Developing a Vehicle Selection Procedure for Logistic Operators of Catalonia, Spain

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Abstract

The worldwide need for energy continues to rise as it tries to meet the growing demands of a growing human population, with fossil fuels remaining the primary source. However, the use of fossil fuels releases greenhouse gases (GHGs) and pollutants into the environment, which contribute considerably to the phenomena of global warming. Alternative fuel vehicles (AFVs) present a dual advantage of reducing fuel expenses and curbing greenhouse gas emissions, making them an attractive choice for consumers in the market. However, the rapid pace of technological advancements has made the selection of the right AFVs a complex decision for goods transport operators. This paper introduces a comprehensive methodology for vehicle selection in an effort to improve access to information about the affordability of alternative fuels and to assist logistics operators in making well-informed decisions about the most appropriate technology for their specific needs. The developed method entails a step-by-step filtration process that includes financial and technical evaluations, infrastructure assessment, a review of risks and opportunities, and emission estimation. A vehicle selection example is also included at the end of the paper to offer readers with practical knowledge.

Keywords: Diesel, Electric, Gas, Hybrid, Hydrogen, Logistic Operators

1. Introduction

The escalating demand for truck transport [1] and the concerning rise in greenhouse gas emissions [2] have spurred extensive research into alternative powertrain technologies for heavy-duty vehicles (HDVs). Governments around the world have set ambitious objectives to curtail and counter emissions in the transportation sector. Conventional HDVs are notably responsible for a disproportionate share of on-road carbon dioxide (CO2), nitrogen oxide (NOx), and particulate matter (PM) emissions [3]. In the United States, medium and heavy-duty vehicles contribute to approximately 23% of total greenhouse gas (GHG) emissions [4], with an even more significant 40–60% share in NOx and PM emissions [3]. This surge in combustion emissions is a source of significant concern due to its direct links to climate change, pollution, and consequential health impacts [5]. As a result, there is a growing call for the development of HDVs with lower or zero emissions.

As the world moves towards reducing carbon emissions, there's a growing focus on "alternative fuel vehicles (AFVs)" as a means to cut greenhouse gas (GHG) emissions in sustainable transportation [6]. They offer the potential for cost savings and a smaller ecological impact.

Sustainable transport, as outlined in the Agenda 2030, is vital for addressing poverty, promoting economic growth, and combating climate change. The transport sector's role in achieving the Paris Agreement is pivotal due to its significant greenhouse gas emissions. Increasing the share of sustainable transport and exploring alternative fuel vehicles (AFVs) are essential steps toward sustainability. Notably, Ghosh [7] examined the use of electric vehicles to reduce the transport industry's carbon footprint, while Kene et al. [8] assessed the current state of electric vehicle research and development. Offer et al. [9] compared battery electric vehicles (BEVs) with hydrogen fuel cell electric vehicles (FCEVs) and hydrogen fuel cell plug-in hybrid vehicles (FCHEVs) for sustainable transport. Faria et al. [10] conducted a life-cycle assessment (LCA) comparing conventional and electric vehicles, focusing on GHG emissions. Krishnan et al. [11] introduced a model to evaluate hydrogen as a sustainable vehicle fuel. Wu et al. [12] proposed models for light-duty plug-in electric vehicle (PEV) fleets for national-level energy and transportation planning. Liu et al. [13] compared alternative fuel vehicles with conventional gasoline vehicles (and hybrids) using sensor data from global positioning systems.

A study by Biswas et al. [14] assessed five alternative vehicles (fuel cell, hybrid electric, battery electric, plug-in hybrid electric, and compressed natural gas bi-fuel) using the CRITIC method for criteria weighting and the CoCoSo method for ranking based on factors like greenhouse gas emissions, fuel economy, vehicle range, acceleration time, annual fuel cost, and vehicle base model cost. The findings showed that the battery electric vehicle outperforms all other alternatives. A study on busses [15] used innovative methods to choose alternative fuels (Electricity, natural gas, biodiesel, ethanol, propane), considering factors like quantity, performance, cost, and efficiency. Selected alternatives aimed to improve bus speed and mileage without harming the environment. The DEMATEL method determined criteria weights, and the COPRAS method ranked alternatives based on environmental safety, carbon emissions, technical cost, and fuel cost. A study by Hackbarth and Madlener [16] on German consumer preferences for alternative fuel vehicles, using stated preference data and a mixed logit model, identified younger, educated, and environmentally conscious buyers with home charging access as the most receptive group. Despite a willingness to pay for various improvements, conventional vehicles will continue to dominate the market.

To improve the affordability information of alternative fuels and to assist the logistic operators in deciding the most appropriate technology for their intended purpose, this paper proposes a methodology for vehicle selection based on a step-wise filtration process that takes into account financial and technical evaluation, infrastructure appraisal, risks and opportunities assessment, and emissions estimation. To assist the readers, a vehicle selection example is also provided at the end.

2. Alternate Fuel Vehicles

Internal combustion engines (ICE) create energy for vehicles using conventional fuels such as petrol and diesel. The decision between these fuels is determined by the size and purpose of the vehicle. Petrol engines are extensively used in low or medium weight trucks in nations such as the United States, Canada, Russia, and China. Diesel engines, on the other hand, are the favored choice for larger heavy-duty trucks. These technologies are found in numerous sorts of vehicles used to move commodities; however, they considerably contribute to environmental deterioration.

Alternative fuels, whether based on fossil fuels or renewable sources, are being used to minimize greenhouse gas (GHG) emissions. Liquefied petroleum gas (LPG), which is predominantly made up of butane and propane, is stored in liquid form at relatively low pressures, often 5 to 10 bar. Liquefied natural gas (LNG) is primarily methane that has been chilled to -160°C for liquid storage and transportation. Compressed natural gas (CNG), on the other hand, is stored as a gas at high pressures, often 200 bar. Biofuel or biogas made from biowaste is an environmentally acceptable alternative to natural gas.

Furthermore, modern automobiles are propelled by electric motors in electrified powertrains. Electricity is stored in onboard batteries in battery electric vehicles (BEVs), which are charged at electric charging stations. Hybrid electric vehicles (HEVs) are becoming increasingly popular in the goods vehicle market. These cars are powered by two distinct sources of energy: a diesel engine and an electric motor. Furthermore, fuel cell electric vehicles (FCEVs) generate electricity utilizing a fuel cell and stored hydrogen as its energy source.

3. Vehicle Selection Methodology

The vehicle selection methodology was developed for the market of Catalonia, Spain. To reach the optimum selection, the developed methodology compared conventional (petrol or diesel), gas, electric, hybrid, and hydrogen vehicles. The available goods transport options in the market were surveyed to assess their financial and technical viability. Later, the refueling infrastructure available for each option was explored. Finally, the risks/opportunities and emissions associated with the compared options were analyzed to arrive at the final selection.

The vehicle selection methodology can be divided into 6 distinct stages, as shown in Fig. 1. Each stage is discussed in the following sub-sections.

3.1 Reference Values

The purchase prices and useful life of the vehicle types based on the current technology available in the market were collected, as given in Table 1. Some of the information was missing either due to the unavailability of such technology in the market at the time of data collection or due to non-response from the concerned companies. It should be kept in mind that the prices change rapidly so any logistic company applying the developed methodology should attain the most recent values. The study took into account the subsidies available in the autonomous region of

Catalonia such as ICAEN grants, Gasnam grants, AeH2 grants, etc. Active grants should be taken into account at the time of implementation.

3.2 Economic Evaluation

3.2.1 Differential Cost Calculation

One of the essential criteria for choosing to buy a vehicle with alternative energy to fossil fuels is to evaluate its differential cost (against conventional vehicles), including the acquisition of the vehicle, renting or leasing (where applicable), maintenance, subsidies, and cost of annual energy during the life of the vehicle. This should make it possible, for example, to establish the minimum period necessary for a possible acquisition cost of a non-fossil energy vehicle to be offset by savings in its maintenance cost, subsidies, and the cost of maintenance. It is worth noting that the differential part refers to the fact that only those costs that differentiate the technologies are taken into account.

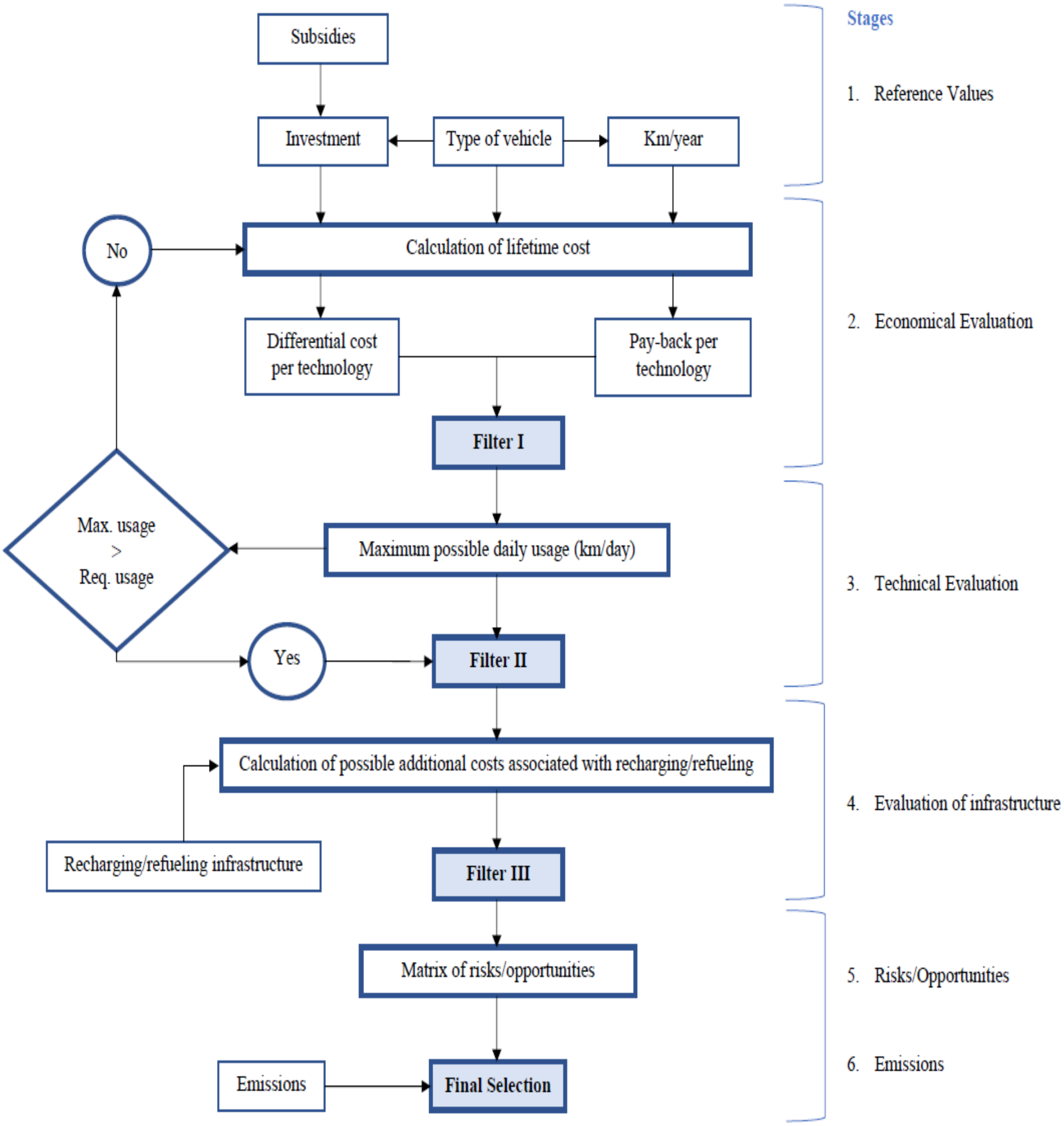

Fig. 1: Outline of the Methodology

Table 1: Vehicle data [17]

Type of Vehicle		Conventional		electric		Gas		Electric Hybrid		Hydrogen	
		Price (€)	**Life**	**Price (€)**	**Life**	**Price (€)**	**Life**	**Price (€)**	**Life**	**Price (€)**	**Life**
General purpose articulated vehicle in international transport	Tractor unit	114k	5	-	-	120k	-	-	-	-	-
	Semi-trailer	35k	7	35k	7	35k	7	35k	7	-	7
Road train	Truck body	106k	8	-	-	120k	-	-	-	-	-
	Trailer	30k	10	30k	10	30k	10	30k	10	-	10
Rigid vehicle with 3 axles for general loading	Truck	96k	9	-	-	160k	-	-	-	200k	-
	Bodywork	10k	8	10k	8	10k	8	10k	8	10k	8
Articulated refrigerated vehicle	Tractor unit	114k	6	-	-	120k	-	-	-	-	-
	Semi-trailer	61k	10	61k	10	61k	10	61k	10	-	10
Articulated refrigerated vehicle in international transport	Tractor unit	114k	5	-	-	-	-	-	-	-	-
	Semi-trailer	61k	9	61k	9	61k	9	61k	9	-	9
Dangerous goods articulated tanker vehicle (chemicals)	Tractor unit	114k	6	-	-	-	-	-	-	-	-
	Tanker semi-trailer	87k	8	87k	8	87k	8	87k	8	-	8
Dangerous goods articulated tanker vehicle (LPG)	Tractor unit	114k	6	-	-	-	-	-	-	-	-
	Tanker semi-trailer	87k	10	87k	10	87k	10	87k	10	-	10
Articulated food tank vehicle	Tractor unit	114k	6	-	-	-	-	-	-	-	-
	Tanker semi-trailer	70k	10	69k	10	69k	10	69k	10	-	10
Articulated tank vehicle of powdered products	Tractor unit	114k	6	-	-	-	-	-	-	-	-
	Tanker semi-trailer	68k	12	35k	7	35k	7	35k	7	-	7
Vehicle carrier (road train)	Truck	98k	6	-	-	-	-	-	-	-	-
	Bodywork	43k	12	30k	10	30k	10	30k	10	-	10
	Trailer	55k	12	-	-	-	-	-	-	-	-
Industrial vehicle carrier (road train)	Truck	98k	6	10k	8	10k	8	10k	8	-	8
	Bodywork	45k	12	-	-	-	-	-	-	-	-
	Trailer	58k	12	61k	10	61k	10	61k	10	-	10

Bulk articulated dump truck	Tractor unit	114k	6	-	-	-	-	-	-	-	-
	Semi-trailer with dump truck	38k	10	61k	9	61k	9	61k	9	-	9
Articulated work dump truck	Tractor unit	114k	8	-	-	-	-	-	-	-	-
	Semi-trailer	31k	12	87k	8	87k	8	87k	8	-	8
3-axle rigid vehicle for live animals	Truck	96k	8	-	-	-	-	-	-	-	-
	Bodywork	13k	-	87k	10	87k	10	87k	10	-	10
Container articulated vehicle	Tractor unit	114k	8	-	-	-	-	-	-	-	-
	Semi-trailer	28k	12	69k	10	69k	10	69k	10	-	10
Van	>3.500 Kg	24k	8	66k	10	26k	-	41k	-	48k	-
General purpose articulated vehicle	Tractor unit	114k	6	-	-	114k	-	-	-	-	-
	Semi-trailer	35k	8	-	-	-	-	-	-	-	-
Rigid vehicle with 2 axles for general loading	Truck	70k	10	-	-	114k	-	-	-	-	-
	Bodywork	8k	-	-	-	-	-	-	-	-	-
2-axle rigid distribution vehicle	Truck	42k	10	-	-	114k	-	-	-	-	-
	Bodywork	7k	-	-	-	-	-	-	-	-	-
Van	<3.500 Kg	16k	7	43k	7	18k	7	-	-	-	-
2-axle refrigerated vehicle	Truck	70k	10	-	-	-	-	-	-	-	-
	Bodywork	39k	-	-	-	-	-	-	-	-	-

This section details the calculation of the updated differential cost (referenced on the day of purchase, renting, or leasing) of the vehicles over their useful life. That is why they are based on the following variables:

T: payback period, service life of the vehicle.

q_t: annual kilometers for the year t.

C_D^T: differential cost for T years.

I_0: initial investment, cost of the vehicle plus infrastructure.

S_0: grant to buy a new vehicle.

C_e^t: energy/fuel cost for year t.

C_e^q: energy/fuel cost per kilometer.

C_m^t: maintenance cost for year t.

C_r^t: cost of renting or leasing for year t.

r: discount coefficient or discount rate (3%). [18]

Fig. 2 shows how costs would be distributed over the years of useful life. It is assumed that the maintenance and energy costs are updated throughout the life of the vehicle using an update coefficient.

$$C_D^T = I_0 - S_0 + \sum_{i=1}^{T} \frac{C_e^i + C_m^i + C_r^i}{(1+r)^i} \qquad (1)$$

The following hypotheses are considered

- The annual kilometers are the same for each of the useful life years: $q_t = q, \forall t$ and therefore $C_e^t = C_e^q \times q_t, \forall t$
- The additional cost per vehicle to cover the price of new shared charging infrastructure is calculated as $\frac{C_{infrastructure}}{n}$, where n is the number of vehicles to be purchased and $C_{infrastructure}$ is the cost of the infrastructure.

The other variables that affect the total cost of the vehicle (such as driver's salary, insurance, tax, tires, tolls, etc.) have been considered the same for all technologies, hence not included in the differential cost formula.

This procedure is used to see which technologies have the lowest costs in their useful life according to the annual mileage of each company and the maintenance of the vehicle.

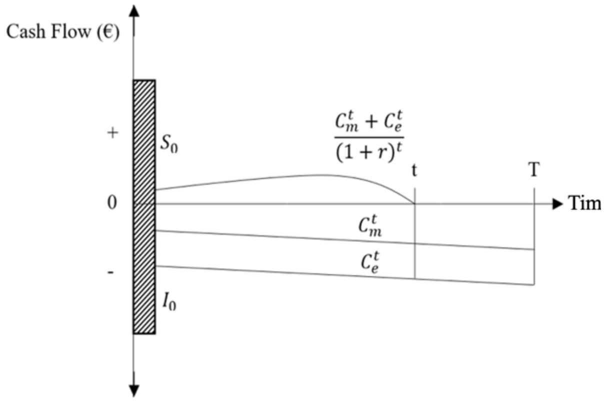

Fig. 2: Representation of the distribution of costs during the useful life of the vehicle

3.2.2 Payback Calculation

Since the initial investment required for a vehicle with alternative energy is higher than the conventional one, it is worthwhile to calculate the time required to offset this difference based on possible annual savings (cost of energy, maintenance, etc.) associated with the alternative technology.

The formula for calculating it is given in equations 2 & 3, as follows:

$$P_{B_l^j} = \left\{ \left(I_0^c - (I_0^j - S_0^j) + \sum_{i=1}^{l} \frac{\Delta C_e^i + \Delta C_m^i + \Delta C_r^i}{(1+r)^i} \right) > 0 \right\} \quad (2)$$

Where

$l \in T,\ j \in (electric, gas, hybrid, hydrogen)$

$$f\left(argmin(P_B)\right) = i, i \in T \quad (3)$$

$if\ f = \infty \implies$ cannot be amortized over its useful life

The variables used are as follows:

P_B: differential cost vector between a conventional vehicle and one with alternative energy.

T: payback period, service life of the vehicle.

I_0^c: initial investment, cost of conventional vehicle.

I_0^j: initial investment, cost of alternative energy vehicle plus infrastructure.

S_0^j: grant to buy a new alternative energy vehicle.

ΔC_e^t: energy cost differential for year t between conventional and alternative energy.

ΔC_m^t: maintenance cost differential for year t between conventional and alternative energy.

ΔC_r^t: differential of renting or leasing for year t between conventional and alternative energy.

r: discount coefficient or discount rate (3%).

$argmin$: returns the minimum value of a vector.

3.3 Technical Evaluation

The maximum daily usage is calculated, i.e. the kilometers that the vehicles can cover per day taking into account the following parameters: average speed (km/h), range (km), recharging time (h), maximum time of driving (h) and rest (h). Fig. 3 shows an example calculation.

The calculation has been made taking into account that the working day of drivers is 9 hours and they have a mandatory break of 45 minutes every 4.5 hours.

Fig. 3 shows the daily mileage according to the working day: the green color indicates when the driver is driving the vehicle, the red one when the driver is resting and/or loading the vehicle, and the blue is the end of the 9-hour working day.

This calculation makes it possible, for example, to identify whether the recharging time of the electric vehicle's batteries coincides with the 45-minute break in the 4.5-hour time interval, thus minimizing the driver's non-productive time.

3.4 Infrastructure Evaluation

Based on the location of the logistic operator and its coverage area, the available infrastructure of each alternative energy source is analyzed. Such analysis allows the logistic operator to identify the number and location of recharging points nearby. Hence, filtering the available alternative options.

3.5 Risks and Opportunities

The risks and opportunities available to each technology help to identify the advantages and disadvantages of each technology, leading to an informed decision regarding the most optimum technology.

3.6 Emissions

Lastly, the emissions for the shortlisted option are evaluated to ensure they are within local regulations as well as in line with the company's environmental goals.

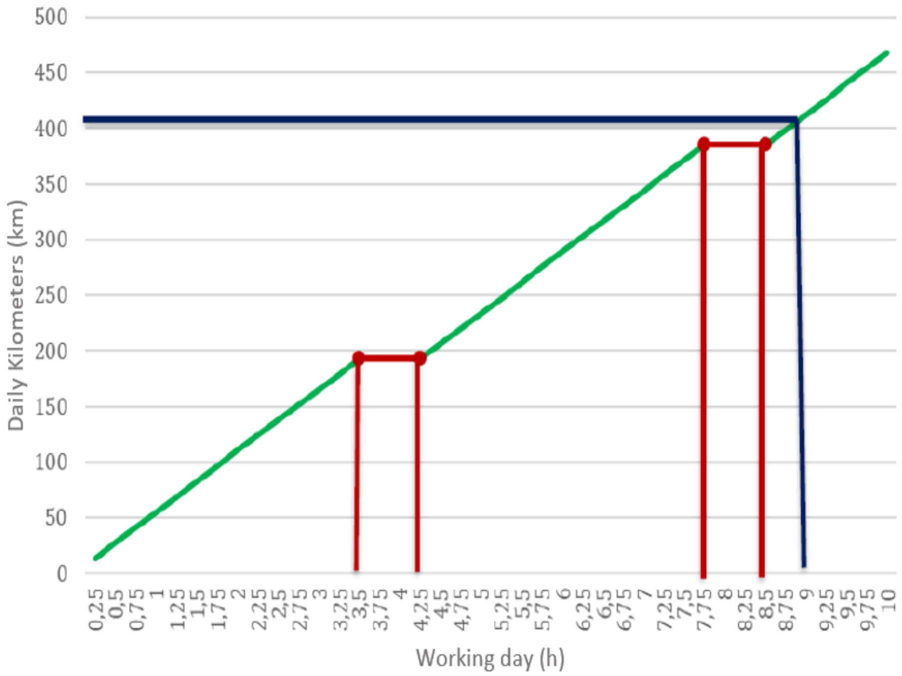

Fig. 3: Example of maximum daily usage calculation

4. Vehicle Selection Example

In this section, the vehicle selection methodology is demonstrated with the help of an example. The example will check the available alternative options (fuels and powertrains) and see if any of them can be a suitable substitute for the conventional one.

4.1 Reference Values

The reference characteristics of the conventional vehicle are as under.

- Power: 130 CV (96 KW)
- Payload: >3,500 kg
- Useful life: 8 years

Based on the reference characteristics, Table 2 provides the initial investment, subsidies, useful life, annual kilometers, energy cost €/100 km, maintenance cost, and the discount coefficient for all alternatives.

4.2 Economic Evaluation

4.2.1 Differential Cost Calculation

The differential costs, given in Table 3, for each alternative are calculated by solving equation 1 using the values in Table 2.

For an annual usage of 50.000 km, gas is the most suitable alternative. It should be noted that if the annual usage was initially set to 75.000 km then the electric vehicle would also have become feasible.

4.2.2 Payback Calculation

Table 4 shows the payback calculations performed for each alternative using equations 2 & 3. From payback calculations, it is evident that the difference in initial investment for the gas-fuelled vehicle will be recovered after one year of usage.

4.3 Technical Evaluation

The data considered for this evaluation is as follows

- Commercial speed: 55 km/h
- Range (Gas): 400 km
- Refueling times: 30 minutes
- Maximum driving time: 4.5 hours
- Rest: 45 minutes

The resulting maximum usage graph is given in Fig. 4. From the figure it can be seen that for maximum usage up to 450 km, a gas-fueled van is a viable option, hence passing Filter-II.

4.4 Infrastructure Evaluation

Fig. 5 shows the CNG stations in Barcelona. It can be seen from the figure that if the company is in the southern area (Hospitalet de Llobregat, Cornellà, or in the Sants-Montjuïc District of Barcelona) there are about 5 gas stations to be able to refuel the vehicle, but if it is located in the Rubí area, as there is no gas station nearby, the vehicle has to travel 25 kilometers to the nearest one.

In this example, it is assumed that the company is located in the area of Hospitalet de Llobregat. Therefore, the gas van passes Filter III. In case no suitable infrastructure is available causing none of the alternative to pass Filter III, the entire activity needs to be repeated with modified initial requirements.

4.5 Risks/Opportunities & Emission

Only one engine technology has reached the last stage, so the risks/opportunities and emissions of gas will only be analyzed, using the following Table 5.

Looking at the last column, it is observed that the risk has an affordable cost for the company. The conclusion is that the best technology for this type of vehicle is gas.

5. Conclusion

This study develops a logistic vehicle selection methodology covering various alternative fuels and powertrains, and demonstrates its application by considering an example. A crucial novelty included in the proposed methodology is to incorporate the maximum range of vehicles before refueling and coinciding the refueling time with the driver's break time, as Filter III. The filters proposed in the study are quite strict, but an iterative method can ensure the analyst approaches the most suitable option.

Table 2: Initial values for all alternatives

Technology	Initial investment (€)	Subsidy (€)	Useful life	Annual kilometers	Energy cost (€/100 km)	Maintenance cost (€)	Discount coefficient
Conventional	23,857	-	8	50,000	10.310	-	0.03
Electric	66,320	5,000	10	50,000	2.400	-	0.03
Gas	25,000	-	10	50,000	3.640	-	0.03
Hybrid	41,118	5,000	10	50,000	8.764	-	0.03
Hydrogen	48,300	-	10	50,000	8.000	-	0.03

Table 3: Differential cost values for each alternative

Technology	Initial investment (€)	Usage (km/year)							
		12.5k	25k	37.5k	50k	62.5k	75k	87.5k	100k
Conventional	23,857	32,903	41,950	50,996	60,043	69,090	78,136	87,183	96,230
Electric	66,320	63,426	65,532	67,638	69,744	71,850	73,955	76,061	78,167
Gas	25,000	28,194	31,388	34,582	37,776	40,970	44,164	47,358	50,552
Hybrid	41,118	43,808	51,497	59,187	66,877	74,566	82,256	89,945	97,635
Hydrogen	48,300	55,320	62,339	69,359	76,379	83,398	90,418	97,438	104,458

Table 4: Payback calculation for each alternative

Technology	Initial investment (€)	Initial investment difference (€)	Usage (km/year)							
			12.5k	25k	37.5k	50k	62.5k	75k	87.5k	100k
Conventional	23,857	-	-	-	-	-	-	-	-	-
Electric	66,320	-37,463	NO	NO	NO	NO	NO	8.00	6.00	6.00
Gas	25,000	-1,143	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hybrid	41,118	-12,261	NO	NO	NO	NO	NO	NO	NO	NO
Hydrogen	48,300	-24,443	NO	NO	NO	NO	NO	NO	NO	NO

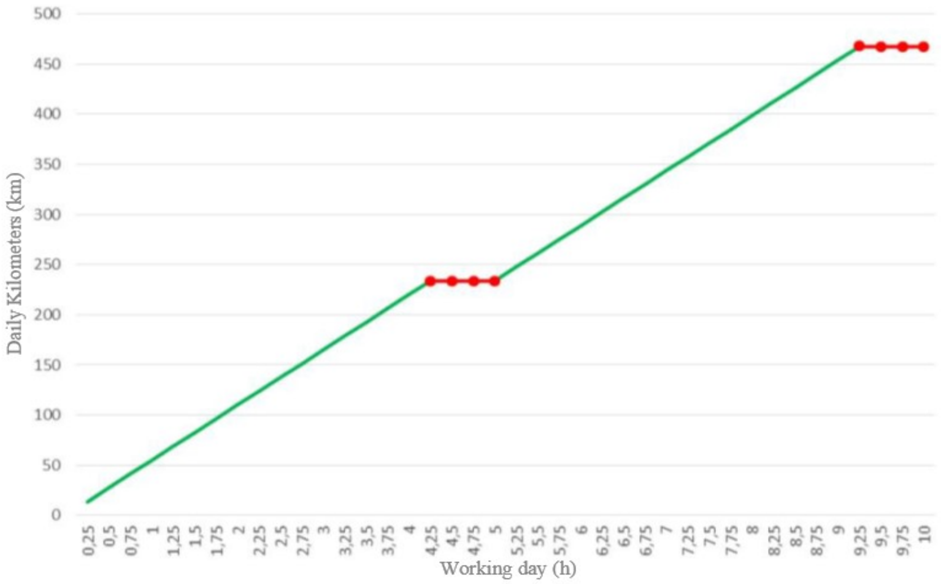

Fig. 4: Maximum daily usage calculation

6. Future Considerations and Challenges

It is important to create a channel of communication between operators and manufacturers so that solutions can be found that are suitable for all parties involved.

The transport sector is both a participant and a spectator in a linear economy that is struggling to leap into the circular economy. The components that will make this transformation possible already exist, but progress is slow.

It seems clear that a simple answer is insufficient and that it will be necessary to complement it with several essential elements: awareness, training, taxation, and a system of rewards that recognize and reward those involved.

Some of the relevant trends that are affecting the transport sector are:

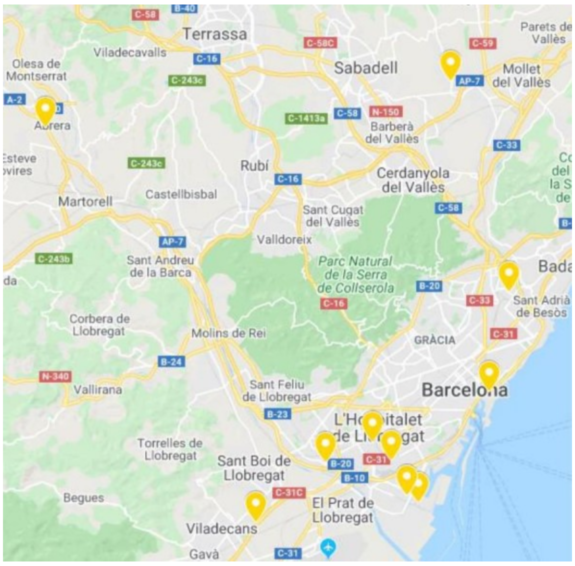

Fig. 5: CNG stations in Barcelona and the municipalities of Voltant

Table 5: Risks/opportunities matrix for Gas Technology

Gas	Risks	Opportunities	Overall rating
Legislation		Incentives for low-emission vehicles	
Current Technologies		Investments	
Economy	Cost of Maintenance		
Infrastructure	Refueling stations	Investment potential	Risk with an affordable cost
Energy Cost	High (CNG), Low (LNG)		
Energy Efficiency (%)	Less efficiency		
Emissions		5% less CO_2 and 85% less NO_x than diesel	

6.1 Digitization

The development of digitization in road freight transport should provide a number of options to optimize transport performance and improve the way equipment is used. Among other things, this means that:

- The management of the supply and demand of transport across large platforms will reduce the number of kilometers traveled without load.
- The real-time connection with the supply chain and artificial intelligence will make it possible to reorganize the loading and unloading programs according to the circumstances, guaranteeing a better use of capacity.
- Permanent control via the internet and geolocation will reduce efficiency losses caused by overloading and excessive energy consumption, as well as provide greater security for people and property.

6.2 Clean Fuels and Multimodality

The current trend in the European Union is to give preference to clean fuels for short distances and multimodal transport for long distances:

- Different carriers offer electric transport services for short distances.
- Railway stations in Germany and Belgium have become true European multimodal hubs, breaking the undisputed dominance of long-distance road transport.
- Efforts are also being made to develop multimodal transport for short distances and the use of clean energy for long distances:
- Zero-powered hydrogen-powered trucks (Tesla, Nikola, Toyota, and Hyundai) offer interesting prospects thanks to their fuel economy, comparable to that of diesel.

6.3 Short Circuit Selection

The theory of the "local economy", which involves, for example, the consumption of local agricultural products, is very popular. We are witnessing the emergence of new consumption habits that, as they develop, could help reduce CO_2 emissions from long-distance transport, which accounts for 50% of the tonne-kilometer CO_2 of transport in Europe.

6.4 Challenges

Nevertheless, the efforts required for road transport to move from a linear to a circular operating model will undoubtedly be met with resistance and obstacles:

- The European transport sector is made up of a myriad of different companies. In addition, the sector is governed by a strong European regulatory regime and numerous national regimes. This creates a very complex situation for large digital platforms that depend on simplification of procedures and deregulation. Therefore, there is a natural misunderstanding and mistrust between the transport sector and platforms. Clear principles of governance need to be established before overall optimization can be achieved through economies of scale.
- The change in the pace of renewal of vehicles and the introduction of new forms of marketing of rolling stock (trucks powered by hydrogen can be rented, not yet in Spain) will have a significant impact on carriers. The existing business model, which is often based on exceptional profits generated by the resale of equipment, will encounter difficulties and will hurt liquidity. Undoubtedly, financial support will be needed to overcome this aspect.
- The implementation of an ambitious policy of clean energy supply, the development of intermodality through railways, and the development of circuits or recycling centers will require large investments in infrastructure. With tight budgets, countries will be reluctant or even resistant to make such investments.

7. Acknowledgment

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