DELIVERABLE D.T3.3.2
FULL ELECTRIC TERMINAL PILOT IN BERLIN

(INCLUDES D.T3.2.2 AND.T3.3.1)

Final assessment of greening transport measures for Full electric Terminal Pilot in Berlin

Version 2

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1. Introduction

The Full electric Terminal Pilot in Berlin is one of 7 pilot actions of the InterGreen-Nodes project. To demonstrate the infrastructure and technological possibilities for the application of clean fuels at the local level, meaning the last mile, and at the terminal, measures to make transport greener have been assessed and validated through stakeholder inputs.

This concluding report is the final assessment report for the pilot activity (D.T3.2.2 + D.T3.3.2) and includes the evaluation of technical performance and environmental impact measurements, as well as lessons already learned from the mid-term evaluation D.T3.3.1).

In this pilot activity, a full operation of an electric terminal in Berlin, including the use of electric road vehicles and electric rail shunting vehicles, are demonstrated.

2. The Basics of the Full electric Terminal Pilot in Berlin

The "full electric Terminal pilot" is meant to demonstrate the viability of electrifying numerous processes along the complete added value chain.

It consists of elements, that are already electrified on a regular basis in numerous ports (such as using electric cranes for transhipment). But it also changes other elements of the added value change to electric drivetrains.

The specific InterGreen-demonstrator-elements are situated in the Berlin Westhafen-port, operated by BEHALA. They consist of:

- Electric rail-shunting Vehicle,
- Electric Crane,
- Electric Terminal Tractor, that doubles as a 40 t road vehicle,
- Electric general purpose cars and
- Electric utility van (for use by maintenance personnel, equipped with maintenance tools).

3. Step by Step description of the implementation and Lessons Learned and Experiences

All vehicles used in this demonstrator, are battery electric. As opposed to other drive-train- and energy-storage-solutions, it is not necessary to install large Meta-infrastructure for the operations of battery-electric vehicles, as the electric grid for recharging electric vehicles is already in place, while other solutions would need their own supply and production infrastructure (e.g. for hydrogen or bio-methane).

As electric vehicles come with certain constraints, the purchase process differs greatly from that of conventional vehicles. For example: The range of an electric vehicle depends greatly on its battery capacity. However, batteries are the most expensive component of any electric vehicle, with prices between 500 € and 1.000 € per kWh. A battery too small would lead to a vehicle that would not meet the operator's demands, a battery too large, would lead to much higher operating costs, than necessary.

The specific characteristics of electric drivetrains have a number of additional positive effects in an urban environment:

HIGH EFFICIENCY in urban areas: Electric motors provide their maximum torque across the complete performance spectrum, enabling quick accelerations at any speed, while conventional engines only provide maximum torque over a certain rate of rotation. Practically this means, that an electric motor can accelerate with less energy-demand than a conventional motor. This leads to a lower energy-demand, especially in urban environments, where vehicles have to decelerate and accelerate often. This leads to a more efficient energy use from "tank/battery" to wheel. Conclusions about the total energy efficiency can only be drawn, when the whole energy-supply chain is considered and will differ, depending on the method of electricity production.

REDUCED NOISE EMISSIONS could allow for new logistics concepts: e.g. night deliveries in urban areas for example to stores. It also allows for direct delivery into buildings, for example: transportation of trailers with production material, directly to production/assembly lines, without additional transshipment at a loading dock. Tough loading and unloading can still emit noise, this noise can be minimized by technical solutions (rubber wheels on transport carts, rubber buffers etc.). The relative quietness of electric vehicles can make them a hazard, when other road users (mainly pedestrians and cyclists) are not able to hear the electric vehicle. Technical solutions, such as noise emitters are currently being discussed.

RECHARGING AND RANGE: Range is an important issue in the operation of electric vehicles. A number of demonstration projects have tested recharging processes in between tours during one day. However, this has often proved to be impractical, as delays in deliveries often lead to a shortage of time for the recharging process. It seems generally more practical to recharge vehicles during longer non-operations-periods (e.g. during the night). Tests with battery-changing systems (i.e. the whole empty battery is being swapped for a recharged battery) have yet not been proven to be practical, as the very high costs of batteries lead to very high additional investment costs.

A general step-by-step process for the selection and operationalization of electric vehicles could look like this:

Step 1: Define your objective:

To make you introduction process a success, you first should define your objective, in order to have clear indicator for your success. What amount of CO_2 do you want to save, do you want to replace your complete fleet or only certain vehicles, what is your time frame?

Step 2: Estimate the necessary range and annual mileage

If you have your vehicle logbook in a digital format (e.g. Excel) you could proceed as follows:

- Sort all logbook entries by days, so that you get a list for each day.
- Sort each day by tour-length, starting with shortest tours.
- Now you can build categories for short, medium and long tours.
- Evaluate the numbers of each tour-category by length, number of tours per day. Calculate the necessary range a vehicle would need to cover per day, in order to get a value for your range demand. Examine, if perhaps a tour category (depending on your objective) could

be covered by electric vehicles. Tweak the category, in order to optimize according to your objective.

Step 3: Decide on Gross-Mass and Payload:

You can use the gross-mass of your current fleet as an indicator and choose a gross-mass as large as the one of the vehicle(s) you wish to replace.

Step 5: Estimate you're the necessary Battery capacity

To calculate the necessary battery capacity in order to reach the required range (estimated in Step 2), the following formula can be used (please keep in mind, that this formula can only give you a rough estimate. Operations in hilly areas may lead to higher energy demands):

$$Battery - Capacity\ [kWh] =$$

$$(max.Range\ [km] * 0{,}3413 + Vehicle - Gross - Mass\ [t]\ *\ 1{,}3579\ +\ 28{,}57) * 1{,}2$$

You should try to find a vehicle with a battery capacity at least as large as the one calculated.

Step 6: Estimate your costs

More on this subject in chapter 4.

Step 7: Estimate CO_2-savings

In order to estimate your current CO_2 emission, determine the average fuel consumption per km of the vehicles you wish to substitute and multiply this number with the mileage you wish to substitute. Then multiply the result with

- In case of a Diesel-vehicle: 3.16
- In case of a Gasoline-vehicle: 2.88

The results are your current CO_2 emissions in kg, for the vehicles/tours you wish to substitute.

In order to estimate the CO_2 emissions for your planned electric vehicle(s), first ask you energy supplier for the CO_2-factor per kWh. Than multiply this CO_2-factor with the total consumption, you calculated in Step 5.

Step 8: Choose the proper vehicle and contact the vendor

Using the input data from Step 3 and 4, you can use the vehicle catalogue in Annex I to choose some matching vehicles and contact the vendor.

Step 9: Talk to your vendor about charging infrastructure and maintenance

Using the inputs, you determined form Steps 1 to 7, clarify the following questions with your vendor:

- Will you need your own charging stations or are there public charging stations you could use?

  You can find public charging stations on the internet, for example here:

  - www.plugsurfing.com
  - www.chargemap.com
- What would a quick-charging station cost and how much faster would a quick-charging station charge?
- Is it possible to install the necessary charging station on your own electric house-connection/property-connection/company connection/municipal connection?
- You might also need to clarify this question with your energy provider.
- Will the available electric-power be sufficient (especially when charging several vehicles)
- When using a quick charging system: Will you need a load management system?
- Can/shall the charging station-status be diagnosed via the internet for maintenance purposes?
- What services are offered within the maintenance contract for your charging station?
- Does the vendor offer a maintenance contract for the vehicle?
- What services are offered within the maintenance contract for the vehicle?
- Does the vendor offer you a guarantee on battery-life?
- Does the vendor offer you a battery exchange after a certain mileage?
- Where are the next maintenance service stations for your electric vehicle?

4. Cost and emission effects

Electric rail-shunting vehicle

The KPI model developed in InterGreen-Nodes DT3.1.2. in order to calculate costs and GHG-emissions was used for the BEHALA electric rail shunting vehicle Windhoff ZRW 50 in Westhafen. Before, a diesel-fuelled road-rail vehicle, a Unimog, has been used for shunting operations. The vehicle was operated by two people, a driver and a shunter. In 2014, the Unimog was replaced by an electric shunting vehicle. Now, only one operator is needed for the shunting, as the vehicle is remote controlled and no driver required.

The differences between the Unimog and the Windhoff rail shunting vehicle in terms of environmental impact were observed between 2012 and 2019.

	Unimog (diesel)		Windhoff ZRW 50 (electric)		
Year	2012	2013	2017	2018	2019
GHG-emissions (kgCO_2e/km)	22.83	13.88	3.59	4.42	3.42

The differences between the vehicles are clear. While the Unimog emits an average of 18.35 kg of CO_2e per kilometer, the greenhouse gas emissions for the electric vehicle are just 3.81 kg of CO_2e per kilometer. This corresponds to a decrease of 79%.

Regarding the costs, literature doesn't provide any detailed information on shunting vehicles. What can be said, though, is that the costs for energy for the electric shunting vehicle per kilometre per year are notably lower than for the Unimog, due to the also lower level of consumption per kilometre. For the Unimog, energy costs amount to 5,32 €/km on average, whereas costs for the electric version are at 1,74 €/km. Together with the savings allowed by the reduction of employees needed for the process, these are already two cost factors indicating at least an ability to compete with the diesel vehicle regarding the costs.

Terminal tractor / 40t truck Terberg YT202EV

We used the KPI model developed in InterGreen-Nodes DT3.1.2.in order to calculate costs and GHG-emissions for the YT202EV and put them into comparison with diesel-trucks, used parallel in the same processes at Berlin Westhafen.

CO_2-emmissions are on average lower for the electric vehicle. CO_2 emissions depend on the energy mix used (for the electric vehicle), as well as from the driving style and traffic situations (accelerating often in urban traffic, leads to higher fuel use and therefore CO_2 emissions):

	Diesel-truck			E-truck		
Year	2012	2013	2014	2017	2018	2019
GHG-emissions(kgCO2e/tkm)	0.32	0.34	0.22	0.24	0.25	0.18

We also put the Total Cost of Ownership (TCO) in relation to a Diesel truck. Due to higher purchasing costs, electric vehicles are usually more costly, than their diesel—counterparts. Additionally the YT202EV is a specialized vehicle, produced in small series, increasing the purchasing costs further.

	Diesel-truck			E-truck		
Year	2012	2013	2014	2017	2018	2019
TCO [€/year]	27,352.62	27,942.24	26,643.65	48,862.36	47,886.40	47,738.32