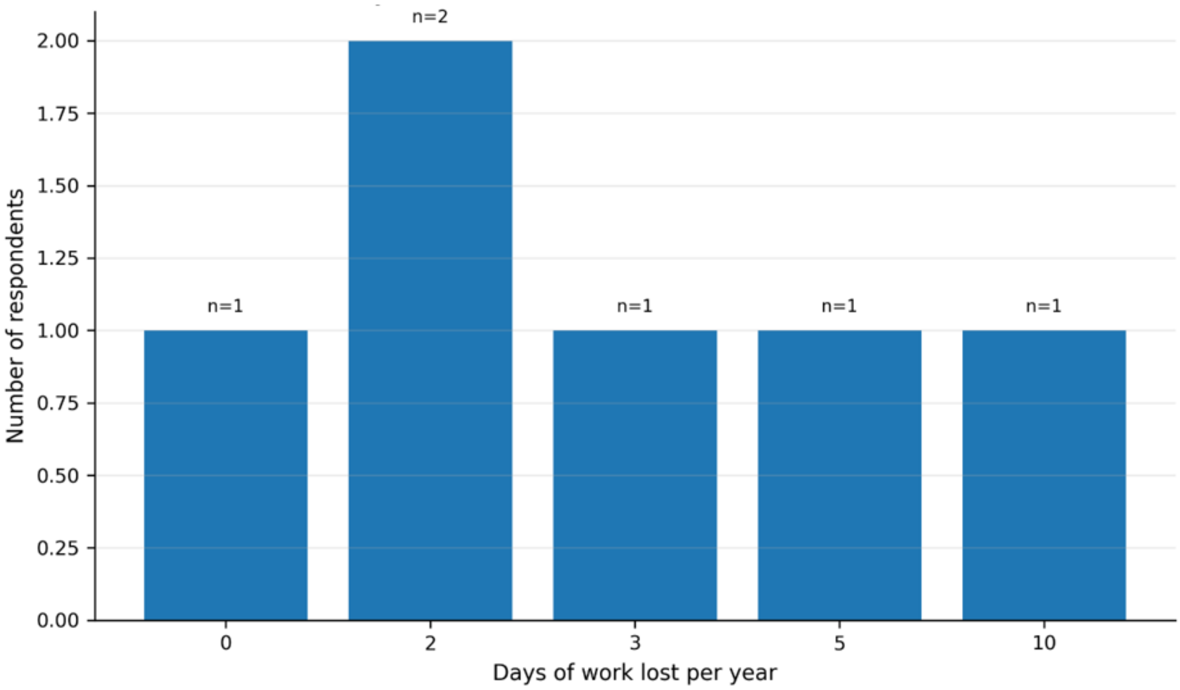

Fig. 41. Days of work lost due to vehicle failure

The survey results among drivers and couriers show that the key constraint of the urban delivery system is not a single parameter, but a combination of several interrelated factors: the dominance of road transport, long working time, high daily mileage, a large number of service points, parking problems and seasonal demand variability.

The most important operational problem is access to a stopping place. This is confirmed by both closed-ended questions and open-ended responses. The parking problem affects working time, the risk of stopping in unauthorised places, traffic safety and the quality of service provided to recipients. Therefore, infrastructure solutions related to short-term stopping should be treated as one of the fundamental elements of urban policy towards last-mile logistics.

The second important conclusion is the very high differentiation of delivery segments. Parcels to individual customers and parcel lockers generate high mileage and long working days. Ready-made food and grocery deliveries are characterised by a large number of short loading and delivery cycles. Pharmaceutical deliveries have a high number of delivery addresses and specific quality requirements. This means that one universal model of delivery organisation will not be sufficient.

7.3. Operators' perspective

The survey of logistics operators included 238 responses. Unlike the surveys of drivers and couriers, which focused on everyday working conditions and the course of the delivery process, the operators' survey primarily describes the organisational and strategic perspective. It therefore includes questions concerning the fleet, vehicle ownership model, drive structure, potential technological changes, investment and infrastructure barriers, the impact of urban policy and periodic changes in the scale of activity. In many questions, the responses are very homogeneous, which limits the possibility of analysing variation, but at the same time strengthens the conclusion about the clear profile of the surveyed entities.

The first area of analysis concerned the declared area of operation of logistics operators. The results indicate a very broad spatial profile of the surveyed group. As many as 236 out of 238 operators, i.e. 99,2% of the sample, indicated the category "all listed service areas". This means that the vast majority of respondents do not limit their activity to one type of area, but serve different urban, suburban and economic spaces.

Such a strong dominance of the response covering all areas suggests that the sample primarily includes operators with a universal service range, rather than entities specialised exclusively in serving city centres, industrial zones or residential areas.

This result also indicates that operators may be simultaneously exposed to different types of urban constraints. In city centres, traffic restrictions, shortage of parking spaces and conflicts with pedestrian traffic will be crucial. In industrial zones, the capacity of the road system and the handling of larger volumes of goods may be more important. In housing estates, short-term stopping, contact with the recipient and the possibility of safely completing the delivery without blocking public space are important. The universal area of operation of operators therefore means that urban policy should be territorially differentiated, but at the same time systemically coherent.

The fleet structure of logistics operators indicates a clear dominance of delivery and heavy goods vehicles (Fig. 42). Delivery vehicles up to 3,5 t GVW were indicated by 237 operators, i.e. 99,6% of the sample. Heavy goods vehicles above 3,5 t GVW occur among 228 operators, corresponding to 95,8% of the sample, while heavy goods vehicles with a trailer above 3,5 t GVW were indicated by 220 operators, i.e. 92,4%. Passenger cars appear marginally, in 2 responses, similarly to the "other" category. Bicycles, cargo bikes, scooters, e-scooters and drones were not indicated by any operator.

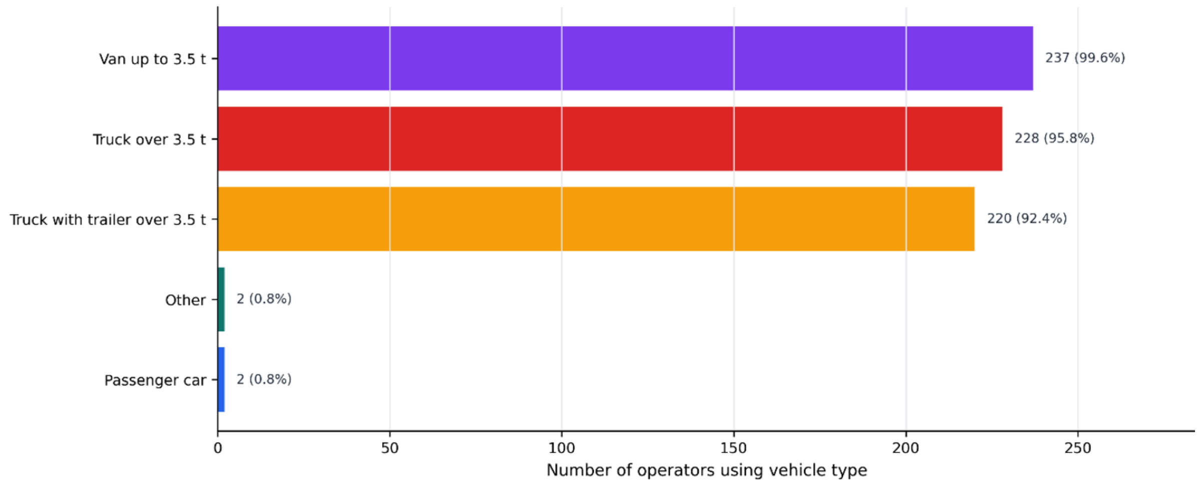

Fig. 42. Vehicle fleet structure of logistics operators

These results show that the surveyed group of operators represents a classic logistics model based on a vehicle fleet, in particular delivery vehicles and heavy goods vehicles. This profile differs from the part of the surveys addressed to drivers and couriers, where passenger cars and light delivery vehicles played a more important role. In the case of operators, however, a greater organisational and infrastructural burden is visible: these are entities whose activity is based on vehicles with higher load capacity, requiring appropriate manoeuvring, stopping, loading and unloading space.

From the perspective of urban logistics, such a fleet structure has direct spatial consequences. Delivery and heavy goods vehicles generate greater infrastructure requirements than cargo bikes or light electric vehicles. They need wider stopping places, appropriate delivery bays, manoeuvring possibilities and stable rules for access to selected areas. At the same time, they are more difficult to replace with micrologistics solutions, because they handle larger volumes of goods and routes that are more complex than a typical last-mile delivery to an individual consumer.

The absence of cargo bikes and other light means of transport in operators' responses does not mean that such solutions are not useful in urban logistics. Rather, it means that they are not currently part of the fleet of the surveyed group of operators. Their implementation would therefore require not only the purchase of vehicles, but also the restructuring of the operational model, including the creation of transhipment points, micro-hubs, route division and the integration of heavier line-haul transport with light final distribution.

The vehicle ownership model in the surveyed group is completely unambiguous. The average declared share of company-owned vehicles is 100%, while the share of vehicles owned by couriers or intermediaries is 0%. This means that the operators' fleet is fully institutionalised and remains under the control of the enterprise.

This result is highly important for interpreting the potential for technological and organisational changes. In a model where vehicles are owned by the company, decisions concerning fleet modernisation, the purchase of new vehicles, drive replacement or the implementation of energy management systems can be made centrally. From the perspective of urban policy, this means that actions addressed to operators may affect entire fleets, not only individual drivers.

At the same time, full fleet ownership by operators means that every technological transformation involves direct investment costs for companies. In the case of couriers working with their own vehicles, some costs and decisions may be dispersed. In the case of operators, costs are concentrated at the enterprise level. Therefore, the results concerning financial incentives and infrastructure barriers for electric vehicles are particularly important in the further part of the report.

The drive structure is one of the most unambiguous results of the operators' survey. The average share of internal combustion vehicles in the fleet is 100%, while the share of electric, hybrid and other vehicles is 0%. This means that the surveyed group of logistics operators is fully dependent on conventional drives.

This result is crucial from the perspective of the project objectives, as it shows a very low level of current electrification of operators' fleets. This is not a segment undergoing gradual technological transformation, but rather a segment where such transformation would first have to be initiated. This means that the implementation of low-emission solutions would require not only increasing the share of electric vehicles, but also breaking the complete dominance of internal combustion drives in the current operating model.

Complete dependence on internal combustion drives may result from several factors. First, operators' fleets include delivery and heavy goods vehicles, for which requirements concerning range, load capacity and reliability are higher than in the case of light urban deliveries. Second, operators may perceive charging infrastructure as insufficient to support a professional fleet. Third, investment costs in electric vehicles may be assessed as too high in relation to operational benefits. The further part of the analysis shows that charging infrastructure is a particularly strongly indicated barrier.

The declared chance of changing the fleet to more environmentally friendly solutions is very low. In the case of electric cars, the average score is 1,08 on a scale of 1-10. For cargo bikes, the average is 1,05; for smaller delivery vehicles, 1,19; and for other solutions, 1,05. This means that all analysed options are assessed close to the lowest possible level (Fig. 43).

The distribution of responses additionally confirms this interpretation. For electric cars, a score of 1 was indicated by 227 operators. For cargo bikes and other solutions, a score of 1 was indicated by 229 operators each. In the case of smaller delivery vehicles, a score of 1 was indicated by 221 operators, but slightly more higher responses appeared, including individual scores of 5 and 10. Smaller delivery vehicles are therefore the relatively best assessed solution, although the overall level of readiness for change remains very low.

These results indicate that the transformation of operators' fleets will not occur spontaneously on the basis of the mere availability of technology. Operators do not declare a high willingness to invest in electric vehicles, cargo bikes or alternative fleet models. From the perspective of urban policy, this means the need to combine environmental objectives with specific support instruments: financing, infrastructure, access preferences, organisational facilitation or regulations that change the operator's economic calculation.

It is particularly important that low readiness also applies to cargo bikes. This means that in the surveyed group of operators, micrologistics solutions are not perceived as a natural alternative to the current model. Their introduction would require not only an incentive to change vehicles, but also the creation of an entire operational background: micro-hubs, consolidation points, transhipment systems, route planning and integration with the main vehicle fleet.

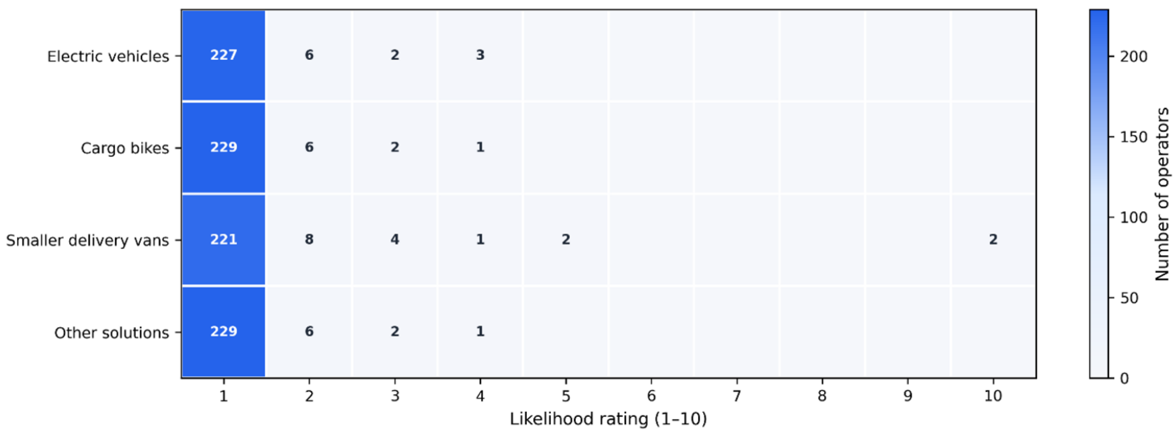

Fig. 43. Declared likelihood of switching to more sustainable fleet solutions

Next, the possible incentives for changing the fleet were analysed and coded into thematic categories. Fig. 44 shows that the most frequently occurring category consists of financial incentives, such as co-financing, grants, financial resources or subsidies. They were indicated in 172 responses, corresponding to 72,3% of the sample. The second important category consists of ambiguous responses, such as “hard to say” or “I do not know”, which appeared in 46 cases, i.e. 19,3% of the sample. Tax reliefs or reductions in operating costs appeared in 13 responses, while the remaining responses were classified as “other”.

The dominance of financial incentives shows that operators perceive fleet transformation primarily as an economic problem. Changing vehicles to more environmentally friendly ones is assessed not only through the availability of technology, but above all through the cost of investment, operational risk and profitability. In this sense, the result is consistent with the low declared readiness to change the fleet: operators do not rule out transformation, but expect its cost to be significantly reduced or compensated.

The relatively small number of indications concerning tax reliefs or cost reductions may result from the structure of open-ended responses, in which respondents more often used general financial terms, such as “co-financing”. However, this does not change the fundamental conclusion: economic instruments are a central condition for any potential fleet change from the operators’ perspective.

It is also worth noting that the responses did not include, to any significant extent, incentives related to access privileges, regulatory preferences or charging infrastructure support. This does not necessarily mean that such instruments would be ineffective. It may, however, indicate that operators think about transformation primarily through the direct cost of purchasing or replacing vehicles, and less through long-term operational facilitation.

In the question concerning barriers to the implementation of electric vehicles, charging infrastructure clearly dominates. The category “lack or weakness of charging infrastructure” was assigned to 222 responses, i.e. 93,3% of the sample. The remaining 16 responses were classified as “other”. In the automated coding, no separate strong categories concerning high purchase costs, range, operational uncertainty or vehicle availability appeared, although this does not mean that these factors cannot be important in a broader context.

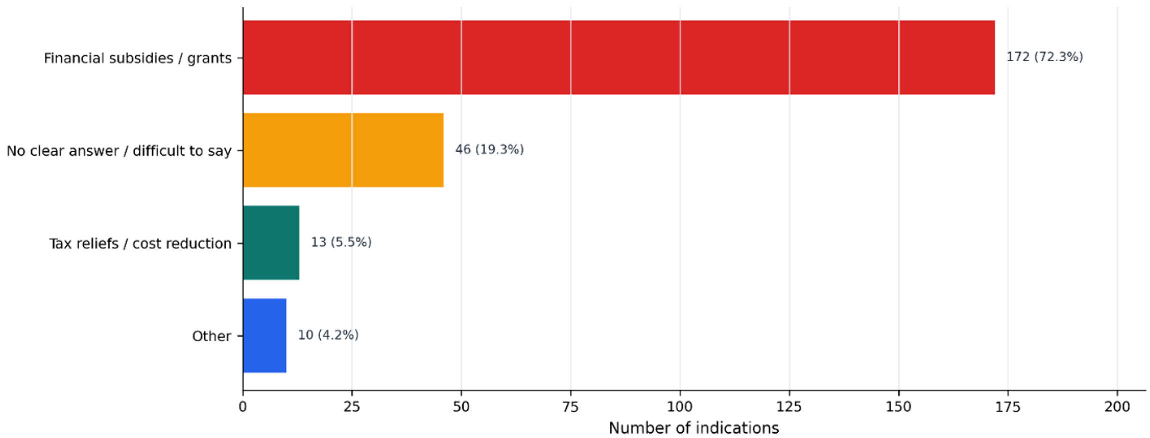

Fig. 44. Incentives for operators to switch to greener fleets

Such a clear dominance of charging infrastructure indicates that operators perceive electromobility in logistics primarily as a systemic problem. An electric vehicle is not assessed in isolation from its operating conditions. In order to function in professional distribution, accessible, predictable and properly distributed charging infrastructure is needed. This applies both to operators' bases and to charging points in urban space or along distribution routes.

Operators were also asked about the impact of clean transport zones. As can be seen in Fig. 45, these zones are perceived by most operators as a factor affecting their activity. The answer "yes" was indicated by 185 operators, i.e. 77,7% of the sample. No impact was declared by 52 operators, i.e. 21,9%, and one response was ambiguous. This result shows that urban policy concerning emission restrictions is an important element of operators' operating conditions.

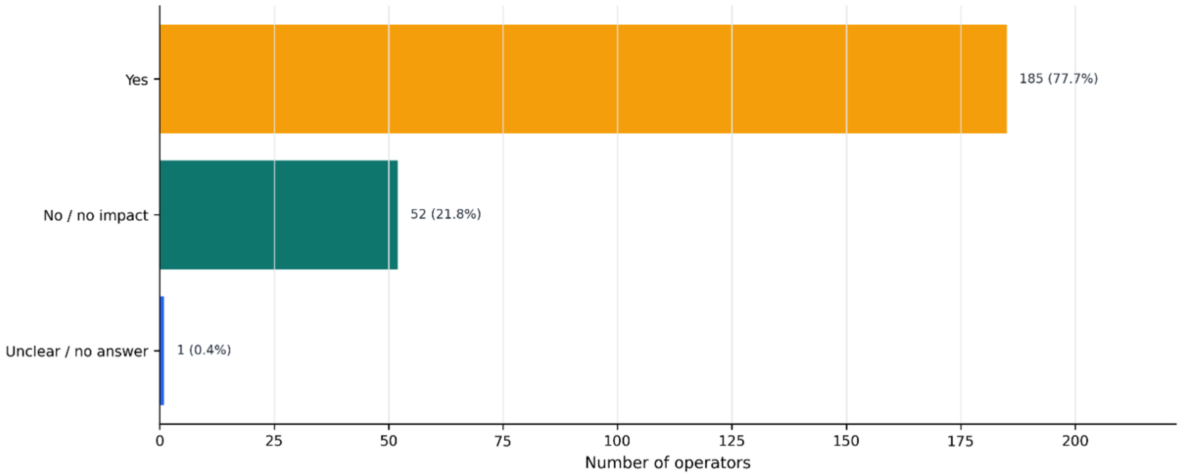

Fig. 45. Impact of green transport zones on logistics operators' activity

At the same time, the declared types of changes resulting from clean transport zones, shown in Fig. 46, indicate that operators more often anticipate organisational rather than investment adaptation. The highest average score was obtained by route modification, with a score of 4,93 on a scale of 1-10. Changes in the type of vehicles assigned to routes achieved an average of 4,02. Changing delivery time windows was assessed at an average of 3,52, and withdrawing from servicing areas within the zone at 3,28. The lowest score was obtained by purchasing new vehicles, with an average of 1,53.

This arrangement of results is highly important. Operators recognise that clean transport zones affect their activity, but they do not primarily assume a response in the form of purchasing new vehicles. Organisational actions are more likely: changing routes, assigning vehicles differently to service areas, possibly changing time windows or adjusting the scope of service. This indicates limited investment capacity or limited readiness to bear the costs of purchasing new vehicles solely in response to urban regulations.

For cities, this means that introducing clean transport zones without parallel infrastructure and financial support may lead to short-term adaptation rather than real fleet decarbonisation. Operators may try to bypass zones, change routes, shift service to other vehicles or limit activity in selected areas. If the objective is lasting technological change, regulations should be linked to access to chargers, financial support and a predictable implementation schedule.

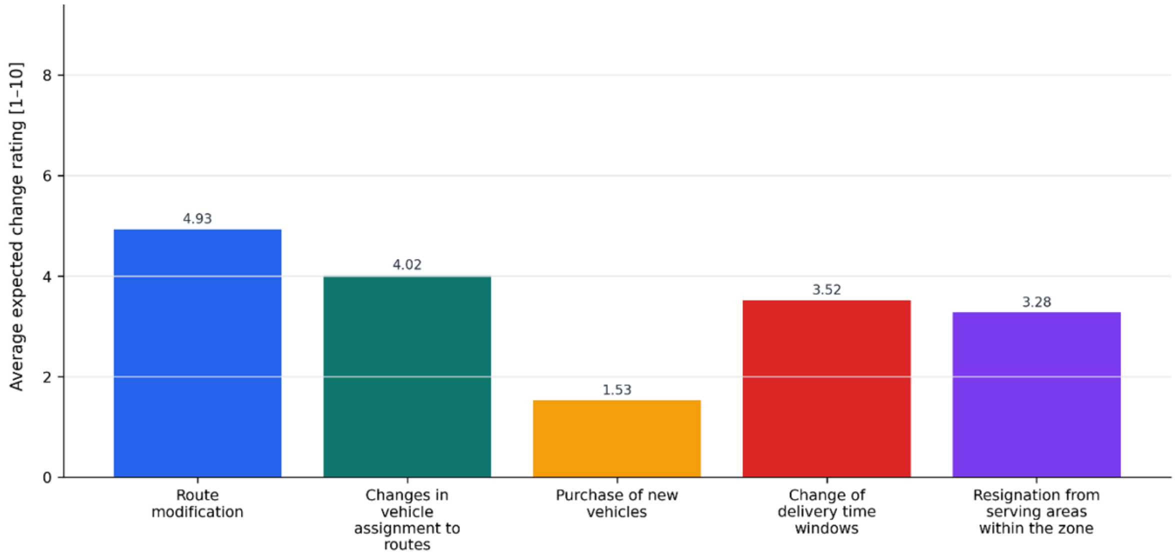

Fig. 46. Operational changes expected due to clean transport zones

The results of the logistics operators' survey make it possible to indicate several main conclusions concerning their position in the urban logistics system. First, the surveyed operators represent an activity model based on a broad service area and a fleet of delivery and heavy goods vehicles. Delivery vehicles up to 3,5 t and heavy goods vehicles are the basis of their functioning, while light means of transport such as cargo bikes, scooters or e-scooters do not appear in the surveyed sample.

Moreover, operators' fleets are fully internal combustion-based and fully company-owned. This model means that operators have the organisational ability to make fleet decisions at the enterprise level, but at the same time every technological change requires significant investment expenditure. This explains why readiness to change the fleet to a more environmentally friendly one is very low, and why financial instruments are the most important type of expected incentive.

According to operators, the most important barrier to electromobility is charging infrastructure. This result shows that fleet transformation cannot be analysed solely as an enterprise purchasing decision. It requires the parallel development of energy infrastructure, preferably linked to stopping and delivery locations. Without this, operators may perceive electric vehicles as too operationally risky.

Importantly, logistics operators recognise the impact of clean transport zones, but the expected responses are primarily organisational rather than investment-related. Route modifications and changes in vehicle assignment are the most likely, whereas the purchase of new vehicles is assessed very low. This indicates a risk that environmental regulations without implementation support may lead to bypassing restrictions or organisational changes, rather than to actual fleet transformation.

7.4. Local authorities' perspective

The next part of the report concerns the perspective of local administration, understood as cities and municipalities. The analysis was prepared on the basis of 244 responses. The scope of questions addressed to local administration was qualitative in nature. Respondents indicated observed delivery-related problems, possible solutions that the municipality would be able to introduce, the nature of cooperation with logistics operators, solutions already implemented or tested, and an assessment of the effects of these measures.

The responses in this part of the survey were open-ended; therefore, before interpretation, they were coded into thematic categories. A multi-label approach was applied: one response could be assigned to more than one category if it contained several themes. For example, a response referring simultaneously to parking in unauthorised places and blocking pavements was classified into both categories. For this reason, the sum of indications in some charts may be higher than the number of respondents.

The first area of analysis concerned delivery-related problems observed by municipalities and districts. The largest share of responses indicates no identified problems. As can be seen in Fig. 47, this category was assigned to 128 responses, which represents 52,5% of the analysed group. This means that more than half of the respondents on the local administration side do not perceive urban deliveries as a significant or clearly visible operational problem.

The second most frequent theme was parking or stopping delivery vehicles in unauthorised places. This category appeared in 87 responses, i.e. 35,7% of the sample. This is the most important specific problem reported by local administration. This result is consistent with the results of the courier survey, in which the problem of finding a stopping place and the necessity of stopping in unauthorised places were also among the most important operational barriers.

Another problem is the blocking of pavements and pedestrian space. This theme appeared in 40 responses, i.e. 16,4% of the sample. This means that, from the perspective of municipalities, the problem of urban deliveries is often perceived not only as a road traffic issue, but also as an issue of public space quality and conflict with pedestrian movement. In 26 responses, i.e. 10,7% of the sample, the theme of blocking traffic or overloading streets appeared. Safety issues were indicated rarely - in 2 responses, representing 0,8% of the sample - although it should be remembered that safety may be indirectly related to parking on pavements and blocking traffic lanes.

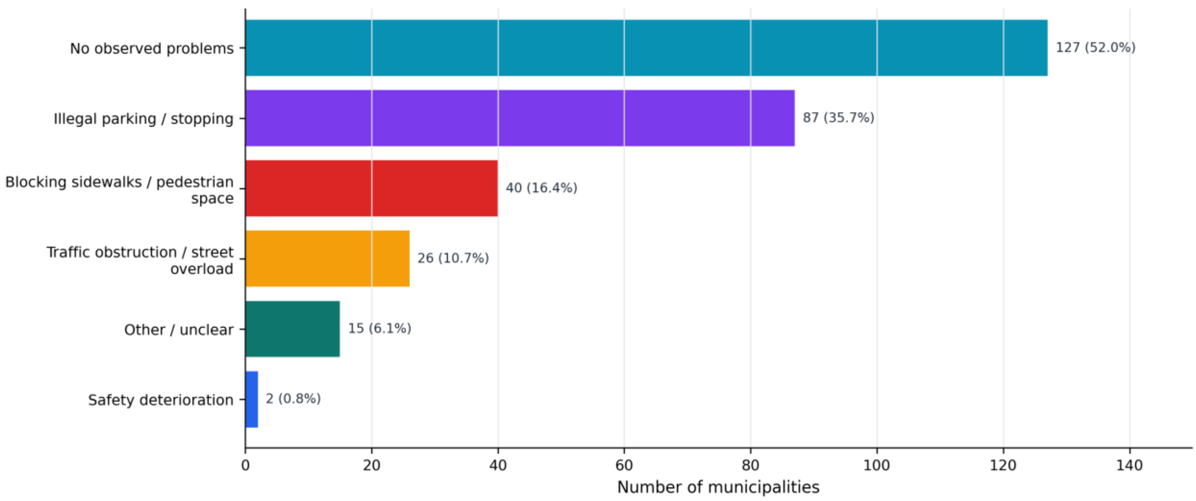

Fig. 47. Observed delivery-related problems in municipalities

The interpretation of this chart should take into account two layers. The first layer is the relatively large group of municipalities that do not see the issue of urban deliveries as a clear challenge. The second layer is the group of municipalities where the problem is visible and has a very specific spatial character: it mainly concerns stopping, parking, pavements and street capacity. In practice, this means that urban logistics is most often noticed by local administration when it begins to interfere with the everyday functioning of street space.

If the category “no observed problems” were not included, it would be clearly visible that the basic dimension of problems reported by municipalities is the availability of short-term stopping places for vehicles carrying out deliveries. Illegal parking or stopping of delivery vehicles occurs more than twice as often as blocking pavements and more than three times as often as blocking traffic or overloading streets. This means that local administration does not describe urban logistics primarily through the lens of large freight flows, but through point-based conflicts in street space.

This result has important implications for the project. It shows that in many local units the first and most understandable intervention instrument will not be advanced digital solutions, dynamic energy management systems or micro-hubs, but the basic reorganisation of stopping and delivery space. If a delivery vehicle does not have a legal and functional stopping place, the natural consequence is undesirable behaviour: parking on the pavement, stopping on an active traffic lane, blocking passage or conflict with pedestrians.

For this reason, the survey results from municipalities complement the courier perspective well. Couriers indicate the difficulty of finding a stopping place as an operational problem, while municipalities observe the effects of this problem in public space. The common denominator of both perspectives is the deficit of organised infrastructure for last-mile deliveries.

The next question concerned solutions that municipalities would be able to introduce in order to improve urban logistics. As can be seen in Fig. 48, the most frequent category was a response indicating no need or no planned actions. This category was assigned to 119 responses, i.e. 48,8% of the sample. This result confirms that for a significant share of local administration, delivery logistics is not yet an area requiring active urban policy.

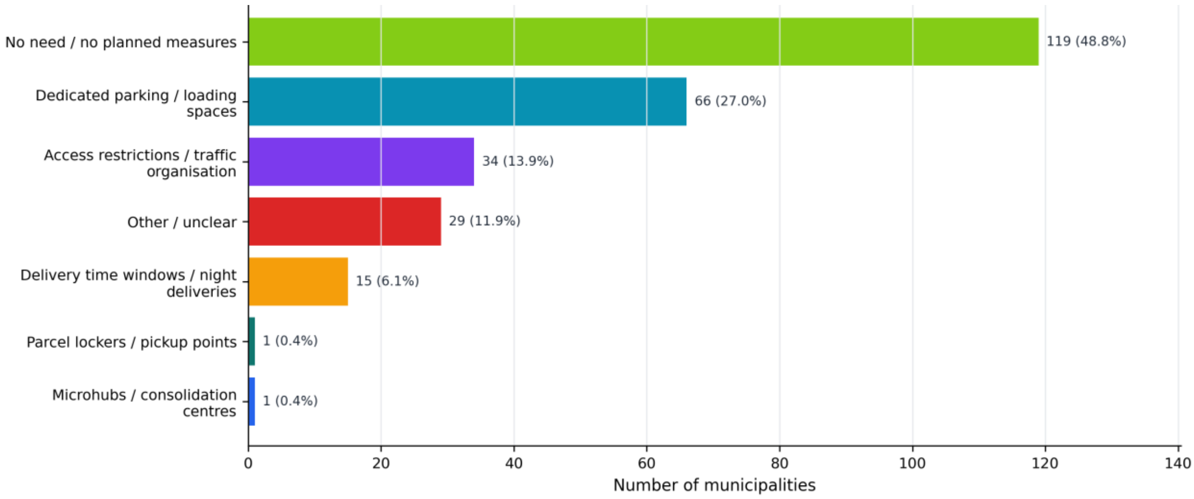

Fig. 48. Measures considered feasible for improving urban logistics

Among specific solutions, dedicated stopping or loading spaces clearly dominate. This category appeared in 66 responses, representing 27,0% of the sample. It is the most important practical instrument indicated by municipalities. The second area was entry restrictions or traffic organisation, with 34 indications, i.e. 13,9% of the sample. The third category was delivery time windows or night deliveries, which appeared in 15 responses, i.e. 6,1% of the sample.

More advanced or systemic solutions were indicated much less frequently. Micro-hubs and consolidation centres appeared only once. Similarly, parcel lockers or pick-up points as a solution were indicated in only one response. In the analysed responses, categories such as charging infrastructure, incentives for low-emission vehicles or dynamic pricing did not appear in a measurable way. This is an important observation because some of these solutions were indicated in the question as example instruments. Nevertheless, respondents rarely referred to them spontaneously.

The chart showing the relationship between observed problems and proposed solutions is particularly important (Fig. 49). In the case of municipalities indicating illegal parking or vehicle stopping, the most frequently co-occurring proposal is dedicated stopping or loading spaces. This pair occurred 57 times. This means a relatively high coherence between the diagnosis of the problem and the proposed intervention instrument.

In the group of municipalities reporting illegal parking, this problem was also linked to entry restrictions or traffic organisation in 29 responses, and to delivery time windows or night deliveries in 12 responses. A similar pattern can be observed for the blocking of pavements or pedestrian space, where dedicated stopping spaces were again the most frequently indicated solution, with 27 co-occurrences, followed by traffic organisation, with 16 co-occurrences. For traffic obstruction or street overloading, these solutions appeared 18 and 11 times, respectively. This arrangement of results indicates that municipalities that identify specific problems usually propose solutions directly related to their source. A deficit of stopping places leads to indicating dedicated spaces for delivery vehicles, while traffic problems lead to indicating traffic organisation or entry restrictions. At the same time, solutions related to electromobility, dynamic pricing, incentives for low-emission vehicles or extended consolidation models are almost absent from the matrix.

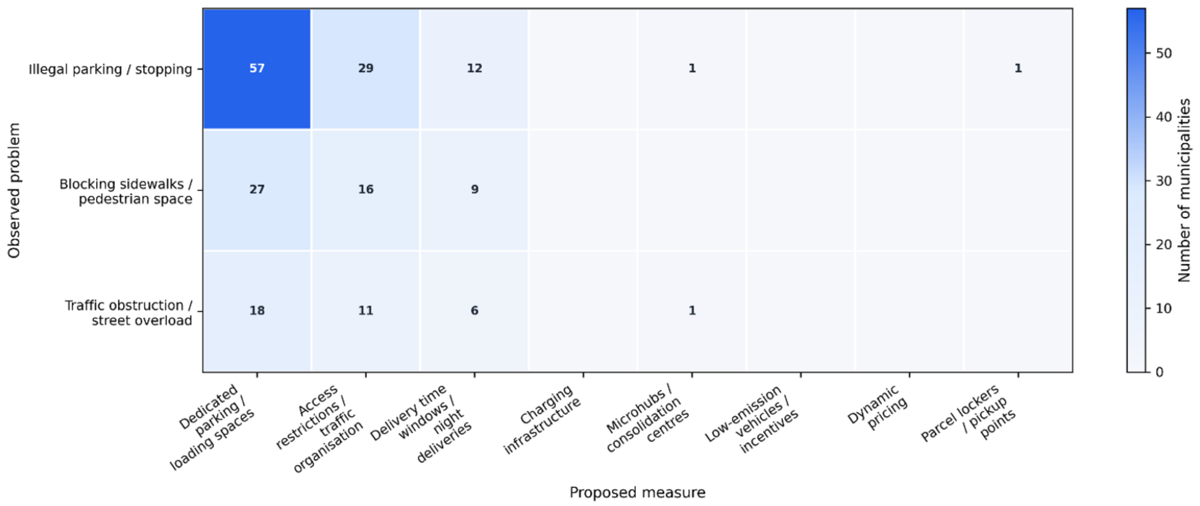

Fig. 49. Alignment between observed delivery problems and proposed municipal measures

The conclusion from this chart is twofold. First, the degree of matching simple tools to observed problems is relatively good. Second, the range of proposed tools is limited. Municipalities identify problems and are able to indicate basic measures, but they rarely move towards more integrated systemic solutions that could combine stopping space, charging, consolidation, delivery time management and operators' operational data.

Cooperation with logistics operators is one of the key conditions for implementing last-mile solutions. However, the survey results show that this cooperation is limited. As shown in Fig. 50, no cooperation or no need for cooperation was indicated in 158 responses, representing 64,8% of the sample. This means that most municipalities and districts do not conduct regular activities with logistics operators in the field of delivery system organisation.

The most frequent specific area of cooperation is the location of parcel lockers. This theme appeared in 57 responses, i.e. 23,4% of the sample. The second area is delivery or stopping infrastructure, indicated in 24 responses, i.e. 9,8% of the sample. Ad hoc or general cooperation appeared in 6 responses. However, there were no real indications of cooperation in the field of charging infrastructure or access to restricted traffic zones.

This result shows that the relationship between local government and logistics operators is most often administrative and location-based rather than strategic. A municipality cooperates with an operator when there is a need to place a parcel locker, issue a permit, agree on a location or designate a specific space. It is less often cooperation concerning the entire delivery service model, data integration, testing new solutions or jointly designing infrastructure.

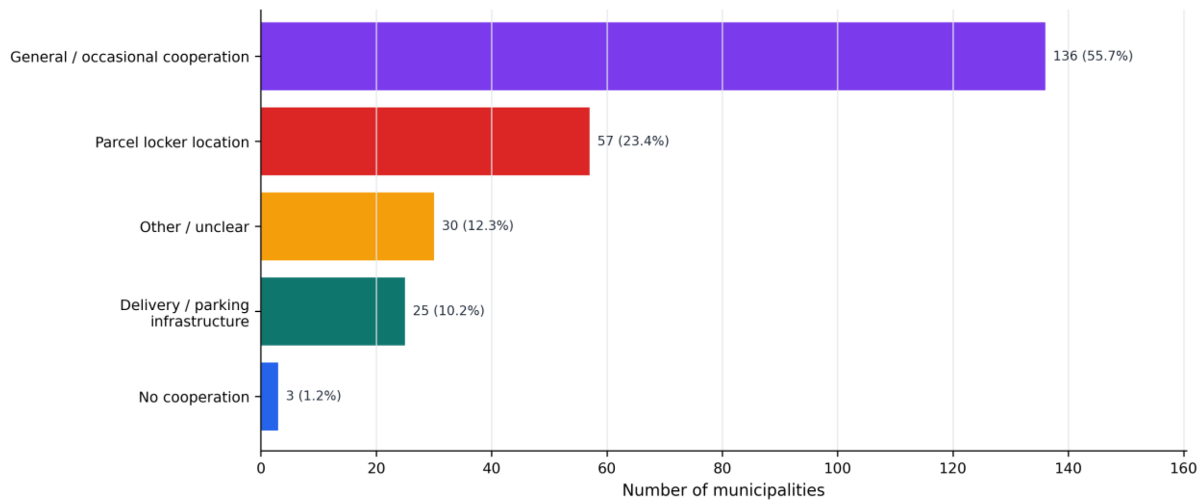

Fig. 50. Municipal cooperation with logistics operators

The next part of the study concerned solutions that have already been implemented or tested by municipalities (Fig. 51). The largest share of respondents indicated no implementations or tests. This category was assigned to 177 responses, i.e. 72,5% of the sample. This means that municipalities' practical experience in implementing urban logistics tools is limited.

Among implemented or tested measures, traffic organisation, signage or bans appear most often. This category appeared in 36 responses, representing 14,8% of the sample. The second type of measures is stopping or loading spaces - 12 indications, i.e. 4,9% of the sample. Delivery time regulations appeared in only one response, and parcel lockers or pick-up points as an implemented solution appeared in two responses. No implementations in the field of charging infrastructure or micro-hubs and consolidation were recorded.

These results indicate a clearly reactive and point-based character of actions taken so far. Where municipalities undertook interventions, these were usually measures within the traditional repertoire of traffic management: signage, bans, changes in traffic organisation or the designation of spaces. More complex solutions requiring cooperation between several entities, additional infrastructure or an operational model remain at a very early stage.

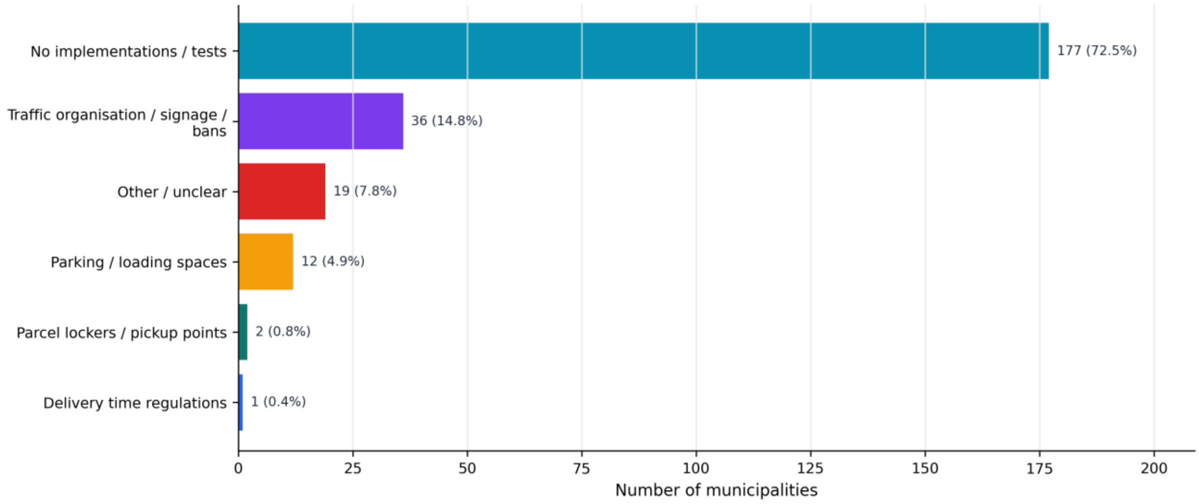

Fig. 51. Urban logistics measures already implemented or tested by municipalities

The comparison of solutions considered possible to introduce with solutions already implemented or tested, presented in Fig. 52, reveals a significant implementation gap. The largest difference concerns stopping and loading spaces. They were indicated 66 times as a possible solution, but only 12 times as a solution already implemented or tested. This means that municipalities relatively often recognise this instrument as needed or feasible, but much less often declare its actual application.

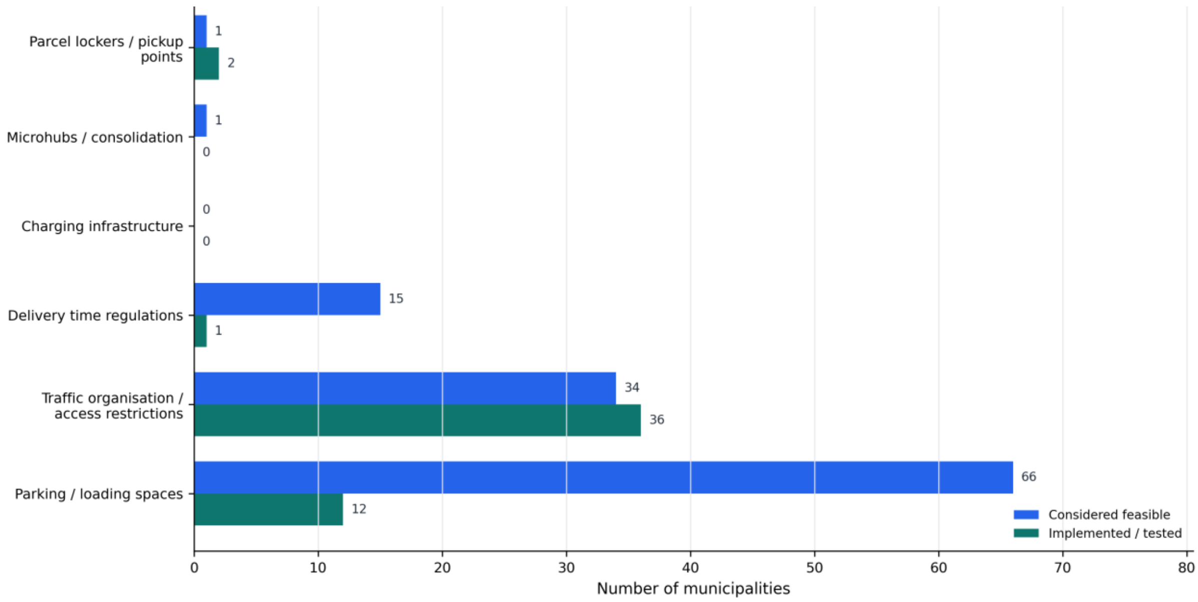

Fig. 52. Gap between feasible and implemented urban logistics measures

The situation is different in the case of traffic organisation and entry restrictions. This type of measure appeared 34 times as a possible solution and 36 times as an implemented or tested solution. This can be interpreted as evidence that traffic organisation tools are already more embedded in urban management practice than solutions dedicated directly to delivery logistics. However, the largest qualitative gap concerns more advanced solutions. Time windows or night deliveries were indicated 15 times as potentially possible, but only once as implemented. Micro-hubs and consolidation centres appeared once as a potential solution and not once as an implemented solution. Charging infrastructure, dynamic pricing and incentives for low-emission vehicles practically do not appear either in declarations or in implementations.

The gap between declared readiness and implementation practice is one of the most important conclusions. It shows that the development of urban logistics requires not only new technologies, but also organisational, regulatory and competence-related support for municipalities. Even relatively simple solutions, such as dedicated delivery spaces, require a process of location selection, consultation, signage, enforcement and monitoring of effects.

The final part of the questions concerned the assessment of the effects of solutions already implemented or tested. The responses are presented in Fig. 53. The largest share of responses again indicates no assessment or no implementations. This category was assigned to 177 responses, i.e. 72,5% of the sample. This result is a consequence of the low level of implementation: if a municipality has not tested solutions, it also cannot assess their effects.

Positive effects or benefits were indicated in 37 responses, representing 15,2% of the sample. Negative effects or side effects appeared in 7 responses, i.e. 2,9% of the sample. In 27 responses, the classification of the effect was ambiguous or concerned other themes. This means that where municipalities formulate an assessment of implemented measures, it is more often positive than negative.

The interpretation of these results requires caution. On the one hand, positive assessments are more numerous than negative ones, which may suggest that basic interventions in the field of traffic and stopping organisation bring noticeable benefits. On the other hand, the number of municipalities with implementation experience is limited, and some responses did not contain a precise evaluation. In practice, this means the need for greater systematicity in monitoring the effects of measures: before implementation, during the pilot phase and after its completion.

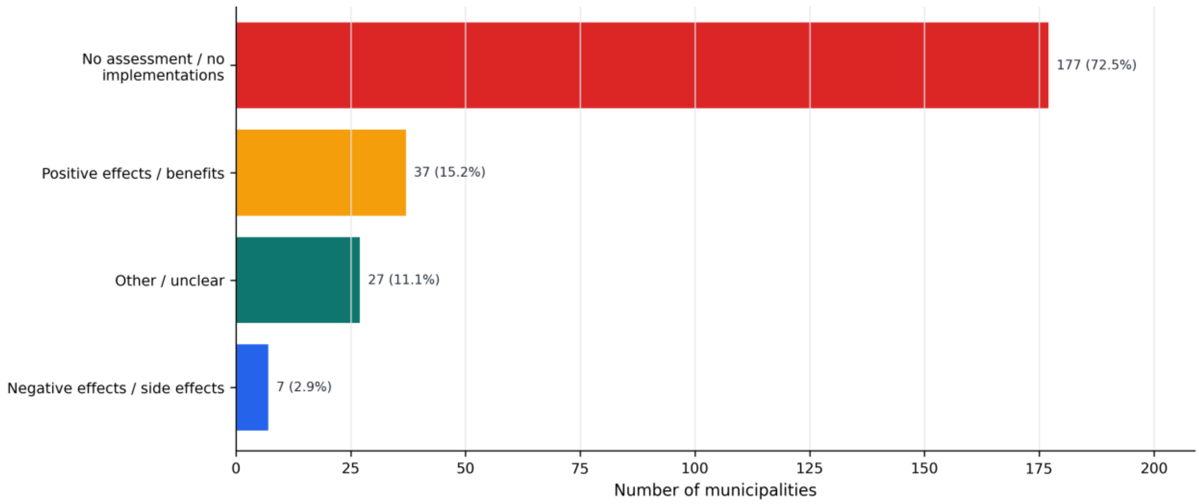

Fig. 53. Reported effects of implemented urban logistics measures.

Fig. 54 presents the classification of municipalities according to the relationship between the occurrence of problems and the undertaking of actions. The largest group consists of units classified as “no problems and no actions” - 115 responses, i.e. 47,1% of the sample. This means that almost half of the surveyed municipalities indicate neither the need for intervention nor active policy in the area of urban deliveries.

The second large group consists of municipalities defined as “problems and actions”. This category includes 99 responses, i.e. 40,6% of the sample. These are units that notice problems and at the same time indicate actions, cooperation or implementations. This group is the most important from the perspective of potential E-Laas pilots, as it combines problem recognition with readiness to act.

A small group of 3 responses, i.e. 1,2%, represents the profile “problems without actions”. This means that the diagnosis of a problem itself rarely remains completely without any indication of an instrument. In turn, 27 responses, i.e. 11,1%, were classified as preventive actions without clear problems. These are municipalities that indicate actions, cooperation or implementations, even though they do not declare clear problems. This may indicate a more proactive approach to the organisation of urban space or actions resulting from other planning processes.

The analysis of the perspective of cities and municipalities shows that urban logistics is not yet perceived in all units as one of the main areas of urban management. More than half of the respondents do not indicate clear problems related to deliveries, which may mean either a genuinely low scale of conflicts or limited systematic monitoring of this area. At the same time, where problems are noticed, they have a very specific and spatial character. They most often concern parking and stopping of delivery vehicles, blocking pavements, occupying pedestrian space and local traffic disruptions.

This structure of responses indicates that, from the perspective of local administration, urban logistics is primarily a problem of organising street space. It is not yet commonly associated with advanced systemic solutions such as micro-hubs, consolidation centres, charging infrastructure or dynamic pricing mechanisms. The most intuitive and acceptable tool remains dedicated stopping or loading spaces for deliveries. This solution responds directly to the most visible problems and at the same time falls within the traditional scope of municipal competences related to traffic organisation, parking and public space management.

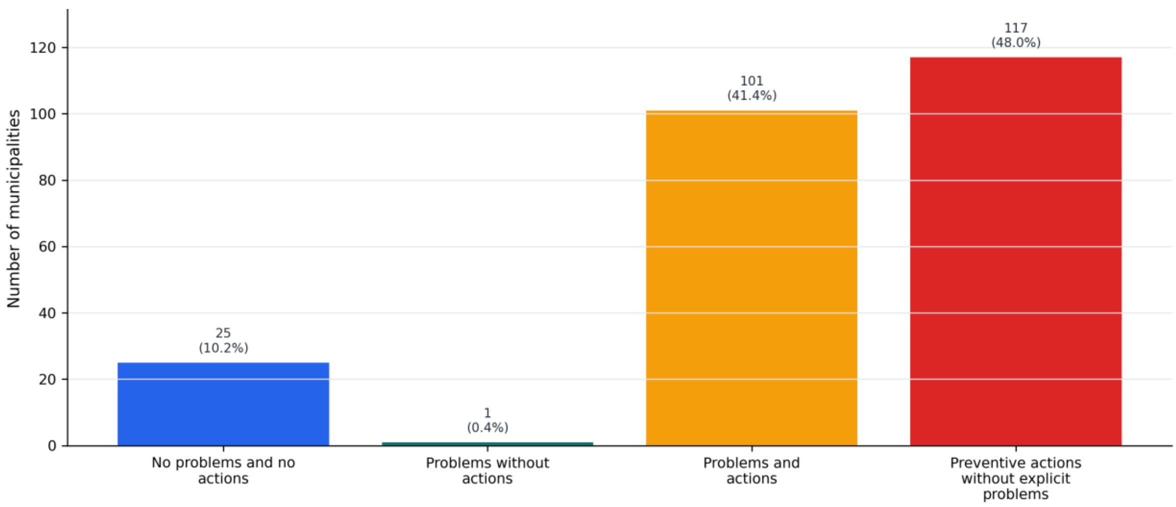

Fig. 54. Municipal profiles in relation to urban logistics problems and actions.

The results also show the limited scope of cooperation between municipalities and logistics operators. If such cooperation occurs, it most often concerns the location of parcel lockers or individual infrastructure elements, and less often comprehensive planning of the delivery system. This means that relations between local administration and the logistics sector are, in many cases, point-based and reactive rather than strategic. There is also a visible gap between the declared potential for action and the actual level of implementation. Some municipalities indicate possible instruments for improving delivery organisation, but significantly fewer units declare their actual testing or implementation.

8. Stakeholder preference insights

The analysis of stakeholder needs and preferences shows that the urban delivery system is not assessed according to a single set of criteria. Individual recipients, couriers and drivers, logistics operators, and cities and municipalities participate in the same process, but each of these actors perceives it through the lens of its own objectives, constraints and responsibilities. From the perspective of the project, this is of fundamental importance, because the energy efficiency of the first-/last-mile delivery system does not depend solely on vehicle technologies, route length or fleet structure. It is also the result of recipient behaviour, courier working conditions, the operational models of logistics operators, and the way urban space is managed by local administration.

Individual recipients assess logistics services primarily in terms of price, convenience, accessibility, flexibility and predictability. For many of them, direct home delivery remains the main reference point, as it minimises organisational effort and does not require any additional activity. At the same time, some users accept parcel lockers and pick-up points, especially when they are located close to their place of residence, work, school, shop or along the route of daily mobility. This means that recipients' preferences cannot be reduced to a simple choice between home delivery and out-of-home collection. Rather, the key issue is the relationship between price, convenience, control over the collection time, spatial accessibility of the pick-up point, and reduction of uncertainty associated with waiting for a courier.

The preferences and needs of couriers result from the practical conditions of carrying out deliveries. The availability of functional stopping places, the possibility of efficient service of parcel recipients, reduction of the time spent searching for a parking place, realistic time windows, and reduction of failed deliveries are of key importance. From their perspective, even a well-designed delivery system may be difficult to implement if it does not take into account the constraints occurring in the final section of the process: unloading, reaching the recipient, waiting time and returning to the vehicle. It is precisely at this level that many losses of time and energy become visible, although they are not apparent when only route length and the number of vehicles are analysed.

Logistics operators focus on cost efficiency, service reliability, fleet utilisation, route organisation and limiting implementation risk. Their preferences are strongly linked to the possibility of maintaining service quality at an acceptable cost level. For this reason, the low-emission transition, the shift to cargo bikes or electric vehicles, as well as the implementation of more complex delivery consolidation models, cannot be treated as neutral technological changes. For operators, they mean investment, organisational and operational decisions. They require available infrastructure, stable regulations, an appropriate parcel volume, and limited risk of deterioration in customer service quality.

Cities and municipalities view urban logistics as an element of managing public space, road safety and residents' quality of life. Their objective is to reduce the negative effects of deliveries, such as blocking pavements, parking in unauthorised places, occupying traffic lanes, increasing congestion and creating conflicts with other users of space. At the same time, the solution is not to restrict or create barriers for distribution systems, because urban logistics is a condition for the functioning of residents, commerce, gastronomy, municipal services and healthcare. Cities must therefore balance the need for efficient delivery services with the need to protect public space and achieve environmental objectives.

The comparison of these perspectives reveals that stakeholder preferences are partly convergent, but often also lead to tensions. The greatest risk of conflict appears when the benefits of one group are achieved by transferring costs, effort or additional constraints to another stakeholder group. Home delivery increases recipient convenience, but may increase pressure on the courier and street space, and may also involve higher service costs. Parcel lockers improve collection flexibility and facilitate delivery consolidation, but only if they are well located and do not generate additional trips by users. Urban regulations may reduce emissions and organise space, but they may also increase operators' costs and complicate route organisation. Fleet replacement with low-emission vehicles supports environmental objectives, but requires available charging infrastructure, financing and adjustment of operational processes.

8.1. Areas of conflict

The most visible conflict concerns the relationship between recipient convenience and the operational feasibility of delivery. Recipients often expect direct home delivery, short delivery times, the possibility of tracking the parcel and flexible selection of the collection time. From the courier's perspective, such a model means the need to reach a large number of individual addresses, find a stopping place, handle building access, contact the recipient and continue the route with limited time flexibility. If street space does not provide the possibility of legal and quick stopping, recipient convenience may lead to longer service time, more manoeuvres, illegal stops and a greater workload for couriers.

The second conflict concerns home delivery and out-of-home collection. Parcel lockers and pick-up points have the potential to increase operators' efficiency because they allow many parcels to be consolidated in one place and reduce the risk of recipient absence. For some users, they are also convenient solutions because they enable collection at any time. However, this benefit is not automatic. If the pick-up point is located too far away, requires a separate trip or is not linked to the user's daily mobility, it may be perceived as less convenient than home delivery. In such a case, improved efficiency on the operator's side may occur at the cost of additional effort by the recipient, while potential energy effects may be weakened by additional user trips.

The third conflict concerns the flexibility expected by recipients and the operational stability expected by operators. Users prefer the possibility of changing the delivery address, redirecting the parcel and receiving precise information about the delivery time. Operators, in turn, need stable routes, a high level of vehicle utilisation and a reduction in the number of failed delivery

attempts. The greater the individualisation of the service, the greater the requirements for planning, communication and route management systems. This tension can be reduced through better data exchange and dynamic delivery management, but it cannot be eliminated completely.
Further challenges concern the low-emission transition. Cities indicate the need to reduce emissions and energy consumption, while logistics operators assess fleet replacement through the lens of costs, reliability, vehicle availability, range and charging infrastructure. Couriers, in turn, need means of transport adapted to actual routes, parcel types, weather conditions and work rhythm. This means that changing the modal split cannot be designed solely as the substitution of internal combustion vehicles with electric vehicles or cargo bikes. It must take into account the type of service, route length, load capacity, time requirements and availability of supporting infrastructure.
Another conflict concerns urban regulations and operators' operational continuity. Cities may aim to introduce access restrictions, low-emission zones, designated delivery hours or new rules for using loading and unloading spaces. From the perspective of local administration, these are tools for organising space and reducing the negative impacts of deliveries. From the perspective of operators, however, they may mean the need to change routes, schedules, vehicle assignment, work organisation and cost structure. The condition for reducing this conflict is the predictability of regulations, their gradual implementation and their connection with the actual availability of alternative infrastructure.

8.2. Areas of converging expectations

Despite the tensions indicated above, the results of the analyses also show areas where stakeholder objectives may be convergent. The most obvious example is dedicated stopping, loading and unloading spaces for delivery vehicles. For couriers, they mean shorter time spent searching for a place and easier service of the address. For operators, they increase route predictability and reduce time losses. For cities, they reduce the risk of blocking pavements, traffic lanes and pedestrian space. For recipients, they may indirectly improve delivery punctuality and reliability. This is therefore a solution that does not eliminate all tensions, but may reduce their intensity.
The second area of convergence concerns well-located parcel lockers and pick-up points. If they are accessible on foot, connected with residents' daily routes and distributed evenly, they may simultaneously increase user convenience, improve operator efficiency, reduce the number of failed deliveries and reduce pressure on door-to-door deliveries. The condition, however, is active management of their location, and not only market-driven expansion of pick-up points in places that are easiest or most profitable for operators.
Improving delivery predictability and communication with the recipient is also an area of potential convergence. Users gain greater control over parcel collection, operators can reduce the number of failed deliveries, and for local administration this means fewer vehicles circulating around the city. At the same time, it should be remembered that overly precise time commitments may increase pressure on couriers, especially under conditions of variable traffic, parking problems and unpredictable events along the route. Therefore, improved communication should be linked to realistic route planning and an operational buffer.
Another solution with compromise potential is represented by micro-hubs, delivery concentration points and load consolidation. They can support operators' objectives because

they enable better organisation of deliveries in dense urban areas. They can support city objectives because they reduce the number of vehicles serving the same area and enable the use of lighter, low-emission means of transport on the final section. They can also improve couriers' working conditions if they shorten routes and facilitate service in areas with a high density of deliveries. Their implementation, however, requires available space, a cooperation model, an appropriate parcel volume and a clear division of responsibilities between operators and the city.

Convergence can also be sought in the gradual implementation of low-emission solutions. For cities, they mean emission reduction and improvement of urban space quality. For operators, they may become attractive if they are linked to access to charging infrastructure, predictable rules for using urban areas, financial incentives and real operational benefits. For users, they will be acceptable if they do not worsen convenience, accessibility and service price, and for couriers if they do not worsen their working conditions.

8.3. Implications for the project

The identified conflicts and convergences show that the solution should not be the selection of one dominant delivery model. A multi-faceted approach is more appropriate, in which different distribution models form elements of one system. Their usefulness depends on location, user profile, infrastructure availability and operational conditions.

The most important solutions are those that do not unilaterally transfer costs to one stakeholder group. If improving operator efficiency takes place at the cost of greater effort by the recipient, social acceptance may be limited. If the city's environmental objectives are implemented through regulations that do not take into account operators' costs and constraints, implementation may encounter resistance or lead to deterioration in service quality. If improving delivery predictability increases pressure on couriers, it may reduce actual feasibility. Therefore, stakeholder preferences should be analysed not only separately, but also relationally.

In practice, this means that the project should support the identification of compromise solutions. Such solutions include, above all, dedicated delivery spaces, well-located pick-up points, realistic time windows, gradual fleet transformation, and micro-hubs implemented in areas with sufficient demand potential. Their common feature is that they can improve energy efficiency while remaining socially acceptable and operationally feasible.

The results of the analysis also indicate that preference conflicts should not be treated solely as barriers. They are an important source of knowledge for scenario modelling. They show which parameters should be included in further analyses, which constraints should be tested and where boundary conditions for implementation may appear. Recipients' preferences influence the choice of delivery channel, acceptable distance to the pick-up point and expectations regarding service time. Couriers' needs influence stopping parameters, service time and actual route productivity. Operators' barriers influence the modal split, fleet structure and the pace of the low-emission transition. The city perspective influences the availability of space and the possibilities for locating infrastructure. Thus, the main challenge is not only to design an energy-efficient system, but also to find such a configuration of services, infrastructure and regulations that will be acceptable to recipients, feasible for couriers, rational for operators and possible for cities to implement.

9. Translation of stakeholder preferences into simulation scenario parameters

The obtained results show that stakeholder needs and preferences should not be treated merely as a description of the project's social context. Their most important role lies in the fact that they can be translated into specific parameters of simulation scenarios. As a result, the modelling of urban logistics flows is not based solely on technical assumptions concerning vehicles, routes, distances or energy consumption, but also takes into account the actual behaviour of recipients, the operational constraints of couriers, the decisions of logistics operators, and the spatial and regulatory conditions on the side of cities.

Table 2 organises the most important stakeholder needs and indicates their relevance for the project scenarios. This table shows that the needs of users, couriers, operators and cities do not function separately, but are linked to specific elements of simulation models.

9.1. From stakeholder needs to model variables

Translating stakeholder needs into model variables requires organising them according to the scenario logic defined in D0.3. In the WP2 simulation-oriented scope, three active scenario groups are of primary importance: BS/AS 1.1, BS/AS 1.2 and BS/AS 1.3. Parcel deliveries to parcel lockers and direct home parcel deliveries are complementary channels within BS/AS 1.3. Pharmaceutical delivery (BS/AS 1.4) and B2B urban freight deliveries (BS/AS 1.5) provide supplementary empirical context and directions for future research. Each of these segments has a different operational logic, demand profile, time requirements and potential for using alternative means of transport.

Ready-made food deliveries are strongly dependent on delivery time, local demand, courier availability and the possibility of moving quickly within urban areas. In this case, user preferences primarily concern speed, predictability and service quality, while the preferences of couriers and operators concern efficient route organisation and the possibility of using means of transport adapted to short, dynamic deliveries. In scenarios BS 1.1, AS 1.1.1, AS 1.1.2, and AS 1.1.3, these preferences can be reflected through the share of individual means of transport, speed, service time, vehicle capacity, energy consumption, emissions, order intensity, courier workload and the system's ability to serve increased demand.

Boxed meal deliveries have a different character. They are more planned, repetitive and more strongly linked to specific time windows, often morning or night windows. User preferences concern punctuality and reliability, while operators focus on route optimisation, vehicle utilisation and service provision for a large number of recurring recipients. In scenario BS 1.2, variables such as the number of recipients, route structure, time windows, service time, vehicle type and load capacity are important. In scenarios AS 1.2.1, AS 1.2.2, and AS 1.2.3, the key issue is whether low- or zero-emission fleet structures can maintain punctuality, capacity and service quality under different demand conditions.

In the case of parcel delivery, one common parcel demand is distributed between home delivery and parcel locker channels. Recipient preferences regarding flexibility, spatial accessibility and the method of parcel collection are therefore particularly important. Parcel lockers can increase operators' efficiency because they allow many parcels to be delivered to one point, but their actual energy effect also depends on user behaviour. If parcel collection takes place during a daily trip, the impact on additional energy consumption may be low. If, however, it requires a separate car trip, the benefits on the operator's side may be partially reduced. In the BS/AS 1.3 scenario group, relevant variables include the home/parcel locker channel split, parcel locker location and capacity, acceptable and actual walking time to the parcel locker, recipient pick-up behaviour, probability of home delivery, probability of failed delivery, route length, vehicle structure, and the eligibility of parcels for drone-based variants. The relevant alternatives include low- and zero-emission operator fleet variants, drone-based variants, and channel-split variants between home delivery and parcel locker delivery.

Direct home parcel delivery should be interpreted as one of the channels within BS 1.3 – Parcel delivery with home and parcel locker channels. It is particularly relevant for analysing the tension between recipient convenience and operational pressure on couriers and operators. The variant most directly related to this issue is AS 1.3.9, while AS 1.3.5–AS 1.3.8 describe different channel-split configurations between home delivery and parcel locker delivery.

Pharmaceutical delivery and B2B urban freight deliveries remain important for interpreting stakeholder needs and provide supplementary context for future extensions of the E-Laas methodology.

9.2. Preferences influencing modal split

One of the most important areas in which stakeholder preferences are translated into scenarios is the modal split, i.e. the share of individual means of transport in delivery services. In projects focused on energy efficiency, modal split is usually treated as a technical parameter related to vehicle type, energy consumption and emissions. In the E-Laas project, however, it should be interpreted more broadly, as the result of the relationship between user preferences, courier capabilities, operator decisions and city policies.

From the recipients' perspective, a change in modal split is acceptable primarily when it does not reduce service quality. Users may evaluate low-emission solutions positively, but they expect delivery to remain punctual, convenient and predictable. This means that modal split scenarios cannot assume an automatic shift to cargo bikes, electric scooters or electric vehicles without taking into account the type of parcel, distance, weather conditions, load capacity and time requirements.

From the perspective of couriers and drivers, modal split is linked to work feasibility. Light means of transport may be beneficial in compact urban areas, but their usefulness depends on load capacity, safety, weather, route length and infrastructure availability. From the perspective of operators, modal split depends on costs, vehicle availability, charging possibilities, range, fleet utilisation and operational stability. From the perspective of cities, changing the modal split is one of the tools for reducing emissions, noise and pressure on street space.

In simulation scenarios, these preferences translate into variables such as the share of internal combustion vehicles, electric vehicles, cargo bikes, e-bikes, scooters or other light vehicles, average speed, vehicle capacity, access restrictions to the network, energy intensity, emissions and the possibility of serving specific cargo types. The strongest link with modal split occurs in AS 1.1.1, AS 1.2.1, AS 1.3.1, AS 1.3.2 and AS 1.3.3. AS 1.3.4 and AS 1.3.10 may be interpreted as additional technological variants of the parcel delivery scenario group.

9.3. Preferences influencing demand

Demand is a key area of analysis. The results of stakeholder research make it possible to better understand which services are used, under what conditions demand may increase, and which user groups generate specific types of deliveries. Demand should not be modelled solely as the number of orders assigned to an area. It should reflect the type of service, frequency of use, spatial distribution of recipients, seasonality, peak periods, temporal profile of orders and acceptance of different delivery forms.

User preferences influence demand in several dimensions. In the case of ready-made food, the speed and availability of the service are important, which may generate strong peaks in orders at specific times of the day. In the case of boxed meals, demand is more regular and planned, linked to repeated deliveries. In the case of parcels, demand depends on shopping behaviour, availability of the collection channel and preferences concerning home delivery or parcel locker collection. In the case of B2B and pharmaceutical services, demand may have a more specialised character, resulting from the cargo type, time requirements and recipient organisation.

In simulation scenarios, demand may be represented by the number of orders/parcels, number of recipients, delivery frequency, temporal distribution of orders, spatial distribution of recipients and the number of active couriers required to operate the system. The most direct link with demand occurs in AS 1.1.2, AS 1.1.3, AS 1.2.2, and AS 1.2.3. However, the results of D2.2 can also feed into BS 1.3, because the choice of collection form and the location of pick-up points influence the distribution of common parcel demand between direct home delivery and out-of-home collection.

9.4. Preferences influencing the choice of pick-up points

The choice of pick-up points is one of the most important areas in which user preferences directly influence the structure of scenarios. A parcel locker or pick-up point is attractive to the user when it reduces time uncertainty and gives the possibility to independently choose the collection time. This does not mean, however, that every pick-up point will be equally beneficial. Its spatial accessibility, connection with residents' daily behaviour and the possibility of collecting the parcel without generating an additional trip are crucial.

For operators, pick-up points are a way to consolidate deliveries and reduce the number of individual addresses. For cities, they may be a tool for reducing pressure on door-to-door deliveries, but at the same time they require control over location, spatial order, safety and pedestrian accessibility. Therefore, parcel locker scenarios must combine the operator's perspective with the user and city perspectives.

In the model, the choice of pick-up point can be described by variables such as parcel locker location, parcel locker capacity, walking time, distance from the place of residence or work, share of collections made during other activities, means of transport used by the recipient, probability of choosing a parcel locker and probability of ordering delivery from a pick-up point. These issues should be interpreted as part of BS 1.3, especially the channel-split variants AS 1.3.5–AS 1.3.9. Where drone-based delivery is considered, AS 1.3.4 and AS 1.3.10 are also relevant, as they allow not only the operator's logistics to be analysed, but also recipient behaviour on the final section of the process.

9.5. Preferences influencing time windows and delivery service

Time preferences are important in all delivery segments, but their significance differs depending on the type of service. In ready-made food deliveries, time is critical because delays directly affect service quality. In boxed meal deliveries, punctuality and alignment with defined delivery windows are important. In parcel deliveries, recipients expect predictability, tracking possibilities and reduced uncertainty related to being at home. In the case of parcel lockers, the time of delivery to the pick-up point is important, but the flexibility of collection by the user plays a greater role.

In simulation models, time preferences may be represented by the length of the time window, acceptable delay, temporal demand profile, waiting time, service time, walking time from the vehicle to the recipient, loading and unloading time, time spent searching for a stopping place and probability of failed delivery. Data concerning couriers and drivers are particularly important here, as they show that the actual delivery time does not result solely from travel on the transport network. It is also the result of many auxiliary activities, such as parking, walking, contact with the recipient, handing over the parcel and returning to the vehicle.

Scenarios BS 1.1 - BS 1.3 should particularly take these parameters into account, as they concern time-sensitive services, planned deliveries or parcel delivery channels involving direct interaction with recipients. In the parcel delivery scenario group, these parameters are especially relevant for the home-delivery channel and AS 1.3.9, as they concern time-sensitive services or direct deliveries to individual recipients. Demand increase variants, such as AS 1.1.2 and AS 1.2.2, additionally make it possible to test whether the system maintains service quality with a higher number of orders and whether demand growth leads to economies of scale or rather to resource overload.

9.6. Preferences influencing consolidation and concentration points

Delivery consolidation, micro-hubs and concentration points are solutions that can reduce the number of parallel trips, improve vehicle utilisation and enable last-mile service using lighter or low-emission means of transport. From the perspective of operators, they may increase route efficiency, but they require an appropriate parcel volume, coordination and additional transhipment organisation. From the perspective of cities, they may reduce the number of delivery vehicles in the most congested areas, but they require available space and integration with urban policy. From the perspective of couriers, they may improve working conditions if they shorten routes and reduce the number of problematic stops, but they may also introduce additional organisational activities.

In simulation scenarios, consolidation can be described by the number of concentration points, their location, capacity, consolidation time, service area, assignment of recipients to points, change in route length, number of vehicles, number of stops and load capacity utilisation rate. In the scenario structure, consolidation and concentration points should be treated primarily as supplementary model variables or possible future extensions, unless they are explicitly introduced as active alternative scenarios. Their logic may support the interpretation of BS 1.2 and BS 1.3, especially where delivery density, route shortening, transfer points or micro-hubs are analysed. They allow an assessment of whether delivery concentration leads to reduced distance, time, energy consumption and emissions, and whether it does not generate excessive organisational costs.

9.7. Preferences influencing infrastructure and regulatory parameters

The results concerning cities, municipalities, operators and couriers indicate that infrastructure and regulations are a condition for scenario feasibility. The availability of stopping, loading and unloading places directly affects service time, punctuality, the number of illegal stops and couriers' working comfort. Charging infrastructure influences the possibility of using electric vehicles. Access regulations, low-emission zones and time restrictions influence the accessibility of city zones for different vehicle types and route organisation.

In scenario models, these parameters can be described by the number and location of delivery spaces, distance from the stopping place to the recipient's address, probability of no available space, access restrictions for selected vehicle types, charger availability, charging time, access cost, detour length and the possibility of serving specific city zones. These variables are cross-cutting in nature and may influence many scenarios simultaneously, especially BS 1.1 - BS 1.3. They are particularly relevant for AS 1.3.1–AS 1.3.3 and the channel-split variants AS 1.3.5–AS 1.3.9. They also provide feasibility context for BS 1.4 and BS 1.5, which are retained as future research proposals.

9.8. Relationship between preferences, scenarios and KPI assessment

The ultimate purpose of translating stakeholder preferences into scenario parameters is the possibility of comparing E-Laas system variants using KPI indicators. Report D0.2 indicated that scenarios should be assessed not only in terms of distance, time, energy, fuel and CO_2 emissions, but also in terms of service quality, punctuality, accessibility, vehicle utilisation, costs, the number of served and unserved orders, and potential impact on users and the local community.

Stakeholder preferences therefore influence not only model inputs, but also the way results are interpreted. A scenario that reduces emissions but significantly worsens user convenience or increases pressure on couriers may be difficult to implement. A scenario that improves operator efficiency but generates additional recipient trips to pick-up points may have a less favourable energy balance than would result from analysing the operator's route alone. A scenario that increases the share of low-emission vehicles but does not take into account charging infrastructure and range limitations may be environmentally correct, but operationally infeasible.

Therefore, in scenario assessment, energy and emission indicators should be combined with operational and social parameters. The most important issue is not only which variant has the lowest energy consumption in the model, but also whether it is possible to implement with existing or realistically developed infrastructure resources, whether it responds to recipients' needs, whether it does not excessively worsen couriers' working conditions, and whether it is acceptable to operators and cities. For this reason, translating stakeholder preferences into scenario parameters is one of the most important results of the research conducted. The most important relationships can be grouped into several categories.

Table 2. Matrix of relationships between stakeholder needs, model variables and project scenarios

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Users/customers	Preference for convenient home delivery	Defines the baseline level of acceptance for changes in last-mile delivery models. Door-to-door delivery remains a reference point for evaluating alternatives.	Share of door-to-door deliveries, number of delivery addresses, density of pick-up points, service time, failed delivery rate	BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.9 Direct home parcel delivery only; AS 1.3.1 Low-emission moderate parcel delivery; AS 1.3.2 Low-emission high parcel delivery; AS 1.3.3 Zero-emission parcel delivery
Users/customers, cities, logistics operators	Preference for parcel lockers and pick-up points	Determines whether out-of-home delivery improves flexibility and reduces repeated delivery attempts or generates additional user trips.	Share of parcel locker deliveries, acceptable access time to parcel locker, pick-up trip mode, pick-up during daily mobility	BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.5 Parcel locker only channel; AS 1.3.6 Major parcel locker share; AS 1.3.7 Equal home and parcel locker share; AS 1.3.8 Minor parcel locker share; AS 1.3.4 Drone delivery from parcel lockers
Users/customers, cities, logistics operators	Need for parcel lockers and pick-up points located on everyday routes	Links logistics services with everyday mobility and determines the real accessibility and energy effect of parcel lockers.	Location of parcel lockers, distance from home/work, acceptable access time to parcel locker, share of pick-ups combined with other activities	BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.5 Parcel locker only channel; AS 1.3.6 Major parcel locker share; AS 1.3.7 Equal home and parcel locker share; AS 1.3.8 Minor parcel locker share; AS 1.3.4 Drone delivery from parcel lockers

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Users/customers, logistics operators, couriers, cities	Acceptance and operational feasibility of low-emission delivery modes	Determines the energy and emission effects of replacing conventional vehicles with EVs, cargo bikes, e-bikes, scooters or other light vehicles.	Vehicle type, vehicle range, vehicle speed, vehicle energy consumption, access restrictions	AS 1.1.1 Low-emission modal split in ready-made food delivery; AS 1.1.2 Demand increase and high low-emission share in ready-made food delivery; AS 1.1.3 Demand increase and zero-emission structure in ready-made food delivery; AS 1.2.1 Electric mix in boxed meal delivery; AS 1.2.2 Demand increase and electric vans in boxed meal delivery; AS 1.2.3 Demand increase and zero-emission boxed meal delivery; AS 1.3.1 Low-emission moderate parcel delivery; AS 1.3.2 Low-emission high parcel delivery; AS 1.3.3 Zero-emission parcel delivery
Users/customers, logistics operators, couriers	Frequency and intensity of using delivery services	Determines the scale of logistics flows, fleet requirements, courier workload and possible congestion of delivery operations.	Number of parcels, temporal demand profile, peak-hour demand, spatial distribution of demand, number of active vehicles	AS 1.1.2 Demand increase and high low-emission share in ready-made food delivery; AS 1.1.3 Demand increase and zero-emission structure in ready-made food delivery; AS 1.2.2 Demand increase and electric vans in boxed meal delivery; AS 1.2.3 Demand increase and zero-emission boxed meal delivery; BS 1.3 Parcel delivery with home and parcel locker channels

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Users/customers, logistics operators, couriers	Need for predictable and timely delivery	Affects service quality, routing constraints, workload pressure and the reliability of delivery operations.	Delivery time window, delay tolerance, punctuality, waiting time, service time, delivery time deviation, failed delivery rate	BS 1.1 Ready-made food delivery; BS 1.2 Boxed meal delivery to homes and offices; BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.9 Direct home parcel delivery only
Users/customers, logistics operators, couriers	Need for fast delivery of meals and other time-critical goods	Particularly important for ready meals, groceries and boxed meals, where delays directly reduce service quality.	Maximum acceptable delivery time, time from order to delivery, waiting time, peak-hour order volume	BS 1.1 Ready-made food delivery; AS 1.1.1 Low-emission modal split in ready-made food delivery; AS 1.1.2 Demand increase and high low-emission share in ready-made food delivery; AS 1.1.3 Demand increase and zero-emission structure in ready-made food delivery; BS 1.2 Boxed meal delivery to homes and offices
Users/customers, logistics operators, couriers	Need to maintain product quality during transport	Important for fresh products, boxed meals, pharmaceuticals and other cargo requiring specific handling or temperature conditions.	Cargo type, weight and volume, perishability, temperature requirement, service time, eligibility of transport mode, share of vehicles with thermal equipment	BS 1.2 Boxed meal delivery to homes and offices; BS 1.4 Pharmaceutical delivery in urban areas; AS 1.4.1 Modal split change in institutional pharmaceutical deliveries; AS 1.4.2 Pharmacy-to-home delivery

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Users/customers, logistics operators, couriers, cities	Need for legal and accessible stopping, loading and unloading space	Reduces time losses, illegal stopping, traffic conflicts and uncertainty in the last-mile process.	Number of delivery stopping places, distance from stopping place to recipient, search time for stopping place, probability of no available space, stopping duration	BS 1.1 Ready-made food delivery; BS 1.2 Boxed meal delivery to homes and offices; BS 1.3 Parcel delivery with home and parcel locker channels; BS 1.4 Pharmaceutical delivery in urban areas; BS 1.5 B2B urban freight deliveries
Users/customers, logistics operators, couriers	Need to reduce repeated delivery attempts	Improves reliability, reduces additional trips and limits wasted time and energy.	User absence probability, number of repeated delivery attempts, share of redirections to pick-up points, failed delivery rate	BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.5 Parcel locker only channel; AS 1.3.6 Major parcel locker share; AS 1.3.7 Equal home and parcel locker share; AS 1.3.8 Minor parcel locker share; AS 1.3.9 Direct home parcel delivery only
Users/customers, couriers, cities	Need to reduce duplicated routes and improve vehicle utilisation	Supports energy efficiency through fewer parallel trips, better vehicle utilisation and more structured last-mile operations.	Number and location of concentration points, service area, consolidation time, vehicle load factor, number of stops, route length	BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.5 Parcel locker only channel; AS 1.3.6 Major parcel locker share; AS 1.3.7 Equal home and parcel locker share; AS 1.3.8 Minor parcel locker share

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Users/customers, couriers, cities	Need for more efficient organisation of dense urban delivery areas	Enables reorganisation of the last mile, supports low-emission modes and reduces pressure on dense urban areas.	Micro-hub location, operating hours, consolidation time, assigned delivery zones, last-mile vehicle type	BS 1.1 Ready-made food delivery; BS 1.2 Boxed meal delivery to homes and offices; BS 1.3 Parcel delivery with home and parcel locker channels
Logistics operators	Need to limit economic risk of low-emission transition	Determines the real feasibility of replacing conventional fleets with low- or zero-emission vehicles.	Vehicle purchase cost, vehicle operating cost, vehicle energy cost, vehicle charging cost, vehicle payback period, vehicle subsidy level, fleet replacement rate	AS 1.1.1 Low-emission modal split in ready-made food delivery; AS 1.1.2 Demand increase and high low-emission share in ready-made food delivery; AS 1.1.3 Demand increase and zero-emission structure in ready-made food delivery; AS 1.2.1 Electric mix in boxed meal delivery; AS 1.2.2 Demand increase and electric vans in boxed meal delivery; AS 1.2.3 Demand increase and zero-emission boxed meal delivery; AS 1.3.1 Low-emission moderate parcel delivery; AS 1.3.2 Low-emission high parcel delivery; AS 1.3.3 Zero-emission parcel delivery

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Logistics operators, couriers, cities	Need for reliable charging access for EV-based delivery models	Conditions the feasibility of EV scenarios, even when charging is treated as a supplementary scenario attribute.	Number of chargers, charger location, charging time, charger availability, vehicle range, detour to charger, charging during route	AS 1.1.1 Low-emission modal split in ready-made food delivery; AS 1.1.2 Demand increase and high low-emission share in ready-made food delivery; AS 1.1.3 Demand increase and zero-emission structure in ready-made food delivery; AS 1.2.1 Electric mix in boxed meal delivery; AS 1.2.2 Demand increase and electric vans in boxed meal delivery; AS 1.2.3 Demand increase and zero-emission boxed meal delivery; AS 1.3.1 Low-emission moderate parcel delivery; AS 1.3.2 Low-emission high parcel delivery; AS 1.3.3 Zero-emission parcel delivery
Logistics operators, couriers, cities	Need to organise access to urban space and reduce external effects	Determines whether scenarios are implementable under urban restrictions and whether low-emission logistics can be supported by access rules.	Access restrictions, delivery time restrictions, restricted zones, detour distance, access cost, vehicle eligibility for specific zones	BS 1.1 Ready-made food delivery; BS 1.2 Boxed meal delivery to homes and offices; BS 1.3 Parcel delivery with home and parcel locker channels; BS 1.4 Pharmaceutical delivery in urban areas; BS 1.5 B2B urban freight deliveries

Stakeholder group	Stakeholder needs	Relevance for the project	Model variable	Project scenario
Logistics operators, couriers, cities	Need to maintain service reliability under difficult weather conditions	Affects the feasibility of light vehicles, travel speed, productivity and service reliability.	Speed correction factor, productivity reduction, delay tolerance, share of weather-constrained days, mode availability under weather conditions	BS 1.1 Ready-made food delivery; BS 1.2 Boxed meal delivery to homes and offices; BS 1.3 Parcel delivery with home and parcel locker channels; AS 1.3.4 Drone delivery from parcel lockers; AS 1.3.10 Drone-only direct parcel delivery
Logistics operators, cities	Need to account for larger loads and different delivery relations	Represents delivery processes with different cargo structure, vehicle requirements and spatial relations than consumer deliveries.	Cargo weight/volume, vehicle type, number of delivery points, delivery time windows, loading/unloading time	BS 1.5 B2B urban freight deliveries; AS 1.5.1 Alternative low-emission modes in B2B deliveries
Users/customers, logistics operators	Need to account for sensitive and potentially urgent urban deliveries	Represents a specialised segment requiring attention to time, reliability, handling and possibly temperature control.	Delivery urgency, cargo sensitivity, temperature requirements, service time, vehicle type, delivery reliability	BS 1.4 Pharmaceutical delivery in urban areas; AS 1.4.1 Modal split change in institutional pharmaceutical deliveries; AS 1.4.2 Pharmacy-to-home delivery

10. Conclusions

The analyses conducted confirm that the design of urban distribution systems requires a multidimensional approach combining the expectations of different stakeholders. Urban logistics cannot be interpreted solely as a problem of route optimisation or fleet replacement with low-emission vehicles. It is a system dependent on recipient behaviour, the organisation of couriers' work, operators' investment decisions and the way urban space is managed. For this reason, energy efficiency should be analysed together with service quality, operational feasibility and social acceptance.

The research results indicate that stakeholder needs are partly convergent, but often also generate tensions. Recipients expect convenience, flexibility and delivery predictability. Couriers need conditions that enable efficient route execution, especially access to stopping places, reduced time losses and realistic conditions for serving addresses. Operators focus on costs, reliability, fleet utilisation and limiting implementation risk. Cities and municipalities perceive urban logistics through the lens of road safety, spatial order, congestion and the quality of public space. Therefore, the project should focus on solutions that balance these perspectives, rather than maximising the benefits of only one group.

The clearest example of tension remains the relationship between the convenience of home delivery and operational and spatial constraints. Direct delivery minimises the recipient's effort, but increases the number of stops, pressure on couriers and the risk of conflicts in street space. Parcel lockers and pick-up points, in turn, may improve operators' efficiency and users' flexibility, but their actual effect depends on location and on whether parcel collection is integrated into residents' daily mobility. This means that delivery channels should be treated as complementary rather than competing solutions.

Dedicated stopping, loading and unloading spaces are a particularly important area of shared benefits. Their importance results from the fact that they simultaneously affect couriers' working conditions, operators' operational predictability, order in urban space and the reliability of service for recipients. In practice, they are one of the most direct instruments for reducing time and energy losses in the last mile. For this reason, the availability of delivery spaces should be treated not only as a traffic organisation issue, but also as a parameter relevant to modelling the energy efficiency of the system.

The transition towards an energy-efficient system should be gradual and conditional. The results of the operator survey show that changes in fleet structure are strongly linked to investment costs, charging infrastructure availability, vehicle range, technology reliability and operational stability. Electric vehicles, cargo bikes, e-bikes and other light means of transport may reduce emissions and energy consumption, but their use must be adapted to the parcel type, route length, load capacity, weather conditions and work organisation. For this reason, the project should treat modal split scenarios as realistic operational variants, rather than as a simple substitution of one vehicle type with another.

An important conclusion is the need to link stakeholder needs with simulation scenarios. Preferences concerning the delivery form affect the share of home deliveries, parcel lockers and pick-up points. Spatial preferences affect the location and attractiveness of pick-up points. Time preferences shape delivery windows, delay tolerance and service requirements. Couriers' problems translate into operational times, time spent searching for a stopping place and the probability of disruptions. Operators' barriers affect fleet structure, costs, modal split and the possibility of consolidation.

A segmentation-based approach to analysis is also of key importance. Ready-made food deliveries, boxed meal deliveries, parcel delivery with home and parcel locker channels, pharmaceutical deliveries and B2B deliveries differ in terms of demand profile, time requirements, cargo type, route structure and susceptibility to consolidation. They should not be modelled according to one universal scheme. Scenarios should take into account the specificity of each segment, because the same change, for example fleet electrification or the introduction of concentration points, may have different effects depending on the type of service.

Ultimately, the results indicate that the project should develop a system supporting the coordination and assessment of urban logistics variants, rather than a single technological solution. The greatest potential lies in measures that simultaneously reduce energy consumption, improve service reliability, decrease pressure on street space and are feasible for operators and cities to implement. Such measures include, in particular, better location of pick-up points, organisation of delivery spaces, consolidation and micro-hubs in areas with appropriate demand potential, and the gradual transformation of the vehicle fleet.