INNOVATIVE LAST MILE SOLUTIONS

TO STRENGTHEN COMBINED TRANSPORT

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CONTENT

1 INTRODUCTION

In the Baltic Sea Region (BSR), an important part of border-based, big market competition is the use of Combined Transport (CT) development from road heavy haulage. BSR is home to a number of international road transport companies. Statistically, nearly two-thirds of Europe's heavy-duty fleet is registered in the BSR. Such a developed market puts competition pressure not only internally but also on potential substitute means—including CT. As a result, it is crucial to understand the need to constantly develop necessary technologies in all CT operations to continuously improve upon economic effectiveness which can lead to better competition potential in the road haulage market. A closer look at the costs of the whole CT chain indicates that the largest costs per unit are connected with last or first mile operations, playing a crucial role for the overall CT chain efficiency.

Last and first mile in the framework of CT definitions are understood as the shortest possible initial or final leg of transport via road. Directive 92/106 known as the "Combined transport directive" precisely defines the distances of last mile operations. Article no.1 states that the initial or final leg should take place:

- between the nearest suitable rail loading station and loading or delivery point or
- within a 150km radius from a seaport or inland waterway port.

In reference to Directive 92/106, the authors originally began piecing together this report from a point of view of verifying whether or not rail transport is a practical means for ITU door deliveries. To better understand the BSR CT market, no practical examples were found—hence no input in the matter is presented.

The output of the research looks at various BSR-based companies by examining CT last and first mile frameworks. To date, not all cargo companies are using the siding and rail door method since it can be expensive to implement and is not always economically viable, e.g., the Warsaw plant (i.e., one of the biggest players in the FMCG market). This plant, an exception to the general market rule, compels cargo owners to use rail as a last mile solution since no access to rail siding or warehousing fitted with rail ramps are available. As a result, additional infrastructure investments are required including changes in spatial planning for logistic parks and the rebuilding of transport chains.

Nonetheless, the utility and accessibility of using railway siding still plays a significant role in terms of the total volume of CT units loaded and discharged annually. The use of external CT terminals still helps to keep companies economically efficiency during sizable fluctuation in cargo volume. For example in the BASF plant in Ludwigshafen, it is serviced via an external terminal and allows for performance enhancements as well as expansive cargo not limited to BASF (i.e., it allows access to non-BASF cargo use). Throughout BSR similar models, e.g., PCC Intermodal's facilities in Brzeg, are developed and continue to play an important role in the overall systemization of the loading and delivery point models used throughout the region.

Defining the innovation is not a strict task. Some sources state that there are more than 40 definitions of innovation depending on context of discipline in which innovation is referenced. The most used and widely accept the definition published by the OECD Oslo Manual:

An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).

Based on the above definitions and market experience, innovations in last mile solutions are closely connected with the innovations in road transport in general. The report consists of three key chapters: (1) increasing capacity, (2) alternative propulsion and supporting tools, and (3) providing the latest innovations which can have real influence on last mile operations.

Increasing capacity puts pressure on innovation which allows for a gain in efficiency on last mile operations. Referring to the definition, the capacity of the last mile has direct influence of economic spheres of the process. This chapter shows three innovative solutions for the different phases of development, that is: longer and/or heavier vehicles (LHV) are a solution partially in use (in BSR) with developmental advantages in all BSR countries, economic research based on case-in-hand of LHV trucks are an example of real usability of a LHV solution in CT last mile operations. Trucks platooning and autonomous trucks are technologies where the first tests in Europe already are arranged. However, these two technological innovations are still not widely used in the market

Similar levels of novelty are presented in the second chapter. LNG (Liquified Natural Gas) and CNG (Compressed Natural Gas) and LBG (Liquified Bio Gas) propelled trucks are widely described as the most popular and available alternative propulsion systems developed, with the latest advances being used in BSR. Verification of internal rate of return (IRR) depending on fuel prices in which vehicle transport work shows its suitability level of NGV in BSR. Electric and hydrogen vehicles are noted as the latest innovations in BSR as well as worldwide with development and availability still in their early stages.

The third chapter provides a list of innovations in BSR not directly connected with the last mile process, by focusing on significant influences via capacity, efficiency, and – at the end – cost effectiveness of the last mile and the whole supply chain.

The study compliments the case research in terms of innovation in CT operations. Considering innovation as a business model or organizational structure – CT gives the opportunities to create a sort of new business attitude for BSR (e.g., intermodal Loading Unit (ILU)/container pooling companies, joint ventures for combined transport or multimodal transport operators) offer only a few examples of innovative approaches to last mile transport business region-wide.

The purpose of this report is to indicate and shortlist the latest solutions which can have a real influence on improving the efficiency of last mile operations. Comparing it with BSR market changes allows us to indicate potential next steps needed by all stakeholders to introduce them to the commercial market.

2 INCREASING CAPACITY

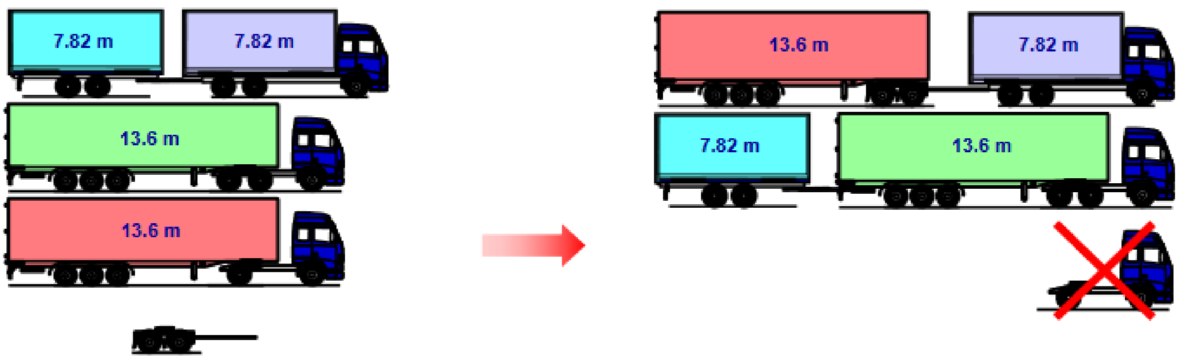
2.1 LHV trucks

A rising number of consignments freighted across Europe and from/to seaports requires a dynamic response from the market supply side – among others the road haulage market which also plays a role in CT last mile operations. Furthermore, based on different studies, Europe needs between 20-40% of additional truck drivers to keep up with market performance (IRU , 2019). These two arguments form the basis to increasing capacity of road transport.

The easiest way to improve the efficiency of road haulage is to extend the capacity of a single truck. As a result, from a legal standpoint, this is possible by using European Modular System (EMS).

A new approach to road transport rose in Europe when Sweden and Finland joined the EU in the 80's. It was unacceptable for both countries to apply EU rules on weights and dimensions, as both countries allowed LHV on their roads. In order to find a solution that would enable foreign transporters to compete on equal terms in Sweden and Finland, a compromise was reached to allow increased vehicle length and weight over all of the EU on condition that existing standardized EU modules were implemented. This solution was named EMS (Figure 1).

Figure 1. European Modular System configurations



Source: Volvo AB

Future development and research on LHV led to the market providing solutions suitable for LHV-use as the last leg for CT operations. Such development included the building fleet of container or swap body trailers, dollies, or B-double suitable for transporting ILU.

In fact, the current status of the modular system and access of LHV is not homogenous in all Member States. The Status quo for maximum allowed vehicle parameters in the EU is indicated in the directive 96/53. It gives allowance to work on 40 tons of Permissible Laden Mass (i.e., 44 tons for intermodal traffic) with a length of 18.75 m) (Council Directive 96/53/EC, 1996).

Presently, trucks longer or heavier than the indicated directive 96/53 are accepted on roads in Finland, Sweden, Estonia, Latvia, Lithuania, Poland, Denmark, and Germany – among others. Conditions of LHV carriage and maximum allowed parameters differ for each particular Member State. BSR is divided into northwest – where LHV are allowed or are currently under trial (Table 2.1) – and Southeast – where the limits are still set according to directive 96/53.

Table 2.1. Maximum allowed truck parameters in BSR countries

COUNTRY	MAX WEIGHT [T]	MAX LENGTH [M]
FINLAND	76	34.7
SWEDEN	74	25.25
ESTONIA	40	18.75
LATVIA	40	18.75
LITHUANIA	40/44	18.75
POLAND	40/42/44	18.75
DENMARK	60	25.25
GERMANY	40/44	25.25

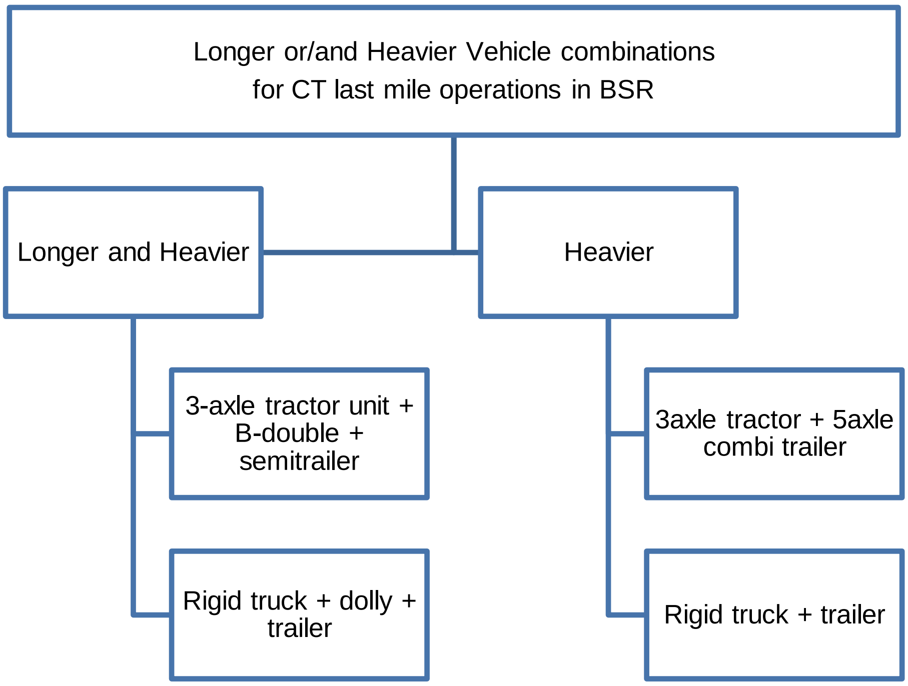
Source: own elaboration

In general understanding LHV refers to trucks 25.25 m or longer developed in Scandinavia. In this report, to better understand specific BSR market conditions, the LHV definition will include truck combinations which do not exceed the length but give the possibility to extend laden mass only.

2.1.1 Equipment used in LHV for CT

In order to meet legal requirements for the maximum weight of trucks, length or axle loads vehicle manufacturers prepare equipment used in CT in Europe. Currently, there are four main ways to build LHV according to EU legal requirements (i.e., modular system) (Figure 2).

Figure 2. LHV combination varieties for CT operations



Source: Own elaboration

Tractor units, rigid trucks

Base vehicles for most LHV are tractor units. To meet legal requirements regarding CT operations and permissible axle loads, tractors used in LHV need to be equipped in three axles in 6x2 or 6x4 configuration (Figure 3). Such units with a variety of engines and cabs are in portfolios of most truck manufacturers in Europe and BSR. Transport enterprises can choose between 420-760 HP diesel engines but, lately, many manufacturers also offer LNG or CNG propelled trucks – with the near future looking at full plug in electric trucks.

Figure 3. European 3-axle 6x2/2 tractor unit suitable for LHV transport operations

Source: Truck1.eu

Heavier truck combinations

A number of ILUs transported in CT are considered as heavy units. This refers mainly to units of 20' containers which can be transported on trailers in two-unit combinations without exceeding the maximum length. Unfortunately, combining ILUs to utilize the maximum capacity of a truck, in terms of twenty-feet equivalent unit (TEU) capacity and weight, is complicated and limited to current workflow on last mile operations. This is the basis for the development of combi trailers. Combi trailers are a solution developed in the Netherlands by manufacturers such as D-Tec and Broshuis. The trailer consists of two modules which can work as separate trailers or as one vehicle. Thanks to an additional two axles of the combination, trailers are combined with a 3-axle tractor unit which can transport heavier units with a total capacity of 2 TEUs.

Higher permissible weight is not the only advantage of combi trailers. For CT operations, cargo discharging time is one of the crucial performance factors. Thus, the possibility of detaching one container for the stripping process and transferring it from one container to another localization allows for valuable time management (Figure 4).

Figure 4. 3-axle unit +5-axle combi trailer combination

Source: Broshuis

Heavier combination can also be built using rigid trucks and trailers, for example 4+3 combination as depicted in Figure 5, but have limited flexibility for other types of trailers or transported cargo, making them less popular due to equipment restrictions.

Figure 5. Rigid truck with trailer as the example of heavier truck

Source: Transbud transport company, Poland

Longer and heavier vehicles

Longer and heavier trucks up to 25.25 m can be build up based on tractor unit or rigid truck. Both options can apply 3 TEU capacity, but in countries which allows LHV traffic the most popular is the tractor unit configuration. In this configuration, three TEU capacity is allowed due to equipment use called B-double. It allows for the load of one TEU directly on the tractor's fifth wheel. The additional fifth wheel allows to attach any kind of semitrailer and, if needed, a 5-axle combi trailer with 2 TEU capacity. Such trailer combinations are available on Scandinavian and Benelux markets – where manufacturers such as VAK, Broshuis, and D-Tec supply the market (Figure 6). To this point, South Baltic markets are a niche for those companies.

Figure 6. B-double trailer (yellow) connected with 3-axle trailer (blue) – 3TEU COMBI-DOLLY solution

Source: D-TEC Trailers

A second method, rarely used, is to combine 4-axle rigid truck with a dolly connected to the 3-axle trailer or (as previously mentioned) combi trailer. This solution is less flexible due to necessity of usage 4-axle rigids which is less common and not as flexible as tractor units. Such configuration allows to transport 3 TEU in regime 25.25 m length and 60 tons total gross weight (Figure 7).

Figure 7 Rigid truck with dolly + 4axle semi-trailer

Source: Verkley Transport

2.1.2 Limitations for launching LHV for CT operations in BSR

Building LHV is closely connected with investments in special equipment like trailers or dollies. Market availability of such vehicles are on a need-basis. In BSR, last mile operators can order rigid trucks or tractors directly through dealer's network. The trailer and dolly sales and service network in the south BSR is not as developed as in other countries, but it is still feasible to order required vehicles. As soon as LHV trucks will be launched on south Baltic regional roads, it will push the development of vendors and relating service network. A question on the real limitations of launching LVH still remains.

Axle loads

Increased gross mass requires proper number of axles to not exceed indicated maximum loads per selected axles as stipulated in the directive. In CT operations, where ILU is sealed, drivers are not allowed to check load distribution and cargo sealing inside the ILU. It is a risk to transport units with exceeded axle loads if the load weight is imbalanced. In new build trailer manufacturers install systems must shows live axle loads. If there is a risk of exceeding parameters, pneumatic suspension must reduce the loads on each axle. As a result, most of CT terminals are equipped with weighbridges or other devices to check gross mass and axle loads of trucks before they start their last mile deliveries (see 4.1).

Road sections availability, parking infrastructure, distribution centers

LHV needs more space to maneuver on road sections like intersections, or roundabouts. Based on arranged research, there is a risk of entering the back of the LHV on the opposite lane of traffic, especially on spiral roundabouts (Matuszkova, 2018). Another risky place for LHV can be in intersections with installed traffic indication islands. According to cited research from Brno University of

Technology, in some cases trucks can enter on the islands which can be risky for pedestrians or opposing traffic.

Moreover, in countries like Poland there are still road sections with axle load limitation. On national or municipal roads, the Ministry of Transportation has put the restriction to a of maximum 8- or 10-tons axle loads which is below the requested EU level of 11.5 tons (as set by the optimum for LHV). In summary, it must be noticed that the network of motorways and express roads is developing in the south of BSR which gives space for LVH development, although this requires coordination by road authorities as well as the transport sector stakeholders. Furthermore, the biggest lack in infrastructure across all BSR countries is the limited number of parking lots, that is, LVH requires special, longer space to stop. Future plans of development for parking lots near the motorways and express roads are needed.

Development of infrastructure cannot be limited to roads only. Distribution centers, warehouses and reloading terminals needs to equip the yards with proper space to let the longer trucks maneuver when calling the loading bays. Coupling and detaching the trailers for loading process may also require additional parking space on yard.

Solutions for this restriction is to create a map of road networks in BSR where LHV are allowed. Such a network has been created in Germany which is called “Positivnetz”. The network includes mainly motorways but also an assortment of national roads (i.e., Bundesstrassen). Further expansion of this network for other countries might be a good starting point for launching LHV in BSR. On the other hand, legal works can limit the maximum turning circle (i.e., radius) of LHV. As an example, the maximum radius in the Netherlands is limited to 14.5 m where in Germany it is 13.5 m. Of course, infrastructure investments are a must, in which special road signs where LHV are allowed, potential retrofitting of intersections, road nodes, and bridges must all come into play – to build a compatible and comprehensive network. Additionally, facilities where LHV are loaded or unloaded should consider special marked zones where LHV can safely perform coupling or maneuvering operations.

Vehicle registrations

The availability of equipment for LHV is a primary issue; however, secondary concerns are the possibility of registering such vehicles. The open European market of used vehicles has given way to the possibility to import from Western Europe used combi trailers. A number of them have been imported to Poland by road haulers. Unfortunately, none of them can be registered and used as combi trailer with two separate sections – the reason is hidden legally. Current law in Poland does not allow three-vehicle combinations on roads except for agricultural tractors. Two sections of combi trailers are identified as independent trailers, which currently are illegal. For the same reason, other combinations of LHV with dolly or B-double are banned on Polish roads.

If the LHV would be implemented in all BSR countries, legal changes cannot be limited to permissible measurements of vehicles. The problem is wider and legal amendments should include the possibilities of registration of LVH components and similar aspects of technical control such as units.

Society and transport market effects

Lack of information about the technology is also an important factor – due to doubt and fear from its citizenry. Citizens (i.e., society at large) can worry about road safety. Tests conducted in the past prove that LVH in many aspects were safer on the road than standard trucks. For example, braking performance in LHV due to more axles can be higher than in standard trucks. First of all, longer combination leads to improve the road safety though less number of vehicles used to carry the same payload.

The solution for society resistance might be any campaign to increase the awareness about LVH and its role in transport.

On the other hand, risen maximum permissible mass can be boosted to unfair competition – market-wise. Technically LVH equipment can bear the cargo weight up to 80 tons and it can be used by some entrepreneurs to overweight their trucks.

Solutions for this is to provide proper devices on CT terminals to check the weight and axle loads on LVH before starting last mile delivery. Parallelly, it can be considered to allow only limited, verified companies to perform tests on first stages on LHV introduction. To keep the LHV traffic on designated road Geofencing technology which is now considered in Sweden might be introduced widely in BSR. It can also support law enforcement i.e. giving penalties or bans for operations.

2.1.3 CASE STUDY – LHV introduction on last mile delivery between Gdansk and Kwidzyn

Background

Last mile deliveries between Port Gdansk and Kwidzyn are a part of the raw materials supply chain operated by Third Party Logistic Operator (3PL). Raw materials are filled into 20' containers owned by short sea shipping carrier. Weekly port calls allow the ocean carrier to provide 15-20 containers of raw material from Immingham, UK to Gdansk or Gdynia port. Each container contains between 14-16 tons of cargo. The distance between terminal and factory equals 120km. Depending on production flow consignee requires to deliver 2-4x20' from Gdansk to Kwidzyn daily, covering raw material demand on production lanes.

General Assumptions

Due to the need of transport solutions with high capacity, for subject ILUs freight forwarding company (3PL) took into consideration four means of transport, as per Table 2.2.

Table 2.2. Summary of all means of transport considered for the project

SOLUTION	PRO'S	CON'S
RAIL	ONE VOYAGE ECO FRIENDLY STABLE SHUTTLE SERVICE	NO TERMINAL NEARBY NOR SIDING IN THE FACTORY TOO SHORT DISTANCE FOR RAIL OPERATORS - IMPOSIBLE TO GET ECONOMIC EFFICIENCY NOT SUFFICIENT VOLUME FOR SHUTTLE RAIL TRAFFIC, RISK OF CONTAINER DETENTION COSTS (OCEAN CARRIER'S EQUIPMENT)

STANDARD TRUCK	GOOD AVAILABILITY FLEXIBLE SOLUTION	LIMITED CAPACITY – AT LEAST TWO TRUCKS IN A SHUTTLES PER DAY REQUIRED
LHV	GOOD AVAILABILITY OF EQUIPMENT FLEXIBLE SOLUTION INCREASED CAPACITY – ONE TRUCK PER SHUTTLE PER DAY	NOT LEGAL IN POLAND
BARGE	FACTORY LOCATED 10KM FROM OLD INLAND PORT KORZENIEWO ON VISTULA RIVER SUFFICIENT CAPACITY	NOT AVAILABLE IN POLAND – LACK OF INFRASTRUCTURE, AND REGULATIONS OF WATER LEVEL IN VISTULA RIVER, LIMITED SUPPLY MARKET OF INLAND CARRIER SERVICES

Source: Internal materials of 3PL company

Solutions based on trains and barges have declined. Heavy weight of the containers in comparison with maximum allowed weight of truck in Poland – 44 tons have given way to a very limited space of combining the containers into 2x20' per one standard truck. Maximum daily working time of drivers is another limitation for building efficient supply chain. The solution has been to engage two trucks each day to keep up with delivery demand.

As a result, a freight forwarding company in cooperation with local trucking has decided to investigate the cost and efficiency of launching one LHV Truck on a last mile delivery in the presented supply chain.

The haulage company had in their vehicle park a 5-axle combi trailer and a 6x2 tractor unit which is a common base to build LHV truck combinations (3+5 combination) suitable for the testbed. After one week of test and 20 containers delivered the project partners were able to conduct an economic evaluation as presented below.

Economic Calculation

Indication of all fixed costs for each vehicle was provided by road hauler based on experience. Service costs included utilization of tires, breaks, oils, and lubricants. Depreciation costs are based on international accountancy standards and are set on 6 years for trailers and 5 years for tractor units. Driver salary and repairs fund are fluent and may vary on market conditions in particular countries and internal company policy but, in general, there is no difference in salary of LHV or standard truck drivers. Also, transport tax is self-determined via country (e.g., in Poland it depends in which county the vehicle is registered) (Table 2.3).

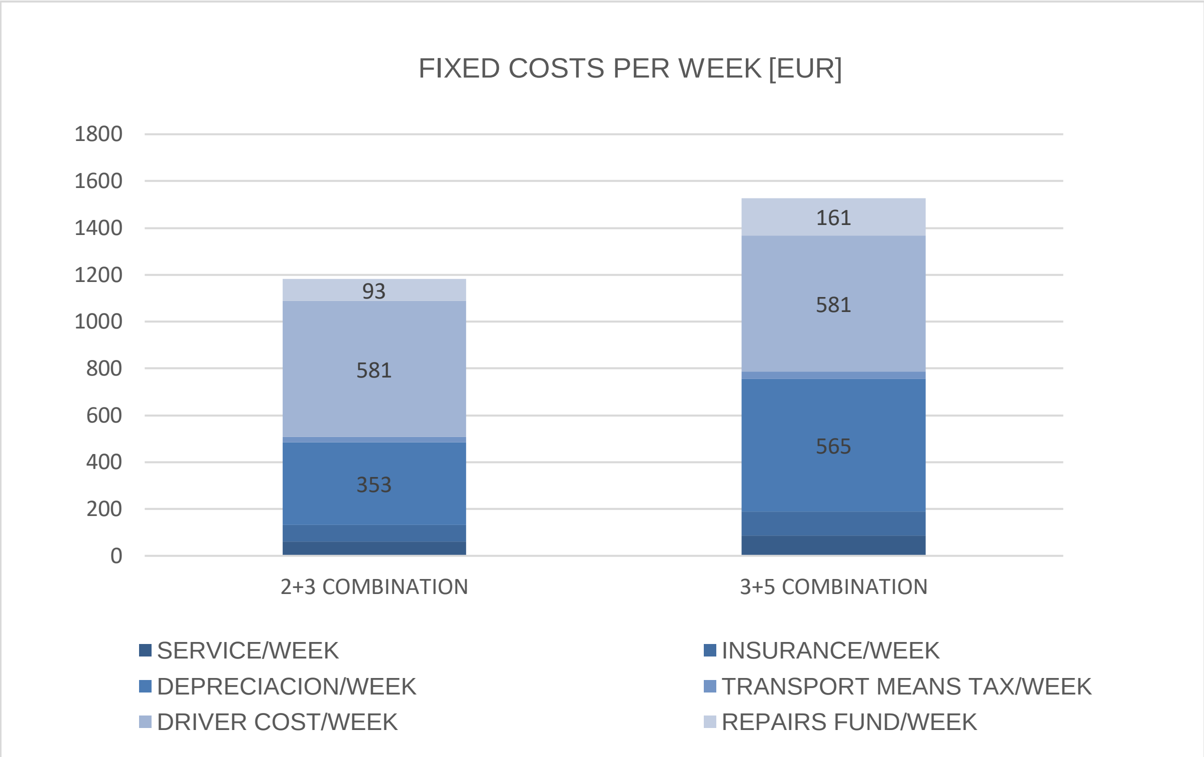
Table 2.3 Weekly Fixed costs per vehicle

	VEHICLE				
WEEKLY COSTS	2-AXLE UNIT	3-AXLE UNIT	3-AXLE TRAILER	5-AXLE COMBI	UNIT
SERVICE	44.72	59.93	15.21	25.34	EUR
INSURANCE	67.08	58.14	5.37	46.15	EUR
DEPRECIACION	307.69	384.62	45.77	180.38	EUR

TRANSPORT MEANS TAX	10.42	10.42	10.20	20.39	EUR
DRIVER SALARY/WEEK	581.40	581.40	0.00	0.00	EUR
REPAIRS FUND/WEEK	76.92	96.15	16.35	64.42	EUR
TOTAL WEEKLY COSTS	**1,088.23**	**1,190.65**	**82.69**	**316.30**	**EUR**

Source: own elaboration based on internal materials of 3PL operator

Figure 8. Fixed costs per week for selected vehicle combinations



Source: own elaboration based on internal materials of 3PL operator

Figure 8 shows the comparison of fixed costs between a standard truck 2+3 axles combination and 3+5 LHV.

Higher costs of 3+5 combination are related mainly to cost of depreciation cost of the truck and combi-trailer including additional service of the vehicles (i.e., tires, spare parts, lubricants, etc.).

Variable costs were measured based on the test week. Telematic solutions installed on board trucks provided average fuel consumption on LHV combination and standard tractors with trailer. Fuel cost is based on average diesel price (i.e., excl. VAT) in Poland during the test week (Table 2.4).

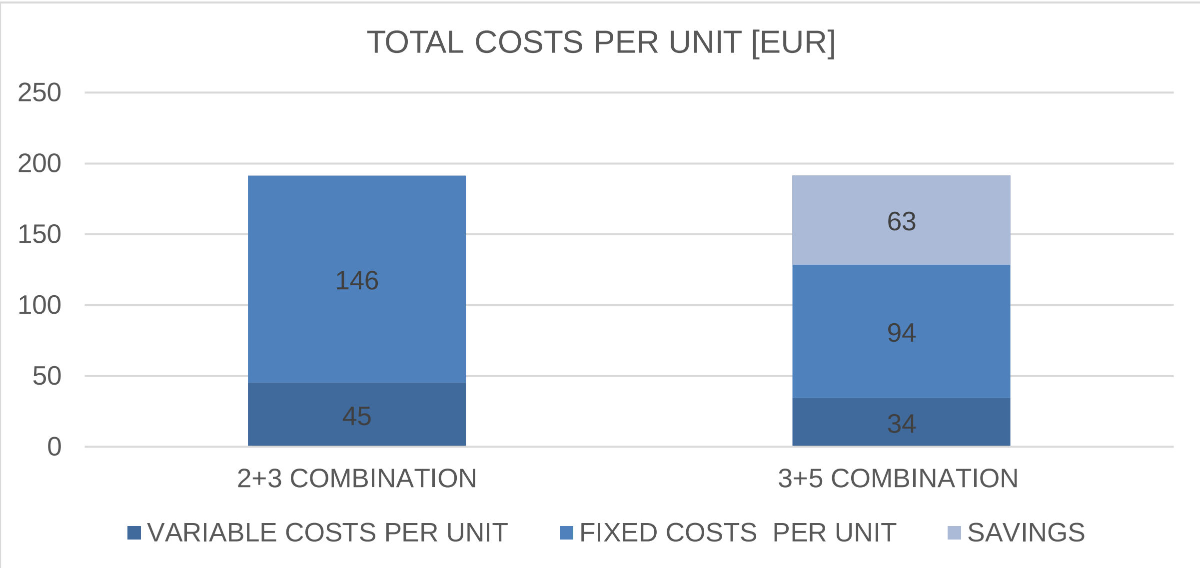
Table 2.4. Variable costs per week for each vehicle combination

	2+3 COMBINATION	3+5 COMBINATION
FUEL COST/WEEK (4.29 PLN/L NET)	306.48	450.15
TOLL ROADS COSTS/WEEK	100.46	100.46

Source: own elaboration based on internal materials of 3PL operator

Once all the costs have been summed up and divided by numbers of transported CT units, project team could make a comparison of total costs per transported ILU (Figure 9).

Figure 9. Total costs per unit, shown savings level



Source: own elaboration based on internal materials of 3PL operator

Total summary of costs for LHV and standard truck/trailer combinations showed that trucking company can obtain a 30% cost reduction per transported unit after one week of last mile deliveries using the LHV solution. This was possible mainly due to high level of fixed costs divided into higher capacity of performed transports. What also has to be noticed, the rise of variable costs by even 1/3 – mainly due to risen fuel consumption per 100 km. However, this increase in cost do not have a substantial influence on the total costs in context of 100% increased load capacity on each truck using the LHV combination.

2.1.4 GHG Emissions by LHV

LHV solution grants measured economic savings, but also have results in positive contributions to environment. Based on the Dutch study in which LHV can achieve 11% depreciation of CO_2 emission and 14% emission of NO_x per ton kilometer compared to standard trucks (EMS Forum, 2010). Similar results provide the analysis conducted by CLOSER and DHL (Figure 10.) for their LTL volumes transported within DHL terminals network in Sweden.

Figure 10. Efficiency gains in reduced CO2 emissions per category

Source: CLOSER

2.1.5 Summary

LHV is the easiest way to improve the capacity of transport in CT last mile operations. LHV technologies were developed and tested for years in Sweden and Finland. Within the last year's, LHV are allowed for road traffic in Germany and Denmark. Expanding this solution to other BSR countries especially for last mile operations should give the incentive to develop further and expand the CT market and its' competitiveness to pure long-distance road transport.

LHV can be built in numerous configurations of tractor units or rigid trucks with 3-5axle trailers supporting a dolly or b-double. In the southeast of BSR, tractors equipped with combi trailers should be allowed to raise their weight of transported ILUs and should be considered as LHV-use.

Based on current research of BSR countries that today allows LHV on their roads it is crucial to adjust legislation on a national level to make LHV move legal within whole BSR.

A second required step would be to develop or adjust the required infrastructure. A number of new roads developed in BSR are suitable for LHV. The biggest financial investment will cover intersections and bridges as well as retrofitting proper road signage. Such development is possible only with close, consistent cooperation between national road administration and municipalities, which are responsible for local infrastructure. Additionally, trucking companies still claims not enough parking places exist, creating additional limitation to develop LHV. Another area which requires infrastructure investments are distribution centers and warehouses where special zones for LHV maneuvering and coupling should be taken into consideration.

To keep up with safety standards, LHV transport in BSR Member States should list roads and CT terminals where LHV transport can be introduced and safely developed. For some countries a social campaign might be required to increase the awareness and convince its citizenry of the safety of LHV technology.

Research and case studies of last mile delivery with LHV has shown economic efficiency. The given example provided 30% total costs decrease per transported unit.

2.2 Trucks platooning

Similar goals as for the introduction of LHV trucks are laid on the basis of trucks platooning. The technology allows to connect the trucks into a convoy with small distances in-between. This to reduce space-use on roads and to decrease the wind resistance by promises on reduced fuel consumption. Communication between vehicles (v2v) allows to follow the first leading vehicle and in the future development to release driver's attention.

Development on platooning technology is divided into four stages, starting from only longitude control on vehicles, through an increased automated transport process with diver's reaction needed in critic situation up to introduction of fully autonomous vehicles (Table 2.5).

Table 2.5. Platooning stages of development

Stage	Launch Year	Level explanation – driver's work
1+2	2020	Hands on, feet off, eyes on the road
3	2023	Hands off, feet off eyes partially off the road
4	2030	Hands off, feel off, eyes off in following vehicles

Source: TNO

2.2.1 Latest tests – technology status

Trucks platooning is one of the key transport innovations in dynamic progress of development. In 2016 the program European Truck Platooning Challenge led to further development of technology. Currently, a group of partners including truck manufacturers and research companies launched a project Platooning ENSEMBLE. It aims to create basis for legal use and development of platooning technology also between trucks of different manufacturers.

At the same time, MAN AG in cooperation with DB Schenker and Hochschule Fresenius launched a test of two trucks platoons in September 2018. Trucks equipped with platooning technology ran between

DB Schenker distribution centers Munich and Nurnberg from September to December 2018. Maximum speed of the trucks was set to 80 km/h and coupled with the distance of 15 m.

The test distance was about 145 km, from which 105 km can be driven in platooning mode. The platoon drove in test period about 35,000 km. There were only four planned breakups and two safety maneuvers due to communication constraints.

Tests results showed relevant fuel savings. Following truck consumed 3-4% less fuel than its identical MAN TGX truck in standard operations. The leading vehicle consumed 1.3% less fuel. According to different studies (PROMOTE, PATH projects) further fuel savings are in range of shortening distance of the following trucks. Distance at the level of 10 meters should give between 8 to 14% savings, 5 meters means between 10 to 16% fuel savings. Following issue is the limitation of PM and GHG emissions connected directly with lowered fuel consumption.

Another advantage of platooning is the better utilization of existing infrastructure. Test conducted by MAN shows space reduction for two trucks from 90 to about 50 meters and for three trucks from 155 to 80 meters which is almost 50% reduction to restrain the issue of traffic jammed motorways. (DB Schenker, MAN AG, 2019). Recommended safe distance between non-coupled standard trucks on motorway is around 50m meters. Tests conducted by MAN and Schenker proved, that platooning allows to shorten the distance to 15m without the risk of losing traffic safety.

2.2.2 Economic calculation

Trucks platooning technology for now it is not available on the market, so the price only can be estimated based on prearranged tests. TNO report estimated cost of equipment needed for truck platooning on 12,000 EUR for first stage, for third 16,000 EUR, and fourth for 20,000 EUR (TNO, 2017).
Such investment requires proper investment return rate. Platooning can provide economic savings mainly due to decreased fuel consumption but also in next stages of development - labor costs savings (Table 2.6).

Table 2.6. Estimated depreciation costs for different stages of platooning development

			2-truck platoon		3-truck platoon	
Stage	Year	Investment per truck	Fuel costs decrease (Team)	Labour cost decrease	Fuel costs decrease (Team)	Labour cost decrease
1+2	2020-2021	12,000 EUR	6%	0%	9%	0%
3	2023	16,000 EUR	8%	8%	12%	8%
4	2030	20,000 EUR	10%	90%	14%	90%

Source: TNO

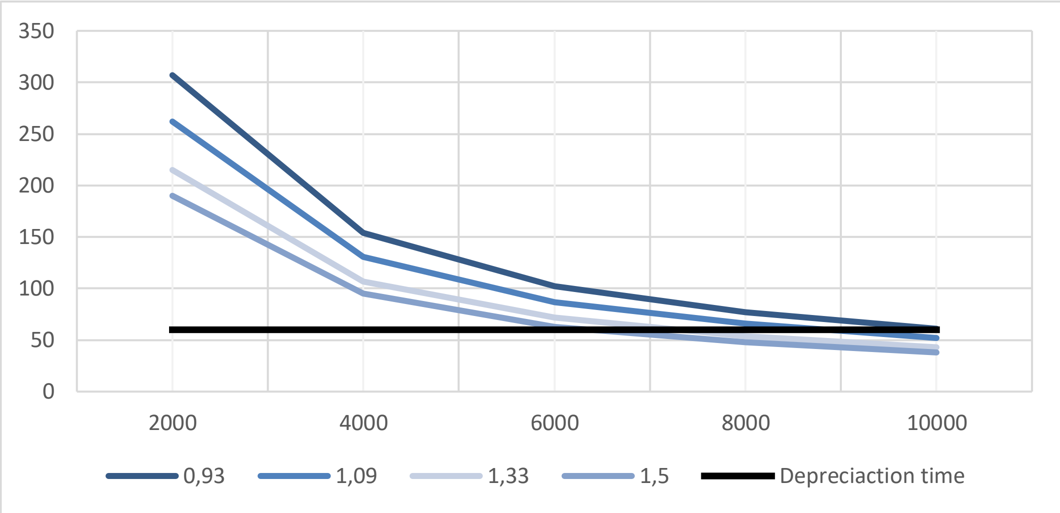
Putting 1+2 stage estimations into the BSR market, it can be said that the following assumptions can apply:

- average diesel consumption 35l/100 km;
- costs of technology: 12,000 EUR / truck;
- average diesel price 1.10 EUR, max 1.30 EUR, min 0.93 EUR, 1.50 EUR as reference;

- average monthly mileage per truck in CT last mile operations may vary between 4,000 and 7,000 km depending on factors like: distances, awaiting time, traffic conditions etc.; and
- depreciation time for trucks is set on 60 months (5 years).

Two trucks platooning gains the efficiency of investment after braking 7,000 km mileage per month of driving. Such mileage levels are possible to gain only in heavy, long distance road haulage, not in CT operations; hence, for BSR is necessary to consider platoons with three trucks coupled (Figure 12).

Figure 11. Months needed to gain return on investment in 2-trucks platoon combination depending on mileage [km] and fuel price [EUR]

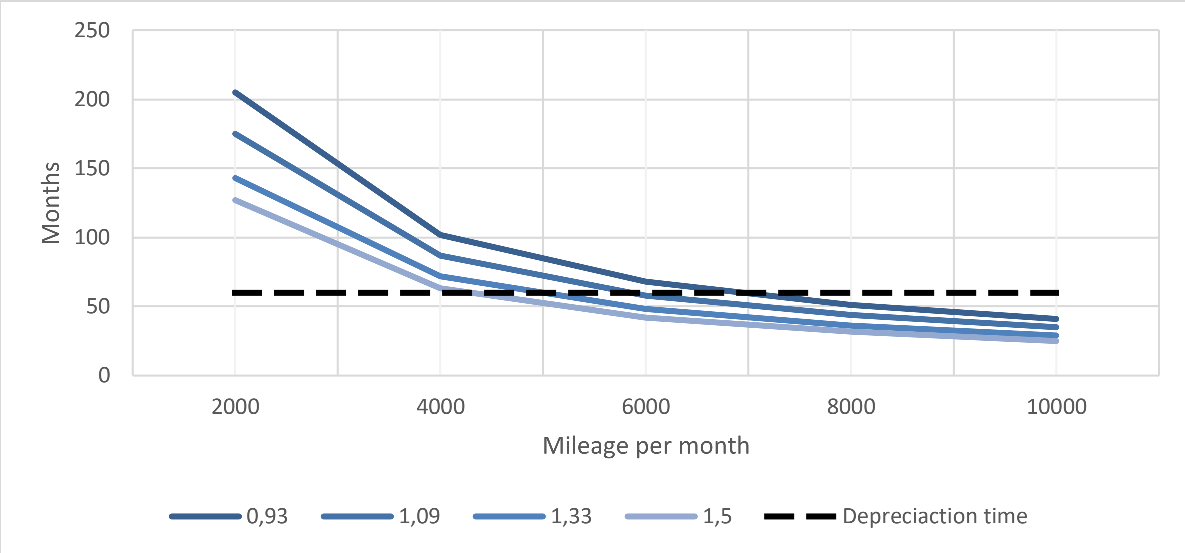


Source: own elaboration based on TNO data

Extending the platoon for another truck moves the investment efficiency point at the level of approx. 5,000-6,000 km per month, depending on real fuel prices (Figure 11).

Another level of platooning development allows to receive further costs decrease closely connected not only with fuel consumption, but also with labor costs. In the fourth phase of technology development, platoons might be able to give up to 90% costs decrease of labor which refers to 20-25% of total costs of truck ownership. Different studies estimate, that the last stage of truck platooning development may lead to decrease of ownership cost by 55% (W. Schildorfer, 2019).

Figure 12. Months needed to gain return on investment in 3-trucks platoon combination depending on mileage [km] and fuel price [EUR]



Source: own elaboration based on TNO data

2.2.3 Business Case – suitability for BSR

Well-developed and legally introduced innovation means nothing when it's unusable in practice. The point is to outline the business environment where platooning can be successfully implemented.

Close connection to Highways

Truck platoons are expected to be allowed on highways and expressways. Also, its value case remains valid if the technology can be used as often as possible. Thus, investment in truck platoons makes sense only for last mile deliveries from/to terminals situated nearby such roads. By analyzing the localization of CT terminals in the BSR – some of the terminals do not have direct access to motorway, nor any kilometer within the vicinity of the terminal based on a 20-50 km radius (see Malaszewicze terminals, Poland).

Proper cargo at proper time and place

Pairing the trucks into platoons during CT last mile operations require to move ILUs at one time into the same time or as much as possible a similar destination. This requirement actually may have negative influence on CT. Combined transport is often considered as a solution to create a "rolling warehouse". That is, ILUs stored at a terminal can be flexibly delivered at a destination due to its close location. Trucks platooning limits this flexibility of delivery time as trucks in platoon will deliver a number of ILUs at once. Secondly, last mile operations time is of crucial importance. On the one hand, platooning in its third stage of development will allow the extension of driver's daily working time. On the other, waiting for the possibility to create platooning might overcome the potential savings in drivers operational working time.

Based on above conditions an individual study should be conducted to analyze flow of last mile traffic from terminals in order to give a real potential of platooning for CT operations. In all probability, platooning can be a proper and efficient solution only for particular supply chains in CT operations.

Distance

As it was mentioned before, distance of last mile deliveries is limited in the legal framework. Limitation is set on the nearest suitable station or to the radius 150 km from seaport. The largest profits in terms of platooning is available on long(er) distances, with the high share of motorways in the voyage. Also, the length of road has the influence on the possibility to successful platooning. In CT operation chance for platooning is possible mainly for traffic from/to terminal.

Market fragmentation

Last mile deliveries are conducted in a variety of business models, depending on the country, local markets, and specific agreement between involved stakeholders. Last mile operations can be arranged by self-employed operators, transport subcontractors, or CT operator's owned trucking fleet. Such fragmentation builds upon the obstacles and innovation to create a coherent platooning network. The ENSEMBLE project will provide the solution to build upon a common interface for different truck manufacturers – a solution is tested between truck of same manufacturer. Technology and ability are the first case, the second case is the proper planning to concentrate the stakeholders. This would be possible with proper software which automatically notifies interested parties about the possibilities of platooning within CT last mile.

2.2.4 Legal status

In the communication from 2018 EC published adopting a common EU vision on automated mobility (Tobar, 2019). One of the three main axes of development contain

"Ensuring automated mobility is safe and future-proof legal framework".

Legal framework insurance for any kind of platooning or autonomous vehicles requires wide range of legal work on revision of legal acts on local and international level. According to the schedule legal works started on 2018 and will be continued by end 2020, current schedule might be extended due to coronavirus pandemic.

Legal works include the updates on documents in wide disciplines. A full matrix of relevant documents for trucks platooning to be revised is available on ENSEMBLE project website. There are documents including among of others (ACEA, 2017):

- required communication protocols for platoons of trucks;
- driver monitoring and training – important especially for third stage of platooning development;
- Signaling and road markings for platoons;
- additional requirements for periodic technical inspections;
- traffic rules – especially according to safety distance; and
- special provisions for using platooning in dangerous goods transport or with use of LHV.

2.2.5 Summary

Trucks platooning is a real solution to increase the capacity of CT operations. Recent tests show, that the technology allows to launch the solution on the market. However, legal and infrastructure works are still underway. From the other point of view, subject technology might not be suitable for selected business cases. To gain economic efficiency in truck platooning, operators needs to get high density of cargo flow at the same time and similar destination, which may not be possible to achieve.

2.3 Autonomous vehicles

The next step to last mile technologies development is to introduce fully autonomous vehicles. This technology was first commercially tested by Volvo in 2019. The Swedish manufacturer tested a vehicle called Vera in container transport operations in Gothenburg.

Tests in commercial operations were conducted also by the company Einride. Tests were taken in the terminal of Schenker in Jonkoping, Sweden. Special permission allowed for testing on public road with a max speed of 5 km/h. T-Pod truck had a maximum capacity of 20 tons and a battery allowance to drive a maximum of 200 km on one charge. First test of Einride autonomous trucks in use under container transport operations are planned in the port of Helsingborg, SE. Einride provided the price of the T-Pod truck which is estimated at 150,000 USD (40ton.net, 2018).

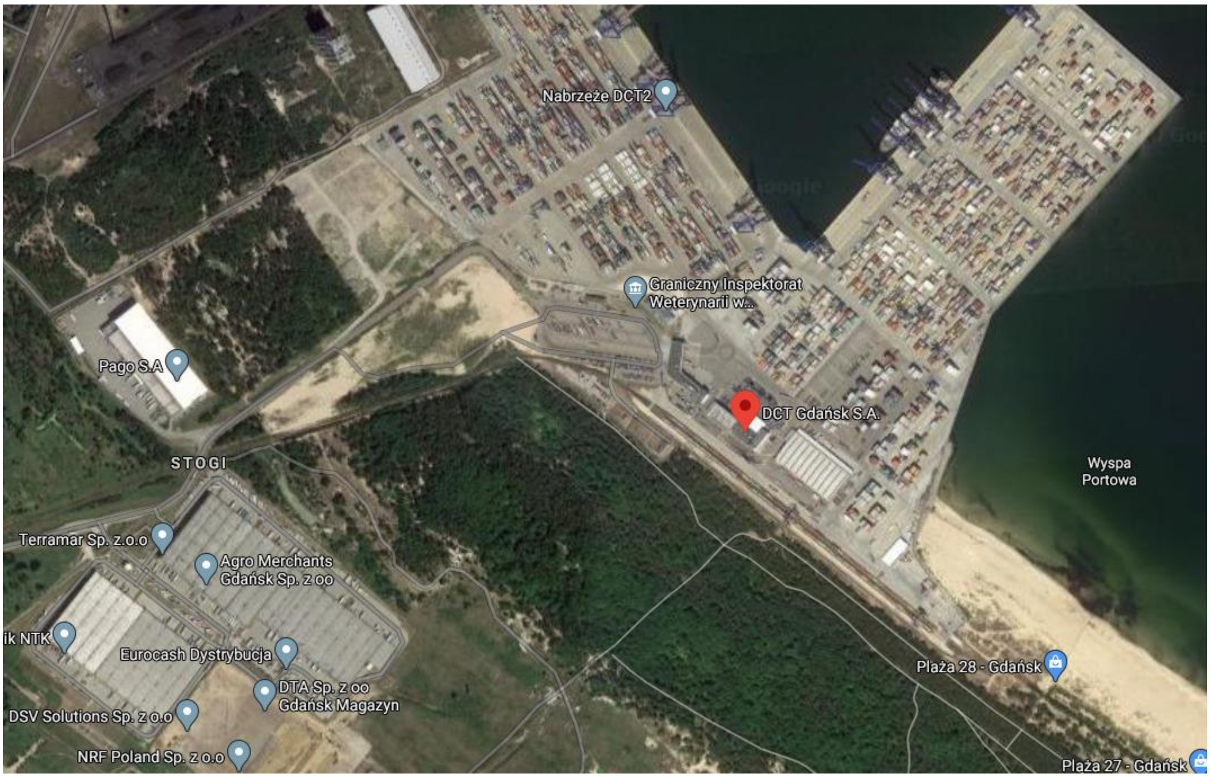
How can autonomous vehicles approach commercial last mile operations in BSR? Observing the very first tests where autonomous trucks were applied, terminals with a nearby location to the logistics or distribution centers is a start.

Access of autonomous trucks on public roads requires a lot of legal work in which is similar to tuck platooning (see 2.2). Thus, it seems, such vehicles will require additional infrastructure like internal roads or paths between terminals and nearby warehouses or distribution centers to allow for them to work – despite legal issues on public roads. Example terminals which might easily access such vehicles include: CLIP terminal Swarzędz – with its close location to distribution park CLIP II (Figure 12) and DCT Gdansk – close location to Pomeranian Logistic Centre and space for future development (Figure 13)

New innovation in technology may also lead to the rise of an innovative market structure. Autonomous vehicles will need providers of IT solutions, controllers, and maintenance services. Such services can be offered by manufacturers directly or with the outsourced subcontractors which can become a new part of Last Mile solutions market.

Figure 13. CLIP Terminal and surrounding logistics center

Figure 14. DCT Gdansk with nearby logistic parks



2.4 Key findings

- LHV are the easiest way to improve the capacity of CT last mile operations in BSR.
- Currently LHV are legally launched in Northern and Western BSR, South and Eastern countries allow vehicles according to EU directive standards.
- There are multiple combinations to build LHV, most of the equipment is widely available in BSR both new and used market.
- Extending LHV network requires mainly legal works, new built infrastructure is ready for LHV, although additional studies for particular road sections might be required.
- Launching LHV on last mile deliveries allow to receive even 30% decrease of transport costs per unit, GHG emissions can be reduced by 11% respectively.
- Platooning is the latest technology which aims to increase capacity of CT operations.
- Latest tests prove the readiness of technology to be launched in market conditions, although, legal works are still underway, a lot of infrastructure works in Europe and BSR will be also required..
- Real suitability for BSR market is hard to estimate, due to necessity of checking real cargo flows from/to terminals in particular period of time
- Autonomous trucks technology seems to be ready to launch in a short period of time, despite lack of law preparation.
- First terminals which should be considered for such traffics should be localized in the nearest area of distribution centers to allow autonomous trucks work on internal pathways instead of public roads.
- Management of autonomous trucks may affect to rise new, innovative market players – autonomous vehicles management and maintenance companies.

2.5 Increasing capacity comparison matrix

Table 2.7. Increasing capacity comparison matrix

Aspect		UNIT	LHV	Increasing Capacity Platooning (3-trucks)	Autonomous Truck
FOOTPRINT	CO_2 EMISSION REDUCTION	g/tkm	15%	14%	0
	PM EMISSION REDUCTION	g/tkm	15%	14%	0
	FUEL CONSUMPTION (av.)	l/100 km	45-50	31 per truck	N/A
CARGO CAPACITY	CBM (1 TEU = 28 CBM)	m^3	84	168	56
	TONS (incl. vehicle)	t	60	120	40
	INTERMODAL UNITS	TEU	3	up to 6	2
LEGAL/ INFRASTRUCTURE SUTIABILITY	SUITABILITY FOR BSR COUNTRIES*	yes/no/partially	yes	partially	partially
	LAUNCHING BAREERS	low/medium/high	low	high	high
ECONOMIC EFFICIENCY	UNIT INVESTMENT PRICE	EUR	20,000 (combi doly cost)	36,000 (platooning equipment cost for 3 trucks)	150.00

*See 21.2 2.2. source: own elaboration

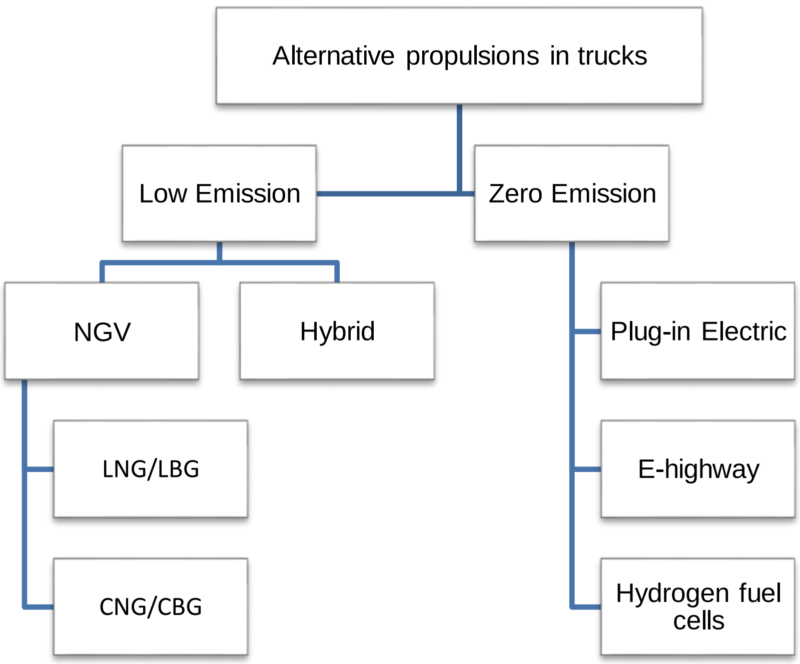
3 ALTERNATIVE PROPULSIONS FOR LAST MILE IN CT

In 2019, the European Council confirmed to introduce new maximum levels of CO_2 emission by trucks and heavy transport. Based on new regulations until 2025 CO_2 generated by heavy transport in EU expects to be decrease by 15% and by 30% until 2030, respectively. One of the reasons for putting such restriction is that 27% of CO_2 emission in Europe is generated by heavy freight haulage (Regulation (EU) 2019/1242 , 2019).

Pressure on limiting emission of CO_2, NO_X, SO_2, and $PM_{2,5}$ requires from truck manufactures to look for any alternative propulsion which can be environmentally friendly and comply with the latest regulations. Council of Europe expects that one of the supporting tools is to develop incentive mechanism which gives extra credits for manufacturers who are developing Low Emission (LEV) and Zero Emission (ZEV) vehicles.

Based on above incentives manufacturers are developing various power trains which most of them are on early stages of production or tests so the market availability is limited. Thus, it is hard to clearly indicate its' suitability for CT operations and especially economic effects. Subject chapter indicates only solutions which based on author's choice has at the moment the biggest change to develop and be used in future CT operations (Figure 14).

Figure 15. Alternative propulsions in trucks, suitable for CT last mile operations



Source: Own elaboration

Medium (above 3.5 t.) and heavy haulage fleet in EU consist on approx. 6.5 mln vehicles. Above 1/3 of them are registered in BSR, mainly in Poland and Germany. Average fleet growth in region is leveled at 2.7% y/y which is a bit above average EU – 2.31%. The biggest fleet growth can be noticed in Poland (4.16%) and Lithuania (7.37%) (ACEA, 2020) (Table 3.1).

Table 3.1. Medium and heavy-duty fleet in BSR countries and EU

Country	2017	2018	change 18/17
Denmark	42,479	42,741	0.62%
Estonia	37,644	38,277	1.68%
Finland	95,948	96,169	0.23%
Sweden	83,025	83,977	1.15%
Lithuania	61,465	65,996	7.37%
Latvia	27,905	27,710	-0.70%
Poland	1,064,671	1,108,975	4.16%
Germany	932,755	946,541	1.48%
BSR	2,345,892	2,410,386	2.75%
EU	6,472,374	6,621,641	2.31%

Source: ACEA

European medium and heavy haulage fleet mainly consists of diesel-powered vehicles with 98% of trucks in EU equipped with diesel engines. Rest propulsions plays a marginal role, and their share in the EU do not exceed 1% per kind of propulsion. Hybrid and electric vehicles actually do not exist in European goods transport. Registrations of this kind of trucks is noticed on in a few countries which can even mean that trucks are registered as a test or demo trucks for manufacturer or dealer.

BSR do not surpass much of the overall EU statistics. Clearly, visible is an outstanding share of petrol trucks in Estonia (almost 15%). Due to unclear statistics in Poland, BSR average of diesel is lowered, but based on observations, much of unknown number should be considered as diesel trucks. In the coming years, it is expected a rise in the number of LNG propelled trucks both in the EU and BSR is expected. Main reasons for such a perspective are a relatively good availability of this technology and government support for LNG fleet development. This gives opportunity for a fast market response to future CO_2 emission limits (ACEA, 2020) (Table 3.2).

Table 3.2. Propulsion composition in medium and heavy trucks segment in BSR countries in 2018

Country	Petrol	Diesel	Hybrid electric	Plug In Electric	LPG+Natural Gas	Other+ unknown
Denmark	0.70%	99%	0.00%	0.00%	0.40%	0.00%
Estonia	15.40%	84.50%	0.00%	0.00%	0.10%	0.00%
Finland	1.60%	98.10%	0.00%	0.00%	0.1	0.00%
Sweden	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	1.90%	95.70%	0.00%	0.00%	0%	2.40%
Latvia	1.50%	97.40%	0.00%	0.00%	1.10%	0.00%

Poland	2.70%	78.80%	0.10%	0.00%	1.00%	17.40%
Germany	0.20%	99.50%	0.00%	0.10%	0.10%	0.00%
BSR average	3.43%	93.29%	0.00%	0.00%	1.81%	2.83%
EU	1%	98.30%	0.00%	0.00%	0.40%	0.20%

Source: ACEA

3.1 CNG/LNG/LBG/CBG

3.1.1 Technology description

Increasing number of vehicles and limited worldwide resources of crude oil gave another ignitive position on the development of alternative propulsions. One of the most popular LEV technologies, which now is relatively widely developed is using natural gas to propel the vehicles called Natural Gas Vehicles (NGV), referred to as Methane (CH_4). It still is considered as fossil fuel, but is still a good alternative for diesel fueled vehicles.

Recently, many studies showed different measures of NGV emissions in comparison to diesel combustion engines. Table 3.3. shows a comparison of emission between diesel and LNG heavy truck on road between Warsaw and Berlin with 12 tons of cargo.

Comparison of LNG truck with the latest generation of diesel trucks shows, that there is no significant difference in emission of CO_2. NO_x emission is lower for LNG propelled vehicles, but PM and SO_x emission indicated in the research are 100% higher for LNG than its diesel equivalent.

Table 3.3 Emission comparison between diesel and LNG truck

Emisions	UNIT	E6 Diesel Truck	LNG Truck
CO_2 EMISSION	g/tkm	72	74
PM	g/tkm	0.0015	0.0034
NO_x	g/tkm	0.054	0.043
SO_x	g/tkm	0.027	0.044

Source: https://www.ecotransit.org/calculation.en.html

There are two main types of trucks propelled with natural gas – LNG and CNG.

LNG which is abbreviation of Liquified Natural Gas is a fuel resultant from the methane cooled and stored at the temperature -160ºC. Such low temperature allows to shrink the volume of methane and change physical state to liquid. Low temperature requires to use proper cryogenic tanks to store the fuel in the trucks. To keep the safety, special tanks are equipped with valves which allows to deploy the gas which increase the volume due to rising temperature. The combustion process may be conducted with pure LNG or mixture of LNG with diesel – then the vehicles are referred to dual fuel engines.

LNG trucks are in general recommended for long and heavy haulage. The reason for this application is longer range in comparison with CNG or electric propelled vehicles. Manufacturers of LNG tractors declares its range up to 1,000 km with engine which generates up to 460 HP which is also sufficient for heavy haulage up to 40 or 44 tons.

CNG as the abbreviation from Compressed Natural Gas refers to vehicles equipped fueled with compressed methane. Compression of methane is possible due to cylinder tanks installed on vehicles. Tanks allows to fill up and store methane compressed up to 21 to 25 MPa.

The biggest disadvantage of CNG trucks is the limited range. For example, Iveco, for their latest generation of CNG tractor units set the maximum range between 400 – 500 km depending on engine and tanks configuration. The other disadvantage of this technology is the diversified fueling time. Depending on station efficiency we can diversify "slow fueling stations" where total time for tractor units is considered between 5 – 7 hours, and fast fueling sites, where the process last maximum 20 – 25 minutes.

3.1.2 LNG/CNG vehicles for CT operations – market availability

Market research arranged at the beginning of 2020 shows three main suppliers of CNG/LNG trucks across Europe and BSR. Well-developed supply side of the market is a prove that, LNG/CNG is the most available alternative propulsion for trucks. Most of the dealers offer them in regular sales, not only based on bespoken orders. However, the widest offer can be found in light and medium trucks for local distribution, which are not suitable for last mile in CT transport due to its' comparatively low power, torque and chassis configuration. Below shortlist shows trucks considered as suitable for CT operations. Optimal configuration for CT operation according to haulage companies and based on current EU directives was described as: tractor unit in 4x2 axle configuration for light ILU and 6x2 for 42 – 44 tons configuration. Engine power according to haulers experience should be considered at approx. 400 HP for light ILU, and above 500 HP for safe transport of heavy ILUs in 42 – 44 tons configuration.

Scania

Swedish truck manufacturer in range of CT suitable vehicles offer Tractor units in G and R series in 4x2 axle configuration. Vehicles are equipped in OC09 or OC13 engines propelled with CNG or LNG. Depending on demand clients can choose between engines with 280, 340 and 410 HP.

Volvo Trucks

Another Swedish manufacturer in range of CT suitable vehicles offer tractor units in FM and FH series propelled with LNG or CNG. In the opposite to Scania or Iveco trucks Volvo's technology called dual fuel mix the diesel and LNG in combustion process (5-10% of diesel). It means that space for LNG tank is limited due to additional diesel tank. In practice it has positive influence on maximum range. Volvo indicates it on max 1,000 km. Depending on demands, Volvo provides LNG tractors in two engine power versions, 420 and 460 HP.

Iveco

The widest range of engines, cabs and axle configuration can be found in the portfolio of Iveco. Italian manufacturer offers tractor units equipped with Cursor NP (Natural Power) engines. Cursor NP engines be propelled with CNG or LNG can generate HP range starting from 360 HP and the maximum 460 HP.

Tractor units can be configured trucks in all cab versions from small daily to long distance and in two axle configurations – 4x2 and 6x2.

CNG/LNG trucks market is not limited to above three manufacturers. There are also trucks powered with NG in the portfolio of Renault or MAN AG. However, is it was noticed before most of them are trucks with limited suitability for combined transport operations.

On the other hand, it is important to notice, that manufacturers like Daimler (Mercedes-Benz) or Paccar (DAF) declared that they are considering natural gas as short-term solution and they will not develop NGV technology. For those manufacturers future of truck propulsions belongs to electricity or hydrogen.

3.1.3 Fueling stations availability

Increasing number of NGV's requires well-covering network of fueling stations. At the beginning of 2020, there are 2.1 mln registered NGV across Europe. Based on NGVA statistics only in 2019 in Europe registered almost 90,000 NGV vehicles among of 21,000 CNG and 45,000 LNG trucks. The same association forecasts, that in the next 10 years the total number of registered NGV vehicles in Europe will grow six-fold, reaching 13 mln (NGVA, 2020) (Table 3.4).

Table 3.4. CNG fueling stations in BSR countries

	EU	BSR	Poland	Lithuania	Latvia	Estonia	Finland	Sweden	Denmark	Germany
2015	2,957	1,150	27	3	2	5	24	163	13	913
2016	3,091	1,078	26	3	2	6	26	167	15	833
2017	3,111	1,132	26	3	2	6	33	171	15	876
2018	3,216	1,134	26	3	2	10	38	177	17	861
2019	3,490	1,156	23	5	2	17	46	192	17	854
y/y 2019/2018	**9%**	**2%**	**-12%**	**67%**	**0%**	**70%**	**21%**	**8%**	**0%**	**-1%**
Stations / 100 km highway	**2.6**	**5.7**	**0.9**	**1.5**	**0.0**	**10.7**	**5.2**	**9.0**	**1.3**	**6.6**
Stations / 1,000 km²	**0.8**	**0.7**	**0.1**	**0.1**	**0.0**	**0.4**	**0.1**	**0.4**	**0.4**	**2.4**

Source: Own elaboration based on European Alternative Fuels Observatory (EAFO)

Average number of CNG stations per 100 km of highway in the EU area do not exceed three. Baltic Sea Region shows bigger availability of such fuels. Drivers can fill up CNG six times on each 100 km of highway. The biggest density to road network shows Estonia and Sweden – approx. 10 stations /100 km. The development of CNG stations network seems to grow stable year by year in whole EU countries and region. It's developing mainly due to local municipalities, who invested in CNG vehicles such like buses or communal vehicles, i.e., dump trucks. What also must be underlined, a lot of the stations are built for purpose of municipalities and are not for the open public, or access requires additional agreements with station operators (EAFO) (Table 3.5).

Table 3.5. LNG Fueling stations in particular BSR countries

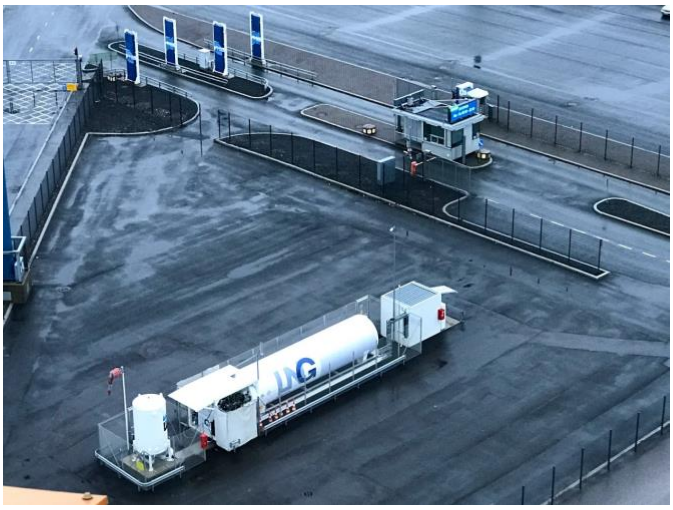
	EU	BSR	Poland	Lithuania	Latvia	Estonia	Finland	Sweden	Denmark	Germany
2015	63	7	1	0	0	0	0	6	0	0
2016	80	11	1	0	0	0	2	6	0	2
2017	110	15	2	0	0	0	5	6	0	2
2018	133	17	3	0	0	0	6	6	0	2
2019	**389**	**47**	**6**	**0**	**0**	**1**	**9**	**16**	**0**	**15**
y/y 2019/2018	**192%**	**176%**	**100%**	**0%**	**0%**	**100%**	**50%**	**167%**	**0%**	**650%**
Stations /100 km highway	**0.30**	**0.23**	**0.24**	**0.00**	**0.00**	**0.63**	**1.01**	**0.75**	**0.00**	**0.12**
Stations /1,000 km²	**0.09**	**0.03**	**0.02**	**0.00**	**0.00**	**0.02**	**0.03**	**0.04**	**0.00**	**0.04**

Source: Own elaboration based on European Alternative Fuels Observatory (EAFO)

LNG filling locations shows a much bigger dynamic for development. In last year, the number of locations across Europe increased almost 200% – mainly due to development of network in Germany. Average increase in BSR in last year also rise for almost 180%. Unfortunately, dynamic development seems to be still not sufficient for forecasted number of vehicles. As per research arranged by ACEA it should reach 750 fueling stations across EU by 2025 and 1,500 by 2035 (ACEA, 2020). In 2019, the total number of those sites did not exceed 400. This means, that average number of stations per 100 km highway in EU and BSR do not exceed 0.3 locations. If we take a look at particular countries – Finland is a leader when compare LNG stations with motorways length. In average, there is possibility to fill up LNG every 100 km of motorway in Finland. Density of stations per 1,000 km^2 in BSR is on average level of 0.03 and it is 1/3 of average density in the EU. What is important to say, there is still no fueling infrastructure available in three countries – Latvia, Lithuania and Denmark (EAFO, 2020).

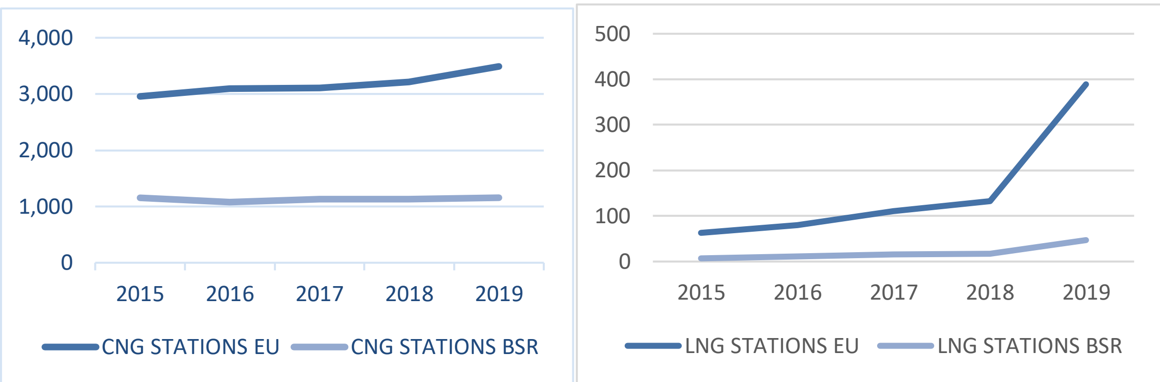
From the angle of CT last mile operations, it is important to install filling stations in the near radius of terminal – to keep fluent supply of NG to trucking companies. As an example of good practice can be indicated station open in Vuosaari Port in Helsinki (Figure 16).

Figure 16. LNG Station in Vuosaari Port, Helsinki.



Source: Own archive

Figure 17. CNG/LNG filling stations number in EU and BSR region between 2015-2019



Source: Own elaboration based on European Alternative Fuels Observatory (EAFO)

3.1.4 LBG/CBG

LBG which is the abbreviation for "Liquified Bio Gas" is the alternative fuel for the fossil natural gas and LNG as fuel. Biogas is the product of the breakdown of organic matter in the absence of oxygen. This reaction is possible in the biogas plants which are commonly connected with sewage or waste plants to deliver raw, organic material for production.

The natural source of the biogas makes that it is considered as a renewable, non-fossil energy. It offers a huge potential for all the NG trucks. Although biogas in its first stage contains Hydrogen sulfide (H_2S). This compound reacts with the machinery due to its corrosive nature, thus biogas needs to be upgraded and cleaned. Carbon dioxide, water, and particulates also must be removed from biogas composition before it will become biomethane which after cooling or compression can become Liquid biomethane as substitution for natural gas. Due to high costs of biogas cleaning and upgrading, truck manufacturers spreads the researches to allow LNG/CNG vehicles to be filled up with biogas.

The main producers of Biogas in Europe are Germany. In 2018 there were almost 11,000 launched plants in Germany. In BSR, the second country is Poland with 308 plants and then Sweden with almost 200 locations (EBA, 2019). That gives a great potential to BSR to develop the fleet of eco-friendly trucks as the next step for development of gas-powered fleet.

3.1.5 IRR for LNG truck on CT operations

Since last years a lot of road haulage companies decide to develop their fleet fueled with LNG tractor units. Most of those fleets are used for long haulage transport across Europe. In the opposite to long haulage CT last mile operations characterize more frequent transport on shorter distances. Such work conditions can make LNG equipment less economical efficient for this purpose (Table 3.6).

Table 3.6. Tractor unit's comparison diesel vs LNG

	Tractor Unit LNG 460HP	Tractor Unit Diesel E6 480HP
Power/Torque	460 HP / 1700 Nm	480 HP / 2300 Nm
Mass (tare)	7,505 kg	7,000 kg
Fuel consumption (12 t cargo)	21 kg/100 km = 0,018 kg/tkm	23,3l/100 km = 0,019 l/tkm
CO_2 emission	559 g/km (-9,1%)	615 g/km
Tanks capacity	2 x 500 l (400 kg LNG)	1 x 550 l
Price	105,000 EUR	75,000 EUR

Source: Own elaboration based on internal data of manufacturer

The comparison of diesel and LNG tractor parameters from same manufacturer with same chassis and cab configuration shows that LNG units are heavier by about 0.5 t compared to a diesel-powered unit. This aspect is crucial for CT operations. Heavier tractor leaves less space for cargo weight; thus, it gives another reason to consider implementing LHV in all BSR countries or at least give a legal space to increase the maximum allowed weight of truck/trailer combination.

What is more, LNG trucks are more expensive than its diesel equivalent. Depending on country markets and individual negotiations difference in price can exceed 30%.

If we consider upkeep costs between LNG and diesel truck on similar levels the decision of buying LNG truck should be considered only based on average monthly mileage and transported cargo weight with spread between diesel and LNG price in filling station.

Table 3.7 shows the months of using LNG truck needed to get return in investment. Cells colored in green indicates time below five years which is considered as optimum time of operation for trucks. The bigger spread between prices, the faster return on investment is possible to get.

The prices of the fuels are fluent in mentioned countries. At the beginning of 2020 average spread between LNG and Diesel price (excl. VAT) in BSR region was set on 0.16 EUR.

Table 3.7. Months required to get IRR on LNG Truck based on LNG/Diesel price spread 0.11, 0.16, 0.20 EUR (excl. VAT)

Price spread 0.16 EUR

AVERAGE CARGO WEIGHT [TONS]	MONTHLY MILEAGE [1,000 KM]						
	6	7	8	9	10	11	12
12	112	96	84	75	67	61	56
14	96	82	72	64	58	52	48
16	84	72	63	56	50	46	42
18	75	64	56	50	45	41	37
20	67	58	50	45	40	37	34
22	61	52	46	41	37	33	31
24	56	48	42	37	34	31	28
26	52	44	39	34	31	28	26

Price spread 0.11 EUR

AVERAGE CARGO WEIGHT [TONS]	MONTHLY MILEAGE [1,000 KM]			
	9	10	11	12
16	74	66	60	55
18	66	59	54	49
20	59	53	48	44
22	54	48	44	40
24	49	44	40	37
26	45	41	37	34

Price spread 0.20 EUR

AVERAGE CARGO WEIGHT [TONS]	MONTHLY MILEAGE [1,000 KM]							
	5	6	7	8	9	10	11	12
10	135	113	97	84	75	68	61	56
12	113	94	80	70	63	56	51	47
14	97	80	69	60	54	48	44	40
16	84	70	60	53	47	42	38	35
18	75	63	54	47	42	38	34	31
20	68	56	48	42	38	34	31	28
22	61	51	44	38	34	31	28	26

	24	56	47	40	35	31	28	26	23
	26	52	43	37	32	29	26	24	22

Source: Own elaboration

As it is shown in Table 3.7, depending on all factors, IRR in LNG truck can be reached starting from even two-three years. However, this can be achieved only if the equipment will be working on heavy loads on long distances. In CT operations the distance factor is strictly limited by the law to 150 km per one way. On the other hand, the limitation of monthly mileage is the working time of drivers. Taking into consideration average last mile delivery at distance 50 km, trucker can perform even three roundtrips per day which can give average mileage 6,000 km monthly based on 20 workdays/month.

Trucking companies in BSR who are considering investing to LNG trucks in CT operations shall strictly calculate expected workflow to keep the efficiency of investment. For many of them from the economic point of view LNG truck might be not the best solution due to specific of their last mile works.

In Germany federal authorities launched special support program for LNG/CNG vehicles. All the trucks propelled with CNG or LNG are exempted from toll on the roads. This was another argument for investment in the LNG fleet for many trucking companies, not only from Germany but also for all international long-distance truckers.

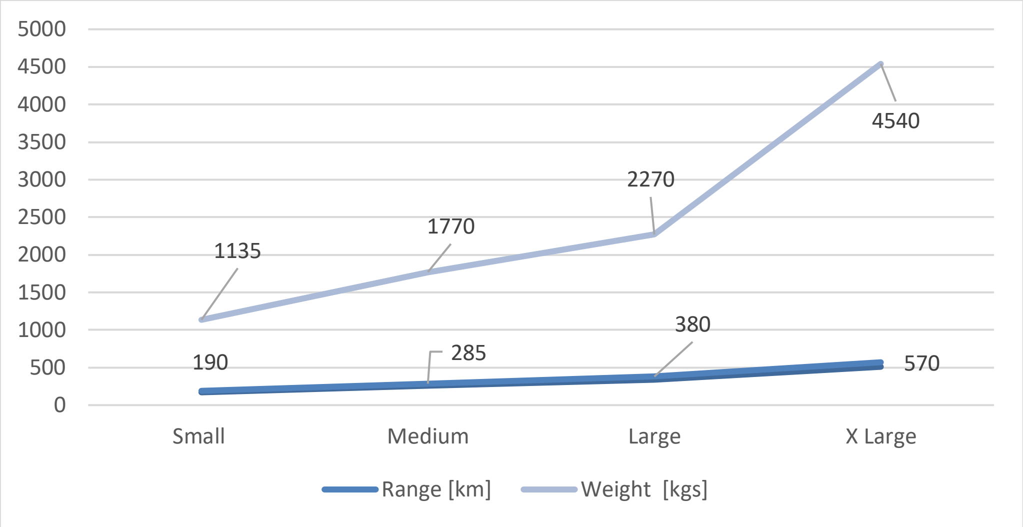
At the moment Germany is the only country in BSR which offer such benefits for the companies equipped in NGV vehicles. At the beginning of 2020 German government discussed if the program will be continued only till end 2020 or extended. One of the arguments was to support other alternative propulsions like hydrogen or electric. However, the authorities decided to prolong the LNG support program till the end of 2023 (IRU, 2020).

3.2 Full electric trucks / Plug-in trucks

Fully electric propulsion for trucks is the domain of light trucks up to 7.5 tons, which plays important role in city logistics and distribution. However, the future task for automotive industry is to implement fully electric trucks for heavy transport, including last mile in CT operations. Currently there are few manufacturers who are working on development electric trucks suitable for CT operations (see market availability).

The biggest limitation for development is the balance between truck weight, maximum speed and range of the vehicle. Below chart shows, that increasing range of electric trucks is closely connected with substantial increase in weight of battery installed on board. If comparing the weights of electric trucks with its diesel equivalents, difference can reach 10-15%. Such difference in weight can be crucial for CT operations with heavy loading units which are common in CT (Figure 17).

Figure 18. Relation between weight and truck range for different size of batteries



Source: Own elaboration based on https://www.futuricum.com/

Market availability – trucks and charging stations

As it was said in previous paragraph, there are few manufacturers developing electric trucks on European Market. E-trucks market can be divided into two groups of manufacturers. First one includes biggest players like DAF and MAN. Second group consists of small developers, i.e., Futuricum and Framo.

Taking into consideration CT-suitable trucks only, for now DAF is the only one from the “great 7” of trucks manufacturers who offer commercially fully electric tractor unit. Electric DAF CF configuration allows to build max 37 tons truck + trailer combination. Electric engine generates 286 HP, and it is supplied from 170 kWh battery which allows to drive up to 100 km between charging.

The next market competitor which expect to launch full electric tractor unit according to the last press release is Nikola which is sister-company of Iveco. The vehicle Is planned to launch on European Market during 2020-2021. Nikola Tre will be an electric unit based on Iveco S-way. Truck configurations allows to get 500 km range with engine power 650 HP.

Although, the biggest development of electric trucks takes place in small companies who are developing electric trucks based on common tractor units.

Trucks under brand Futuricum are manufactured and designed in Switzerland based on Volvo FM/FMX cabs. Those tractor units allow to get over 600 km range on single charging. Units are equipped with the electric engine which generates up to 680 HP.

Another example of “new-born” truck manufacturers or companies who offer electric vehicles is Framo. Units built by Framo in Germany are based on MAN TGX tractor units with an electric engine on board. It allows to build 44tons combination with maximum range of 150km. In 2019-2020 Framo trucks have been tested in CT operations under Dutch-German Interreg project eGLM – Electric Green Last Mile.

Despite the large number of projects underway, electric trucks are not widely available on the market as for diesel or NGV trucks. Sales network for small developers actually does not exist. Only DAF CF electric and Nikola Tre will be available in sales network of DAF and Iveco. Furthermore, also lead times for electric trucks which for now are truly custom-made products is much longer than diesel equivalents. One of the manufacturers declare lead time around 20-22 weeks.

Limited availability and costs of technology development has the influence on the price of such vehicles. Built-to-suit constructions are even two times more expensive than conventional diesel units, and the price can exceed 200,000 EUR (Table 3.8).

Table 3.8. Fully Electric tractor units available in EU market - comparison

	DAF CF Electric	Nikola Tre Electric	Futuricum unit	Framo Tractor Unit	Emos TYPE 4220
Max permit weight /t/	37	44	44	44	50
Range /km/	100	500	600	150	180
Power /HP/	326	644	680	400	495

Source: Own elaboration based on manufacturer's materials, press releases

The number of projects which are developing electric trucks generates the influence on new trucks registrations in the EU. In 2019, there was registered 747 pure electric trucks, whereas 608 in Germany which is the leader of Electric trucks fleet in Europe. Comparing that to 2018, the number of electric trucks registered in the EU has risen by 109%, specifically in BSR by 115% mainly due to the German market. Growth number of such vehicles in other BSR countries is marginal and is noticed only in Denmark and Sweden. Hybrid electric trucks are marginal in BSR trucks fleet and consist of 23 new registrations in 2019 which is 53% more comparing to 2018 y/y (Table 3.9).

Table 3.9. New electric trucks registration in 2018-19 in BSR countries

Country/Region	Electrically-Chargeable			Hybrid Electric		
	2019	2018	% change	2019	2018	% change
Denmark	3	3	0	0	0	0
Estonia	0	0	0	0	0	0
Finland	0	0	0	5	5	0
Sweden	2	2	0	6	5	20.0
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a
Latvia	0	0	0	0	0	0
Poland	0	0	0	2	1	100.0
Germany	608	279	117.9	10	4	150.0
BSR	613	284	115.8	23	15	53.3
EU	747	357	109.2	272	305	-10.8

Source: ACEA

Same organization provides the estimates for the demand on public charging stations. What has to be noticed, the technical specification of chargers for trucks differs from those known from passenger cars. Because of their significantly higher power and energy demand, as well as the many parking spots required along all major routes in Europe, heavy duty trucks cannot use infrastructure for passenger cars.

Currently the network of charging points for trucks across EU actually does not exists. According to ACEA estimations, the need of public charging points for trucks till 2025 exceed 16,000 points. By 2030 this number might be even four times higher. Such development of network requires financial support from local and European authorities. It is crucial for electric trucks fleet development to build stable efficient network of charging points. Thus, close cooperation with electricity providers, investors and trucking companies/logistics operators is necessary. A study of the traffic and work patterns with the local trucking companies would be a necessity. This way it might be possible with government support to create comprehensive and consistent network. From the angle of CT operations network should include logistics nodes like CT terminals to give the ground to develop electric, green last mile solutions (Table 3.10).

Table 3.10 Public charging stations for trucks – forecast

Power	Current availability	Needed by 2025	Needed by 2030
DC <100kW	<10	4,000(+20,000**)	50,000 (+20,000**)
DC 350kW	0	11,000	20,000
DC >500kW	0	2,000	20,000

Source ACEA ** charging station on private depots

3.3 E-highway and hybrid trucks

The limitation of range due to battery capacity and the charging stations for e trucks. was one of the reasons to develop the project called e-highway. The project assumes to build on the motorways overhead power lines as the source of energy for trucks equipped in pantograph. Connection between truck and lines is arranged automatically in speed range up to 90 km/h. Road sections without the lines like internal roads in logistics centers or local streets can be covered using battery installed on board of truck. To improve the efficiency of the system, energy inverters installed on board can give back energy produced, i.e., during braking.

Based on available data, in 2020 there are only four sections of e-highway within BSR, in Germany and Sweden. E-highway section in Sweden between Sandviken and Kungsgården has been built as the very first one and tested from 2016 till 2020. The plan for the nearest future is to close this project and evaluate the technology on first state e-highways planned on road E20 between Örebro and Hallsberg and Road 73 between Nynäshamn and Västerhaninge.

The three sections in Germany are developed during project ELISA which was started in 2018. In 2019 first section on A5 motorway in Frankfurt/Main area was ready to launch five test trucks. On A1 motorway in Lübeck area first trucks started tests in December 2019. Tests will take place until 2022, to collect the data under differentiated transport environment. First tests on third section – on state road in Baden-Württemberg will take place probably in 2020 (ELISA - eHighway Hessen, 2020).

For ELISA project the exclusive truck manufacturer is Scania. Swedish manufacturer expects to provide 15 trucks (5 for each test fields). As the project is on early stages and only few trucks have been delivered so far, it is hard to indicate the market availability of vehicles suitable for e-Highway.

Interesting option seems to be retrofitting old trucks with combustion engines into e-Highway suitable vehicles. The process includes changing the combustion engine to electric one with full equipment as inverters, batteries, and pantographs. It is also a good solution for rising number of trucks which are not comply to latest EURO emission standards. Similar retrofitting has been arranged within the scope of project Trolley, where diesel buses were converted to trolleybuses (ELITIS The Urban Mobility Observatory, 2014).

The costs of developing e-Highway on A5 in Germany is estimated on ca. 15,000,000 EUR, which means that each kilometer of infrastructure costs 1,5 mln EUR. Such investment should be considered only for locations with heavy traffic of goods haulage in last mile. A5 motorway in Germany bears average load of 135,000 cars per day. Approx. 10% of them are heavy haulage trucks (ELISA - eHighway Hessen, 2020).

E-highway requires close cooperation not only between infrastructure manager, power supplier and financing party. Every infrastructure has their users – here trucking or forwarding companies. What has to be noticed, transport services market in Poland or Baltic States is fragmented. The trucking companies are owning average few trucks which are universal, suitable for many destinations or types of cargo. Thus, projects such as e-Highway will require additional investment on vehicles, to be conducted by stakeholders like freight forwarders, 3PL companies or terminal operators.

The market of Hybrid trucks for CT operations is actually limited to diesel tractor units with electric engines to support the transport in urban areas. This solution is provided by Paccar (DAF) in CF trucks as an alternative to short distance pure electric. CF hybrid is propelled with diesel truck on standard roads and highways. In urban areas truck can be switched into electric propulsion with max range 30 — 50 km. Thanks to the fast charging, batteries can be filled up in 0,5 hours, time that can be used for example during stripping or stuffing ILUs.

3.4 Fuel cells – hydrogen

Trucks propelled with hydrogen are actually vehicles with installed electric engine propelled with fuel cells. These cells need the hydrogen to generate the energy, so the H_2 is considered as the fuel.

Hydrogen heavy duty vehicles market in Europe is in its' early stages now. Scania tests their trucks with Cummins cells in Norway for local distribution. Volvo and Daimler (Mercedes) started the cooperation to develop the hydrogen fueled trucks.

At the most advanced level seems to be Hyundai. Its' Xcient H_2 truck was nominated for Truck Innovation Award 2020, and Korean manufacturer started to deliver the truck to first customers in

Switzerland. The truck with 34.5 kg of H_2 on board can reach total gross mass of 34 tons and keep 400 km range between fueling. Unfortunately, based on current data, Hyundai offers only rigid trucks configuration for hydrogen fuel. This means, that hydrogen, similar as electric trucks can be of the nearest future of CT last mile operations. For now, trucks suitable for last mile operations propelled by H_2 are not available on the market.

Not any single hydrogen truck will work without efficient fueling network. ACEA calculates, that in 2020 there were 16 H_2 fueling stations across Europe. Future development of technology will require dynamic development of fueling points. Referring to ACEA estimations in 2030 Europe will need at least 500 H_2 fueling points.

3.5 Summary – a road map

The nearest future of propulsion for last mile deliveries is closely connected with EU policy to decrease CO_2 emissions in heavy haulage transport. EU policy expects to obtain Zero-emission economy until 2050. This requires from truck manufacturers to develop wide range of zero-emission trucks fleet. Group of leading European truck manufacturers declared to develop and sale only fossil free trucks by 2040. After 2025 and launching EURO VII emission standard is expected dynamic drop of diesel trucks in total share of European fleet. Exact details of planned EURO VII standards are still under preparation, but it is expected, that the levels will be hard to achieve by conventional diesel trucks.

Most of the propulsions are now under research or testing process so it’s availability on the market is limited. The most available technology for now are NGV trucks which are widely available on the market. Total share of NGV vehicles should rise constantly up to 2025 whereas EURO VII emission standard might get into force. After that, LNG or LBG trucks will be phased out of the market.

The technology of pure electric vehicles is developing dynamic. Manufacturers are capable to provide pure electric trucks with range and power suitable for CT operations. For now, those trucks are pure custom, built-to-suit work, so the price is for now the main limitation to the development. As soon as the technology will get in commercial serial production, the availability and the price should improve significantly. In the nearest future also proper network of charging stations has to be considered as the must for this technology Hybrid trucks for CT operations should be considered more as transitional solution towards pure electric plug-in trucks. E-highway as a cost-intensive solution will remain in use for long haul trucking, and might not play significant role in CT operations.

Third propulsion which can be considered as a solution for last mile CT operation is the hydrogen, which its constant development will transform from last mile city logistics to heavy trucking used for CT operations.

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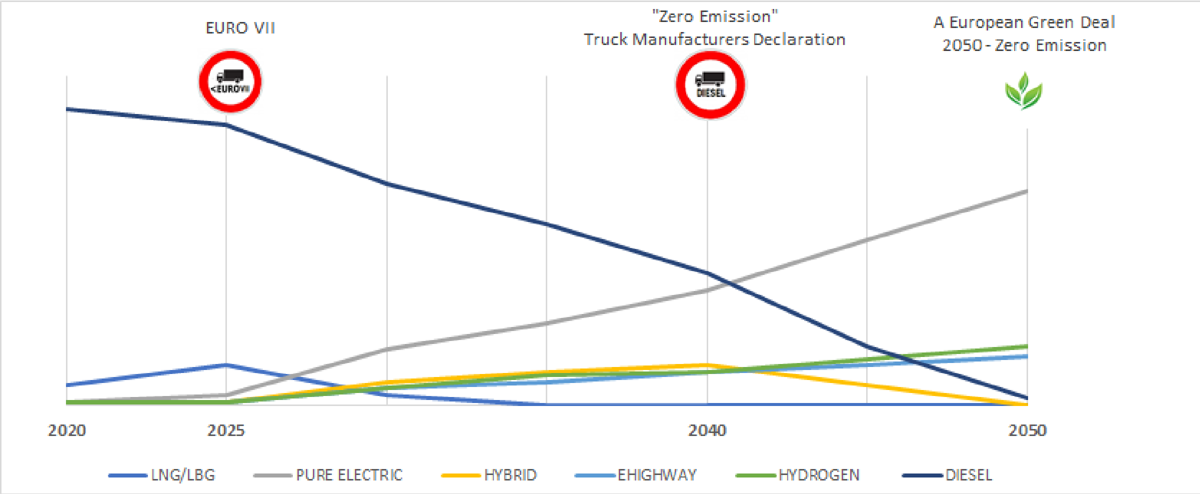
Figure 19. A roadmap for propulsions in heavy duty transport in EU



Source: Own elaboration

3.6 Key findings

- Shape of propulsions in last mile operations will be created mainly by EU policy within the scope of reduction CO_2 emission.
- NG vehicles are the most common available alternative propulsion trucks in BSR, but the emission levels are still under research process.
- Future of NG trucks depends on the possibility of using biogas or LBG/CBG which are considered as renewable sources of energy, and comprehensive network of fueling stations.
- Return on investment in LNG trucks is feasible only in transportation on long distances relatively heavy loads, thus for CT last mile operations LNG trucks might be not economic efficient.
- Increased weight of electric trucks – mainly due to batteries installed on board should push to rise the limitations on max permissible weight of truck/trailer combination.
- Range of electric trucks suitable for CT operations is limited, most of them are custom builds which increase the costs of purchasing and limits the development.
- New registrations of pure electric trucks rise in BSR by 115% y/y, mainly in Germany, thus development of fast charging stations and its' rising number in BSR is a must.
- E-Highway should be considered as transitional solution and due to significant costs, should be implemented only on heavy traffic nodes and CT terminals. Although, retrofitting diesel trucks into trolley-trucks seems to be interesting way to extend the lifecycle of the older truck fleet in BSR.
- Hydrogen fuel cells is the latest technology which is under first tests in distribution trucks in Europe, next step which can be considered is to implement it to CT operations.

3.7 Alternative propulsions comparison matrix

Table 3.11. Alternative propulsions comparison matrix

			Propulsions				
Aspect	Details	UNIT	E6 Diesel Truck	LNG Truck	Plug-In Electric Truck	E-highway	Hybrid
AVERAGE FOOTPRINT	CO_2 EMISSION	g/tkm	72	74	0	0	n/a
	PM	g/tkm	0.0015	0.0034	0	0	n/a
	NO_x	g/tkm	0.054	0.043	0	0	n/a
	SO_x	g/tkm	0.027	0.044	0	0	n/a
	FUEL CONSUMPTION	g/tkm	19	18	0	0	n/a
LEGAL/ INFRASTRUCTURE SUTIABILITY	SUITABILITY FOR BSR COUNTRIES		YES, IN USE	YES, IN USE	PARTIALLY*	PARTIALLY*	YES
	MAIN DEVELOPMENT BAREERS		EU Policy - limitations of GHG emission	Still fossil fuel - possiblity of use biogas is a key development factor	Limited availablity - both vehicles and charging points Limited range Weight of vehicle limits maximum cargo weight	Suitable only for heavy traffic nodes Expensive infrastructure Solution in test now, no results or findings available	Transitional solution from diesel trucks to pure electric
ECONOMIC MEASURES	REQUIRED INFRASTRUCTURE COSTS	EUR	n/a	n/a	n/a	1.4 MLN EUR/km	n/a
	VEHICLE PURCHASE PRICE (AVERAGE)	EUR	80,000	105,000	200,000	N/A	130,000

* see 2.2.2., 2.2.3.

Source: Own elaboration, emissions calculated via https://www.ecotransit.org/calculation.en.html

4 SUPPORTING TOOLS

4.1 OCR/LPR gates

CT terminals are acting as a node for modern supply chains. It's flexibility and ability to fast proceedings are important for the total costs of whole supply chain. Last mile delivery process for each ILU starts at terminal road gates.

One of the factors of efficiency for last mile operations is the idle time for trucks when waiting for container pickup or by terminal gates to get in-out of facility. For small terminals gate operations are arranged manually. This means that truck, driver and ILU verification process is done by a terminal staff. With the increase of terminal turnovers manual verification is not sufficient and most of terminals decide to install gates equipped with Optical Character Recognition (OCR) and License Plate Recognition systems (LPR). These features allow to verify the license plates, ID number of driver and Ilu number and condition with data provided in delivery notification. If the data is complying, system opens the gate to let the truck in.

Such solutions are domain of the biggest terminals in BSR and Europe. Mostly visible in port terminals – both roro and container, but also installed on inland CT terminals. As the examples in Europe should be indicated: APM Terminals in Rotterdam and Aarhus or HHLA Terminals in Hamburg. As the examples of inland CT terminals with OCR system can be showed Antwerp Combinant or Hupac terminal in Busto Arsizio in Italy.

Based on internal materials of OCR gates supplier, efficiency of terminal gates after installation of OCR improves by 30 – 40 %. In practice – gate in process for trucks last less than one minute. It helps to keep fluent traffic flow even in terminal operation peaks.

4.2 Tracking devices and supporting software

One of the megatrends of future logistics is the transparency in supply chain. Thus, modern fleet of trucks in last mile operations cannot work without efficient and durable tracking devices. Nowadays, most of the fleet vehicle manufacturers provides their own tracking and telematics services. For bigger and not homogenous manufacturers, fleet telematic solutions can be provided by variety of manufacturers and dealers in BSR. Latest telematic devices for trucks and trailers do not limit the collected data to current truck position and its history. It provides among others:

- Current fuel consumption (alarms deviation of fuel level in case of theft);
- Informs about requires vehicle maintenance;
- Rates the driver performance (eco-driving); and
- Customized history data about truck performance for easier management and forecasting.

Data provided by tracking devices has to be stored in safe way – that's why cloud computing plays important role in latest telematics system. Collected data gives a good background for making decisions and efficient utilization of the fleet.

Telematic solutions has positive influence on carbon footprint. Driver performance measures gives the potential to reduce fuel consumption and GHG emission.

Total costs of introduction telematic solutions inside the company depends on key factors like fleet number, data expected to collect, software and data analyze tools to be used. In general, telematic solutions offered by truck manufacturers is calculated on level of several dozens of euro per month.

Referring to software supporting last mile operations, it also has to be noticed that there is a number of web platforms supporting CT equipment interchange. In practice a lot of ILUs in CT last mile operations are full only one way – retuning empty to depot. It is typical especially for ocean carrier's containers – where shippers have a variety of carriers to choose, but not always with proper availability of equipment on nearest terminal. To avoid repositioning of empty containers, operators can use platforms like Avantida or container X-change. Such platforms help to receive information about the availability or need of empty containers on chosen terminals across Europe, supporting optimization of last mile fleet usage and minimizing transport of empty units giving bigger efficiency.

4.3 Lifting jacks / standing foots for container

As it was mentioned few times in subject report, one of the crucial factors of CT last mile effectiveness is the time. The trucks operating in CT deliveries or pickups working constantly in loops between terminal and warehouses or logistic centers in a relatively small distance. Thus, the number of loops done per day determines economic efficiency of single truck – which can be owned by CT operator or self-employed trucker.

Intermodal loading units carry a lot of different kind of logistic packaging inside. Starting from the pallets through big bags up to cartons in loose – which are mostly used for overseas shipping in sea containers.

The way of ILU must be stuffed combined with the efficiency of stripping/stuffing party determines the total time which truck spend idle by the gate of warehouse. Depending on configured delivery chains in to possible to leave the ILU by the gate for cargo operations and move the truck to terminal for another tasks. If the ILU is a trailer for CT operations it is feasible to detach from tractor, but the complications starts when cargo needs to be loaded or destuffed form a container which has no foots to stay by the gate.

Thus, there are solutions on BSR market which allows to put the containers lifted by the gate and release the truck to another tasks.

Lifting jacks provided by ConFoot from Finland or Move It logistics from Poland allows to lift up the containers and easily put in down on the ground level or keep the gate level to use a forklift and continue the loading operations. Both devices can handle containers in variety of sizes up to approx. 30 tons (Figure 19).

Figure 20. ConFoot (left) and Lifting Jacks (right)

Source: manufacturer's materials

For cargo operations which lasts even 2 – 3 hours like stuffing container in loose cartons or consolidation containers stripping it gives the trucker in last mile operations additional time for extra operations per day. Depending on variety of factors like traffic, distance between terminal and delivery, workflow on terminal and destination points etc. trucker can arrange 2 – 3 last mile loops in his 9-hourly workday. If we cut the idle time by the gate for 2 – 3 hours – it allows to improve the efficiency by 30%.

4.4 Special ILU

Some of the goods may require special equipment in CT operations. For example, bulk cargo like grains or aggregate can be transported in standard dry ILUs after loading in bags or can be loaded into special containers. Bulk liquids require special tank containers and trailers equipped with hoses etc. Unfortunately using special containers shortens the flexibility of multimodal operators and have the influence on total operating costs. How using special loading units can positive influence on CT last mile operations and its costs?

One of the examples of use special containers is the multimodal operator Laude from Poland. This entrepreneur use CT solution to transport steel coils and grain mainly between EU and CIS countries. In one of their projects Laude developed special containers which can be used to transport both bulk cargo and palletized standard cargo. Bulk cargo can be loaded gravitationally through the hatches in the roof, palletized cargo using standard back doors.

Containers 20'HTSYP among of the advantage of multiuse have direct influence on last mile operations. Discharging the bulk cargo from container implicates to use container trailer with tipping mode. It is an investment for the CT last mile operators, but what has to be noticed, it shortens the time of discharging operations. Tipping cargo out of 20'HTSYP do not exceed few minutes, whereas stripping of container loaded with big bags extends to 15 – 30 minutes. If the bulk cargo is loaded into 25 – 50 kg bags loaded loose into container, stripping time extends above 3 hours (Figure 21).

Figure 21 20'HTSYP special container in operations

Source: Laude Smart Intermodal

Development of special equipment is not the main role of CT operators, nor last mile operator or trucking subcontractors. Nevertheless, using of innovative loading units like indicated Laude HTSYP container can have crucial role in last mile operations. Cutting the time of waiting for discharge by 50 – 70% have positive influence on total efficiency of trucks involved in CT last mile operations and at the end on economic efficiency of whole chain based on CT. Additionally, combining special equipment with using it as standard dry container gives the opportunity to keep the flexibility of chain created by CT operator.

4.5 VGM devices

Launching LHV trucks on BSR roads can improve the efficiency and capacity of last mile operations. Besides, LHV can also carry the risk of overweighing the trucks. Especially, when the CT terminal do not verify the mass of handled ILUs. Starting form 2016 all sea containers loaded on board vessels has to have verified gross mass, which should be declared by shipper. This requirement might be implemented for CT last mile operations with LHV.

One of the tools to prevent traffic of truck in CT last mile with exceed weigh is to verify ILUs mass once it is received on terminal or once it leaves terminal full for delivery. Verification of gross mass is allowed among others by weighing the container on weighbridge or by devices installed on terminal handling equipment. Unfortunately, not all terminals in BSR are equipped by such devices. A solution for them is to invest with weighing jacks or scale for containers and swap bodies. Supply market offers a sort of devices, even wireless which provides verified mass via mobile app. Devices may not improve directly the efficiency, but it might be an indirect tool to improve the capacity of the last mile deliveries by launching LHV transport.

4.6 Key findings

- Efficiency of last mile operations in CT depends not only on the mean of transport but also on external factors, like using special ILUs or additional terminal or warehouse equipment.
- Stakeholders in last mile operations should consider IT solutions as a tool to improve the company effectiveness by measuring the performance and by avoiding empty runs of trucks.
- Launching LHV vehicles will require continuous verification of ILU mass to avoid truck overweight. It might be possible due to good market availability of mass checking devices.

5 LIST OF TABLES AND FIGURES

6 ABBREVIATION LIST

3PL	Third Party Logiststic Operator
ACEA	European Automobile Manufacturers Association
BSR	Baltic Sea Region
CBG	Compressed Bio Gas
CNG	Compressed Natural Gas
CT	Combined Transport
EAFO	European Alternative Fuels Observatory
EC	European Council
EMS	European Modular System
GHG	Green House Gas
ILU	Intermodal Loading Unit
IRR	Internal rate of return
LBG	Liquid Bio Gas
LEV	Low Emission Vehicle
LHV	Longer and/or Heavier Vehicles
LNG	Liquid Natural Gas
LPR	License Plate Recognition System
NGV	Natural Gas Vehicle
NGVA	Natural Gas Vehicle Associacion
OCR	Optical Character Recognition
OECD	Organisation for Economic Co-operation and Development
TEU	Twenty-feet Equivalent Unit
ZEV	Zero Emission Vehicle

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