Long Distance Freight Transport Research

Decarbonizing Freight Transport with available green energy

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Background

The uptake of zero emission solutions for long distance freight transport will lead to increased demand for clean energy well-to-wheel. The need for renewable electricity, clean hydrogen and alternative fuels will rise, whilst the need for traditional fossil fuels will decline. Decarbonizing long distance freight transport requires the availability of sufficient green energy at affordable price. The energy system – i.e., energy production, storage and distribution – will need to accommodate an increasingly decarbonized freight transport sector.

In addition, logistics companies' acceptance of zero emission transport solutions should be considered, as the green transition is to be driven by demand, in the end. Who are the main beneficiaries of the green transition? Who should carry the risk in this time of uncertainties and to what extent?

The objective of this paper is to describe research & innovation actions that would accelerate the implementation of decarbonized, long distance, freight transport from a life-cycle perspective, considering the whole ecosystem – including energy production, storage, distribution – as well as customer's perspectives.

Trends overview & main assumptions

The decarbonation of transport is a necessity but it is not proceeding at the right pace. Transport has been singled out in the EU Climate Action Progress Report 2023[1]**:** to stay on track, the report warns, it will be necessary to *"almost triple the average annual reduction [in greenhouse gas emissions] achieved over the last decade"*, targeting the areas *"where action is most needed […] mainly buildings and transport".*

Decarbonizing transport requires access to sufficient green energy at affordable price.

The Green Deal targets are technically achievable with a few powertrains being used, zero (tailpipe) emission technologies being the largest[2]. The ERTRAC study[3] concluded that "*in a WtW perspective, electricity is […] in many cases, the dominant energy vector to be used in EU27 road transport in 2050 […] either [...] as [a] final energy or as [an] intermediate feedstock"* and that *"firstly, road vehicle fleet electrification* [including Electrified Road Systems]*, focusing on battery and fuel cell electric vehicles [first], is the strongest single enabler for transport final energy consumption reduction"*.

However, whilst the introduction of zero emission technologies will need to ramp-up as quickly as possible, infrastructure bottlenecks will constrain progress until 2030[4]. This was illustrated in the metastudy[5], comparing the cost of the energy transition in a selection of roadmaps. In addition, both reports investigated potential resource (and critical component) scarcity, as the demand for critical minerals for clean electricity supply and electrification technologies will increase drastically. Other studies highlighted that even if resource availability would not be a concern, scaling-up mineral supply fast enough might still be a challenge.[6]

By 2030, electricity generation should no longer be an issue: as an example, according to the Fraunhofer Institute energy charts[7], renewables would already account for 44% of the EU power production in 2023 - which is an

1 EU Climate Action Progress Report 2023-eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023DC0653
2 Fit for 2035: a vision for a Heavy-Duty Portfolio in that Year, Simon Edwards, T. Downes and A. Auld, Ricardo
3 Jette Krause, Marta Yugo, Zissis Samaras, Simon Edwards, Georgios Fontaras, Roland Dauphin, Peter Prenninger, Stephan Neugebauer, Well-to-wheels scenarios for 2050 carbon-neutral road transport in the EU, Journal of Cleaner Production, Volume 443, 2024, https://doi.org/10.1016/j.jclepro.2024.141084
4 FVV__1378_Future_Fuels__Study_IV_Briefing_Paper__R600_2021-10__EN.pdf (fvv-net.de)
5 Evolution of the EU Energy system to 2050: comparison of selected roadmaps and reports, EUCAR, frontier economics
6 https://www.energy-transitions.org/wp-content/uploads/2023/08/ETC-Materials-Report_highres-1.pdf; IEA & US Geological Survey (2023)
7 Pie Charts Electricity Generation | Energy-Charts, Fraunhofer Jan. 2024

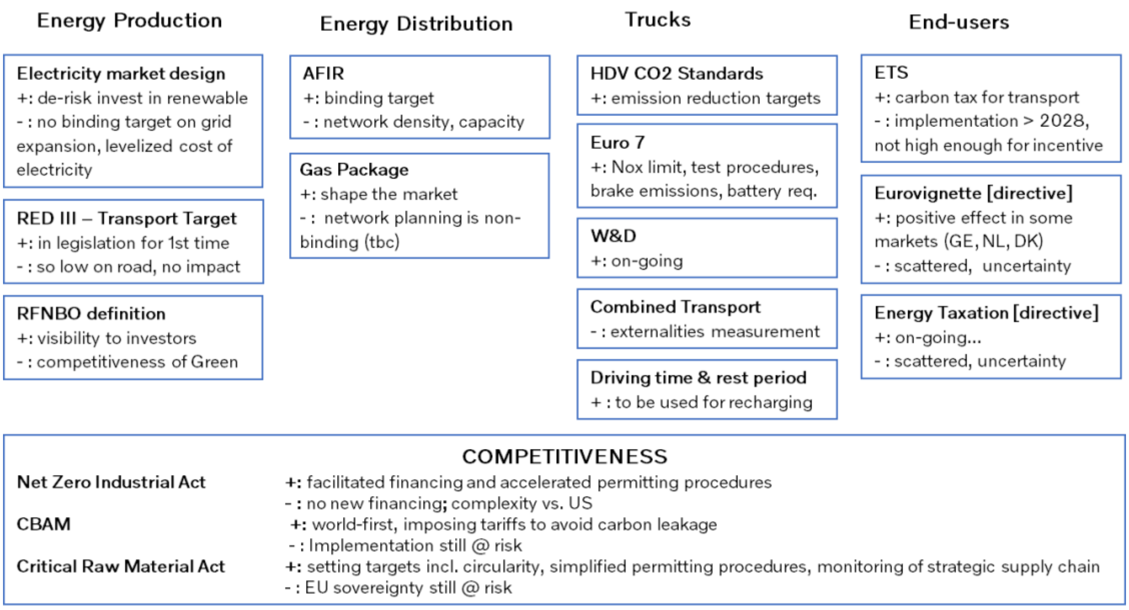
enormous increase from previous years. However, efforts should be pursued, since the European Commission[8] found that current national climate plans add-up to only 39% renewable energy by 2030 (the target being 42.5%[9]).

However, the distribution of electricity and the capacity of the power supply will remain bottlenecks. According to ENTSO-E, *'HDEV charging shall have an important impact on the local grids; the advanced planning of network upgrades and reinforcement, coordinated with higher voltage levels, will become crucial as the permitting and construction of new substations and HV lines usually takes a long time, which is incompatible with the fast needs of transport electrification''*[10]. Investments in distribution grids will need to increase on top of the historic efforts[11], and must grow threefold this decade[12]. The IEA indicates that worldwide *"80 million kms of power lines will need to be added or upgraded by 2040, in less than twenty years"*[13]. Transport is not the only sector that needs to decarbonize – e.g., an ERT report shows there is not enough clean energy to cover the needs for energy intensive industries and that *"we need to invest as much in our electric grids as in new solar and wind capacity by 2050"*[14].

Nevertheless, we should note that this is not unique to the electricity grid, and that investment capacity issues apply to all new infrastructure (pipes etc.). Energy "availability" also applies to green hydrogen: some analysis[15] shows that there is not much green H_2 left for road mobility by 2030. Factors for the transformation are currently not in place: grid infrastructure, availability (and price) of renewable energy etc. The access to energy is jeopardizing the speed of the green transition of the transport sector.

The current EU legislative framework does not address enough energy access for road transport.

As of today, the most binding regulations are on trucks, as shown in the picture below. There is a need for some cohesive legislative framework with target consistency, so that the green transition is driven at the same pace across all sectors. Some bold decisions might be required in the areas of renewable energy generation and energy distribution for road mobility. Additionally, this needs to happen across-member states, as a scattered system would just enhance uncertainty.



8 eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52023DC0796
9 Renewable Energy Directive
10 Deployment of Heavy-Duty Electric Vehicles and their Impact on the Power System (windows.net)
11 Decarbonisation Speedways - Full Report - Eurelectric – Powering People
12 BloombergNEF, 2022
13 Electricity Grids and Secure Energy Transitions – Analysis – IEA, October 2023
14 ERT Competitiveness of European Energy-intensive Industries, ERT & BCG
15 Hydrogen Europe; RED RFNBO transport sector targets calculation

Who will take the risk of investment?

The demand-side of the transport market is crucial to get the whole new energy system coming into place. The transition will be driven by users in the end. There is a need for building consensus on which technologies to choose (depending on the use case), especially as there is some uncertainty about the future energy mix. Customer acceptability is the cornerstone – and the total cost of ownership is one of the main drivers for it, combined with common and agreed sustainability method calculation (LCA)[16]. Some learnings show that *"There are many interdependencies among variables such as: range, capex, efficiency, payload, charging time, driving/speed, routing etc. for electric trucks. The starting point should be the use case and mission profile that will define the battery pack, charging strategy etc. and, therefore, the most suitable vehicle configuration for the mission profile/use cases."*[17] In other words, relevant TCO analysis will be use case specific, it must start with the mission profile. The same applies for LCA, as every transport task will be unique, thus the overall result will change drastically based on operational conditions. LCA and TCO will give an overall indicator of the environmental impact and of operational costs for road vehicles, but they could be misleading to use them as a comparison tool in absolute figures.

Regarding the terminology 'users' or 'customers', we should distinguish between 'carriers' (or 'hauliers') who are operating the trucks, 'logistics services providers' who are either outsourcing to another company or subcontracting from, and 'shippers' who are the owners of the goods to be transported, i.e. an organisation which buys transport services. Finally, there are less clearly defined intermediaries who play a key role in contracting transport and price negotiations.

Customers are also looking into decarbonization pathways other than *"cutting [the] carbon content of [the] energy used"*, including *"reducing the total amount of freight movements"* or *"improving [the] energy efficiency of logistics operations"*[18]. Citizen acceptance needs to be considered as well, especially in the context of inflationary pressure. If no limitation for transport is foreseen, logistics companies and shippers must change, considering innovative logistics schemes at several levels in the system and becoming even more efficient. Will logistics patterns change (restructuring of logistics systems, role of the driver, route planning etc.)? Will ownership of the trucks change with the current uncertainty? New services are to be considered, with data exchange as a key enabler, win-win business aspects and safety. In addition, the connection to other modes of transport could be an opportunity.

The cost of the transition cannot be borne by small 'carriers' or 'hauliers' and fragmented operators with very thin margins. So, we should understand how much society (logistics providers, shippers, industries and citizens) is able to pay for decarbonized transport and who the main beneficiaries of the green transition are, in order to consider feasible and effective value sharing models.

Key issues

1. **How to speed-up the rate of change that we can execute in the transport sector?**
   - Technology is there but the key question is the pace of the green transition. Different solutions might be required to accelerate the transition towards zero emission[19] – this is especially true for heavy-duty trucks that embrace a wide array of use cases: *confined areas*, *hub-to-hub*, *highways* and *urban freight*.
   - An 'realistic' mix of propulsions technologies for these different use cases needs to be set with regard to TCO and LCA by 2030, as well as beyond (once the energy mix is more certain).

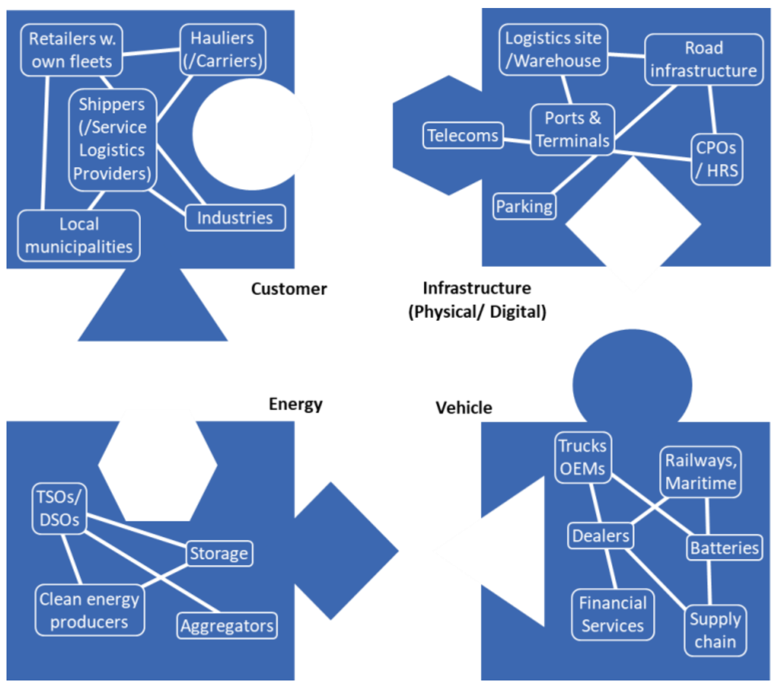
16 TranSensus project - https://cordis.europa.eu/project/id/101056715
17 Learnings in ALICE/ZEFES over 2023 and plan for 2024
18 Logistics Research Network Conference, Sept. 2023 - https://www.alanmckinnon.co.uk
19 Definition of 'zero pollution' according to EU Action Plan "Towards a zero pollution for Air, Water and Soil"

2. **Which are the common technology building blocks that can be deployed cross-sector – and, by that, benefit from an additional scaling factor?**
   - Battery technology represents a significant part of the truck's value. It is a game changer and will require further investments and research.
   - Power electronics is a cross domain technology with application in all sectors, for instance mobility, energy and manufacturing. Wide Band Gap technologies will enable a strong increase in the performance of the power converters whilst ensuring cost-effectiveness through economy of scale.
   - Circularity needs to be considered across actors (due to lack of resource in Europe), in order to achieve sustainable development goals.

3. **Can we change the carbon intensity of road transport with new operational business models? What are the "touchpoints" – upstream and downstream – with the other sectors (energy, logistics etc.) as well as with other industries (energy intensive industries etc.) and other modes of transportation (ports etc.)**
   - There will be some competition to access energy (freight/transport vs other needs such as intensive energy industries), but this could also be an opening for new business models and opportunities.
   - There is a need for substantial investments to improve access and distribution to renewable energy. The scaling of new technologies should be coordinated to the deployment of new renewable energy production and distribution, as well as to significative demand centres.

Research Areas – System perspective

The efficiency of the whole system is at stake, as not all the parts are fitting together. We need to work with the system (consisting of customer, infrastructure, energy and vehicle) - grasp how the pieces of the puzzle will even fit further together. We have identified below some hot spots for further research efforts to help improving efficiency.



Customer

- What would incentivize change for different types of end-users and make them use/ buy/ pay for decarbonized transport?
- Innovative logistics decarbonization pathways – e.g. new logistics schemes, EMS2 and IoT cargos, trailers (/ driver) swapping
- Large scale demonstrations of new technologies in a few TEN-T roads/corridors (or eco-hubs) in real logistics flows with specific mission profiles.
- Achieve a common definition for the goal and scope of LCA. Converge towards some common formula with common parameters (battery sourcing, energy sourcing, recycling, components etc.), as well as knowing shared assumptions.
- Regulatory efficiency and harmonization over related sectors (including some comparison with the US IRA) – compared with the legislative aspects mentioned earlier.
- Projections of most likely future availability, quality and price of alternative carriers in the EU

Infrastructure

- Understand public charging opportunities, costs and framework conditions (aligned with driving and rest time rules). How to optimize charging utilization (profitability) with charging point availability (charging congestion), as well as route optimization considering charging (book a time slot, book& pay).
- Cooperation of vehicles with local energy networks: location of vehicle flows compared to energy/grid vulnerability → identify additional charger spots needed
- Validate system business case of dynamic charging, including energy system impact – define most fruitful use cases, build scenarios for willingness to invest etc.
- Alternative business cases for vehicle standing still (loading, charging, driver resting etc.): distinguish key differences in requirements for trucks when compared to passenger cars
- Optimization of road maintenance related to zero emission technologies

Vehicle & Power systems

- Use case tailored battery sizing and optimization. Understand the business case impact of battery operation (2^{nd} or 3^{rd} life of batteries) versus battery acquisition: cost for changing the battery with regard to sustainability – including circularity aspects
- Measure the impact of dynamic charging (conductive and inductive technologies) mixed with stationary charging (impact of V2G on battery durability etc.)
- The different uses of hydrogen (fuel cells or direct hydrogen injection) in the transition to a decarbonized long distance freight transport system
- Transmissions, electric motors: improve reliability, package and efficiency
- Artificial Intelligence (AI) in relation to R&I of new solutions, such as battery charging process, power generation process etc.

Energy

- Design business models for energy delivery (and energy storage) services to the transport sector and vice versa (V2G)
- Update scenarios for energy infrastructure investments for diverse transport decarbonization futures, to support regulation, investment decisions and preparation of the transport sector
- Optimize infrastructure roll-out by combining industries opportunities driven by the energy transition → Investigate synergies cross-sectors and industries