Advanced Logistic Systems Vol. 10, No. 2 (2016) pp. 19–26.

ECONOMIC EFFICIENCY ANALYSIS OF THE APPLICATION OF ELECTRIC TRANSPORT VEHICLES – CASE STUDY

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Abstract: In the current logistics common the small amount and short-range transport. The increasing complexity, decreasing batch sizes, shortened product life cycles and the continuously declining stock sizes lead to regular scheduled deliveries appreciation in the value. The enterprises are almost exclusively internal combustion engine trucks used for these deliveries. In turn within the factories and warehouses used generally electric material handling machines. In our study we explore those areas of application where the use of electric or hybrid vehicles may have economic benefits, instead of using internal combustion vehicles. As an example we present the potential costs of a transport-logistics system.
Keywords: *logistics, transport, electric vehicle, cost analysis*

1. INTRODUCTION

The optimal design of the material flow processes are concerns of all market participants.

As it continued to raise the technical and economic level of production processes it equally important the constant monitoring of the material flow processes. These corporate interests.

Many manufacturers make the mistake that to only focus on production activities within the company. However, the shortcomings of this approach are obvious, as the increasing complexity, decreasing batch sizes, shortened product life cycles and the continuously declining stock sizes lead to regular scheduled deliveries appreciation in the value. The lower transport volumes and increasing frequencies will necessarily lead to increased transportation costs. [1] In order for the companies to reduce the rising transportation costs, it may be appropriate examination of new techniques and technologies as well.

Nowadays the transport sector is responsible for a quarter of global CO_2 emissions, the transport sector and the greatest dependency on oil as well (98%) [2].

The expected increase in the number of vehicles causes a further increase in carbon dioxide emissions and dependence of on oil sector. [3]

For these reasons and the progressive spread of electric vehicles also in the interest of industry participants up to date analysis of the technology's potential.

Several studies have been written about the small carrying capacity electric cars urban applicability and the application of economic and emission potential such as an article written by LEONARDIA et al., 2014. [4] They presented the benefits of using these vehicles in urban freight and now we try to describes where else and for how much can be used these vehicles or even exists such vehicles?

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1.1. Limits of technology

As already mentioned the application of electric freight vehicles are limited besides the current technological level. In the battery development is still not happened a substantive breakthrough so these vehicles are only short term and long charging periods could operate therefore they can be used only a few situations. Because of technology the current research and development projects are mostly in urban applications examined.

In our view many market participants might be interested in the purely electric-powered adequate transport capacity trucks. Most of the industry players are used for several decades electric-powered handling machines so certainly not would be foreign to the electrical technology so if they wanted to operate such an electric truck fleet. The low range is not necessarily a problem in fact ideal to be scheduled transport between factory units where feasible the construction of charging points is relatively low cost.

Maintenance and running costs of electric vehicles as yet not fully known, but past experience has shown that costs far lower than the costs of conventional internal combustion cars [5].

We can be said that all of the internal combustion engines each have negative properties.

On the one hand the petrol motor operation inherently chokes starts (lot of gasoline) caused by over-consumption on the other hand washes the lubricating oil to the cylinder wall, thus rapidly wear out the engine.

The diesel vehicle after a cold start did not ask for chokes and the diesel do not wash the lubricant to the cylinder wall so the wear out is negligible, but the engine negative characteristics require the use of dual mass flywheel and turbocharger therefore require significant attention and maintenance.

Because of these properties internal combustion engine vehicles are not ideal for a short distance transportation.

1.2. Requirements of industry

According to the new logistics theories (JIT, JIS etc.) factories used different pay loaded trucks. The most commonly used are as follows:

- vans which can be useful payload of between 0.7–1 ton,
- box-type structures, which can also 1–7,5 t ton payload,
- open or closed structure body types, which can be 7,5–24 t payload.

For the industry participants only those electric-powered vehicles may present solutions that have a minimum 3 tons of payload.

If these parameters are fixed may want to deal with fuel costs. Currently these vehicles fuel cost is much cheaper than internal combustion engine vehicles. This value, taking into account the European Union’s energy prices for passenger cars, approximately 4-5 times smaller [6]. Significant investment costs are daunting but their properties not. Mentioned disadvantages would be easy to handle in production environments and economical operation for every company attractive.

The main problem is that these trucks are not commercially available, in addition to not have much abroad. An example just in this summer (2016) the BMW Group and a SCHERM Group together was the first who used 40 ton electric-powered truck.

Electric vans and smaller trucks have been more common, but they also mainly on North America and Western Europe spread to smaller urban freight transport with sufficient load capacity of 700–7500 kg [8].

Figure 1. Terberg electric truck
(Source: http://griin.de/entwicklungen/terberg-umweltfreundlich-und-leise-erster-elektrischer-40-tonnen-lkw-transporte-im-stadtverkehr-bmw-group-und-scherm-gruppe-pilotprojekt-muenchen)

Figure 2. Emoss truck
(Source: http://www.studiomango.nl/portfolio-items/emoss-electric-daf-truck/)

2. CASE STUDY

In our research we wish to point out that in which cases makes sense to think to use of electric vehicles (in the present study we disregard the difficulties of their purchase).

Main data of case study:

- In our case the company warehouse is located 8 kilometres from the main factory.
- The material flow is currently solved by conventional diesel-powered vehicles.

Our research in this chapter we wish to point out the potential of the electricity from the existing business opportunities through example.

2.1. Present situation

The company currently has one establishment and one external warehouse:

- Factory (F1) contains assembly workshop, warehouse of finished and half-finished goods.

- Warehouse (W1) contains: operating units, purchased parts and all parts needed for assembly can be found.

Locations relations between the factory units are shown in the following schematic figure *(Figure 3).*

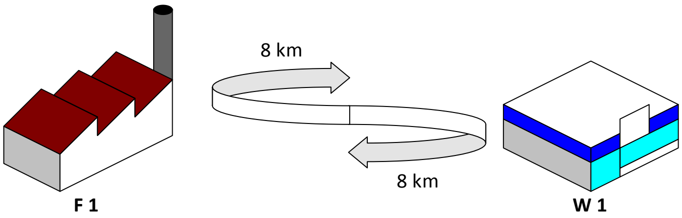

Figure 3. Central relationship of factory and warehouse

(Source: Own)

2.2. Location relationships

Domestic relations can be divided into two parts:

- Unscheduled deliveries typically in F1 to W1 context.
  Because of technological and other reasons, the factory and the warehouse "as a supplier" function for each other and so permanently carry each other.
- Scheduled deliveries in the following contexts:
  W1 – F1 – W1: average daily scheduled run is 144 km

The examined timetable is as follows *(Table 1).*

Table 1
F1 – W1 Timetables

1. Truck				
Start from W1	**Arrive to F1**	**Start from F1**	**Arrive to W1**	**Km**
6:15	6:30	7:15	7:30	16
8:15	8:30	9:15	9:30	16
12:15	12:30	13:15	13:30	16
14:15	14:30	15:15	15:30	16
16:15	16:30	17:15	17:30	16
20:15	20:30	21:15	21:30	16
23:15	23:30	0:15	0:30	16
1:15	1:30	2:15	2:30	16
4:15	4:30	5:15	5:30	16
			Summary	**144 km**

In *Table 1* above it is clear that among the departures and arrivals has significant available time in order to recharge the electric vehicle this ensures the continuous operation necessary amount of energy. But it may be enough for a half-hour quick charge in the daily operation, since these vehicles in the operating range is between 100 and 160km.

2.3. Current and envisioned operational costs

2.3.1. Monthly operating costs

More foreign research deals with electric and conventional propulsion comparison of the cost of vehicles but most of these studies only includes data on passenger cars. We tried to compare the consumption of traditional diesel trucks (7.5 t gross vehicle weight) and new similar gross weight electric truck costs.

The calculation of the cost of diesel given by the current NAV accounting statements and the company's costs were compared, so we calculated an average of 19L/100km consumption value.

We took into account the average gross 40 HUF/kWh of electricity costs. The commercial electric vehicle factory-specified consumption values were calculated with 120 kWh [9].

Table 2
Cost differences between electricity and diesel vehicles

	km/month	**Cost of diesel 366**	**Cost of electricity 40**
	km	***HUF/l***	***HUF/kWh***
Truck 1 (7,5 t)	2 880	200 275 HUF	138 240 HUF
Truck 2 (7,5 t)	2 720	189 149 HUF	130 560 HUF
Truck 3 (7,5 t)	3 184	221 415 HUF	152 832 HUF
Truck 4 (7,5 t)	3 408	236 992 HUF	163 584 HUF
Monthly all running and energy costs	12 192	847 832 HUF	585 216 HUF
Yearly all running and energy costs	146 304	10 173 984 HUF	7 022 592HUF

(Source: Own)

The *Table 2* shows adequately tie that even such a small fleet can be a significant cost savings. The exact value is difficult to say because the constant change requires constant correction by the price of fuel but we found in the literature and our own research is not based on mistaken if we say that the operating cost of the electric trucks for approximately two-thirds of the conventional drive vehicle-mounted trucks.

It is also greatly influenced by the cost when charged of these cars as for an example at "night charge" may result in further savings for the company moreover in our study we skipped on purpose the lower maintenance costs.

But there is another side of the coin. Currently the price of electric cars and trucks still higher, than the combustion engine counterparts. Generally speaking, the current price of a standard diesel-powered 7.5 ton gross vehicle weight trucks compared with the price of a same-duty electric trucks is close to double (including battery pack), to come even to the individual charging points design costs, which it is also not negligible (~ € 25–30).

Of course it is expected that the energy storage technology advances the individual costs will decline but the rate is still quite unpredictable.

2.3.2. Yearly operating costs

We calculated only default consumption and investment costs.

We calculated 4 pcs normal and 4 pc electric vehicle purchase and consumption costs. The total weight of these vehicles are 7.5 tons and purchase cost is as follows:

- Diesel-powered truck purchase price ~ 14 million HUF / pcs,
- Electric truck purchase price ~ 21 million HUF / pcs.

Table 3
Investments costs

Electric	**0 year**	**1 year**	**2 year**	**3 year**	**4 year**	
Capital investment needs	84 000 000					
Fuel costs		7 022 592	7 022 592	7 022 592	7 022 592	
Total cash flow Electric	84 000 000	91 022 592	98 045 184	105 067 776	112 090 368	
	5 year	**6 year**	**7 year**	**8 year**	**9 year**	**10 year**
Fuel costs	7 022 592	7 022 592	7 022 592	7 022 592	7 022 592	7 022 592
Total cash flow Electric	119 112 960	126 135 552	133 158 144	140 180 736	147 203 328	154 225 920

Diesel	**0 year**	**1 year**	**2 year**	**3 year**	**4 year**	
Capital investment needs	56 000 000					
Fuel costs		10 173 984	10 173 984	10 173 984	10 173 984	
Total cash flow Diesel	56 000 000	66 173 984	76 347 968	86 521 952	96 695 936	
	5 year	**6 year**	**7 year**	**8 year**	**9 year**	**10 year**
Fuel costs	10 173 984	10 173 984	10 173 984	10 173 984	10 173 984	10 173 984
Total cash flow Diesel	106 869 920	117 043 904	127 217 888	137 391 872	147 565 856	157 739 840

Table 3 shows that despite the significant investment cost of electric truck but lower operating costs due to its “return on investment” shows the ninth year.

In this case, the broken-year is quantified to last more favourable (diesel) negative cumulative value (–147 million HUF) is divided in the following years (electricity) Total cash flow of the investment (–154 million HUF) so the “payback period method” shows a return on investment within 9,5 a year.

In our calculations the expected changes in energy prices in the period under review are not modelled whereas the appropriate extrapolation cannot be made completely on the basis of the available data.

The expected domestic price movements in respect important to note the Government's intention that the price of electricity in the medium term intends to significantly reduce, so in the present case from the discounted return on investment indicators can be more favourable.

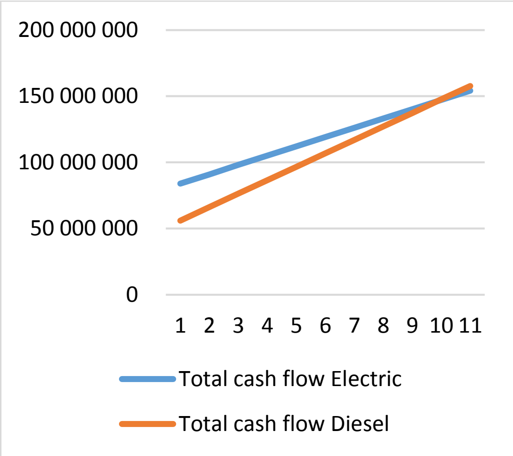

Figure 4. Return on investment

3. CONCLUSIONS

In our study, we would like to point out that to a single industrial operator should not be refuse the examination of the application of electric-powered vehicles because the expected savings by the service are significant cost savings and environmental benefits to the company, furthermore justified by economically the purchase of an electric-powered trucks.

In addition to cost savings in business efficiency and increase the reputation and "may be green" the supply chain. The using of electric vehicles up to be part of the long-term corporate strategy. The effective environmental management of the supply chain a competitive advantage can be achieved [7].

It has a lot of open questions and our calculations only static their purpose is only awareness raising, but it can provide a good starting point to be supplemented by dynamic calculation methods more accurate picture of the economic benefits arising from the application of electric propulsion.

Until then, we cannot do anything else just we look forward to that in industrial environment will be new and efficient electric vehicles.

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