14

ELECTROMOBILITY FROM THE FREIGHT COMPANY PERSPECTIVE

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BACKGROUND

In Europe (EU-27), there are approximately 600 000 commercial freight transport companies and 20 million road goods vehicles transporting 1900 billion tonne-kilometres annually.[1] The number of heavy duty vehicles is increasing rapidly. While it has been argued that the market prospects of electrified heavy duty vehicles are improving, it remains to be seen how quickly electrification will be picked up in different market segments. In this chapter we ask the question what benefits, and drawbacks, electromobility has to offer a commercial freight transport company (see Chapter 10, 11 and 12 on similar issues for passenger transport). We present a model that can be used by a freight transport operator to evaluate alternative energy carriers. The model takes a systems perspective and encompasses several dimensions apart from the pure technical.

COMMERCIAL FREIGHT

Typically, road freight companies have a low profit margin, often around 1-2%.[2] The largest share of the costs is staff, ranging from 35% to 55% of the total. The second largest is diesel (10-23%) and the third is depreciation, i.e. vehicle cost

1 Eurostat 2009 "Panorama of Transport", (2009). Some of these vehicles operate outside the commercial freight sector in privately owned fleets, i.e. at companies that use these vehicles to transport their own goods (for instance a manufacturer of office furniture with trucks of their own for deliveries etc.). Since these vehicles exist outside the commercial freight market they are excluded from this chapter, although several of the results and observations should be applicable to them as well.
2 Sternberg, H. (2011). Waste in road transport operations - using information sharing to increase efficiency. Institutionen för teknikens ekonomi och organisation, Logistik och transport,

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(10-13%). Overall, the ratio of fixed versus variable costs is high in the transport industry. Between 18-35% of the costs are considered variable (fuel, maintenance and tires), the rest are more or less fixed (staff, insurance, depreciation etc.). This means that the revenues must cover not only the running costs but also a large overhead.[3] As a result of this, there is little room for non-revenue generating activities. In fact, a study of German transporters shows that only 1.1% of their revenue is spent on innovation.[4]

There are some intrinsic properties of the freight transport industry that are worthy of notice. In Sweden, 91% of the road freight (in tonnes) is transported less than 300 km.[5] The transportation industry is very fragmented, both when it comes to company size and services provided. The average number of trucks of a Swedish haulage company is 3.7, and more than 80% of the companies have five trucks or less.[6] Moreover, the transport industry services everything from waste management to agriculture, manufacturing, trade, mining, forestry, and construction industries. These industries have little in common when it comes to the nature of the transportation service in terms of distance, vehicle type, goods type, market situation and administrative processes. The heterogeneity of the companies and of the services they provide leads to difficulties in finding solutions that will fit all needs.

The freight industry acts as an intermediary in supply chains. There are a large number of stakeholders involved, including consignor, consignee, transport buyer, transport company, hauler, driver, governments, municipalities and private citizens, that have demands concerning reliability, security, safety and sustainability. The transport system is not allowed to break down, be delayed or otherwise impeded. Measurements such as uptime, delivery precision and service level are used to ensure reliability. Since the 9/11 attacks, there are also stringent regulations in place guarding against terrorist threats. There is an increasing focus on crime-related security issues.[7] The Swedish government has famously proclaimed that no people should be seriously harmed or killed in traffic related accidents (also called the Vision Zero).[8] Companies, both sellers and buyers of transport services, are now working systematically with transport safety issues.[9] Regarding sustainability demands, both public opinion as well as EU-wide regulations, are forcing the transportation industry towards alternative energy as well as higher energy efficiency.

In order to evaluate an energy carrier like electricity, all aspects above must be considered. Moreover, the evaluation will likely differ between stakeholders. In this chapter the perspective is that of a freight transport company.

3 Swedish Association of Road Haulage Companies, (2012)
4 Wagner, S. M. (2008). "INNOVATION MANAGEMENT IN THE GERMAN TRANSPORTATION INDUSTRY." Journal of business logistics 29(2): 215-231.
5 Swedish Association of Road Haulage Companies, (2012)
6 Ibid.
7 Ekwall (2009) Managing the risk for antagonistic threats against the transport network, Chalmers University of Technology.
8 Road safety (accessed 2013)
9 The newly created standard ISO39001:2012 "Road traffic safety (RTS) management systems - Requirements with guidance for use" is starting to come into use by the transport industry. Först i världen med ISO 39001-certifiering (accessed 2013)

EVALUATION OF ENERGY CARRIER ALTERNATIVES: THE MEET MODEL

The MEET model is a tool that has been used by freight companies to evaluate the consequences of switching to alternative fuels.[10] It was developed to help the companies evaluate alternative fuels from a systems perspective. There are also other similar models[11] but common to all models is that they include several aspects of the fuel or energy carrier, not only environmental or economic effects.

The MEET model takes four perspectives into account: *Money*, what are the economic consequences of choosing the energy carrier? What are the *Environmental* consequences? Are there any *Ethical* considerations? What are the *Technical* specifications?

Each of these perspectives is important when evaluating a technical option, although each individual evaluation will of course be subjective and based upon that single company and their preferences.

When comparing energy alternatives from an *economic* standpoint we may notice that since fixed costs amount to between 65-82% (as mentioned above), the freight company is highly dependent on reliability and uptime in order to maximise the return on investment. It is also of importance that a large part of the variable costs is related to energy (normally diesel). Three separate types of risks can be identified: operational risks, supply risks and investment risks, each with a number of critical issues.

The operational risk - the risk of disturbing or otherwise affecting the operations as a result of energy choice – is affected by three factors. The first is the risk for increased cost per km. The fuel price is, as previously stated, very important. This price is not only affected by supply and demand relations but also by taxes. The government can change the tax on various energy carriers and related emissions and thereby change the price (in the examples below we will leave out this political risk). The second issue is change in maintenance cost. An alternative energy carrier may increase, or decrease, the required maintenance (both total time as well as frequency). The third issue is range. A new fuel may require a higher refill/recharge frequency thereby affecting operations.

The supply risk is the risk of not being able to gain access to the alternative energy carrier in the same quantities and geographical locations as the current alternative. If the number of suppliers are too few, competition may be weak, which in turn may affect prices and quality. The availability of raw material is also an issue here. How and where is the energy carrier produced? What else besides energy carrier production is competing for the raw material (see also Chapter 8)? Another issue is that of infrastructure maturity, i.e. if there is a distribution system in place that is able to supply energy when and where needed. The energy carrier must be available as close to the geographical area of operations as possible.

10 The model was first developed in 2010 together with Jan-Olof Arnäs, then CEO of TRB Sverige (a Swedish company working with the road freight industry in R&D), as a tool to evaluate alternative fuels. The model has since been modified further to accommodate new prerequisites.

11 See for example Konrad (2007), Visual Comparison of Alternative Transportation Fuels, and Alternative Fuels Data Center (accessed 2013)

The Investment risk - the risk of investing in new technology – is hard to quantify. Vehicle price, changes in vehicle life-span and projected second-hand value are all important factors in determining the life cycle cost of a vehicle adapted to or designed for a novel energy carrier.

When evaluating an energy carrier from an *environmental* perspective, some important properties are emissions of greenhouse gases and pollutants, renewability (how much of the energy carrier is produced from renewable energy), degradability (effects when fuel is spilled) and toxicity (how harmful it is to handle or breathe). Also, competition for raw materials (both for energy and components) may lead to a negative environmental effect if the energy carrier is produced from a resource that could have been used elsewhere with greater effect (see Chapter 7 and 8). The local effects of production are important as well as more indirect effects in the well-to-wheel chain (Chapter 5 and 6).[12]

Even if an energy carrier is better technically, economically and environmentally than the current alternative there may still be *ethical* concerns. Marketing is one area that needs to be scrutinized. Not all producers are truthful in their marketing and sometimes statements are made based on assessments designed to clearly favour one alternative, or at least, make comparison difficult. When studying an energy carrier, the origin of the raw material is an issue of great importance. The local social effects of production, treatment of personnel and handling and transportation of materials and the fuel are all areas that may raise ethical concerns.

Assessing the *technical* properties might be more straightforward since they can be measured directly and compared across alternatives. Some important properties are related to the energy carrier itself. The presence of a standardized specification is important, i.e. a range of prescriptions that need to be met in order for the energy carrier to be recognised as valid. Energy density is of particular interest here since a commercial transport vehicle needs to be able to load as much cargo as possible (both by volume and weight). Another thing worthy of note is the temperature properties of the energy carrier. The vehicle should be able to operate during very hot as well as very cold outside temperatures.

Some technological aspects are more related to the engine technology than to the energy carrier *per se*, for instance, the level technological maturity. A newly developed powertrain type may malfunction while a diesel engine is based on a mature technology. The powertrain and its parts can also be affected by the energy carrier in different ways, such as corrosion/oxidation. Many of the liquid fuels require that lubrication is added to the mix in order to keep the fuel pumps from braking down (see also Chapter 4 on safety issues for electric drivetrains).

12 See also Systems Perspectives on Biorefineries 2013 for environmental effects of biofuel use.

TWO EXAMPLES

To exemplify how the MEET model can be used, we evaluate two plausible applications of electric heavy-duty trucks and compare them to diesel trucks. The first is an electric road system (ERS) and the second a battery electric city distribution truck (BEV).

The evaluations are performed from the perspective of the freight company investing in the truck. As previously stated, there are large differences between various types of transport services. The model assumes that the freight company already has a functioning business and that it is confronted with a choice of a new energy carrier. This is not a comparison between the two applications but rather two comparisons for two different companies.

The nature of the transportation service plays a big part in choice of energy carrier. The transportation distance affects the demand for range, size of energy carrier infrastructure and maintenance. A city may have restrictions on noise levels or exhaust emissions. These restrictions affect viable choices for haulers active in city logistics. Some services are unique and one-time-only whereas some are repetitive. This affects the impact of parameters like fuel availability, range etc. Therefore, the choice of energy carrier is specific to the individual company and its situation.[13]

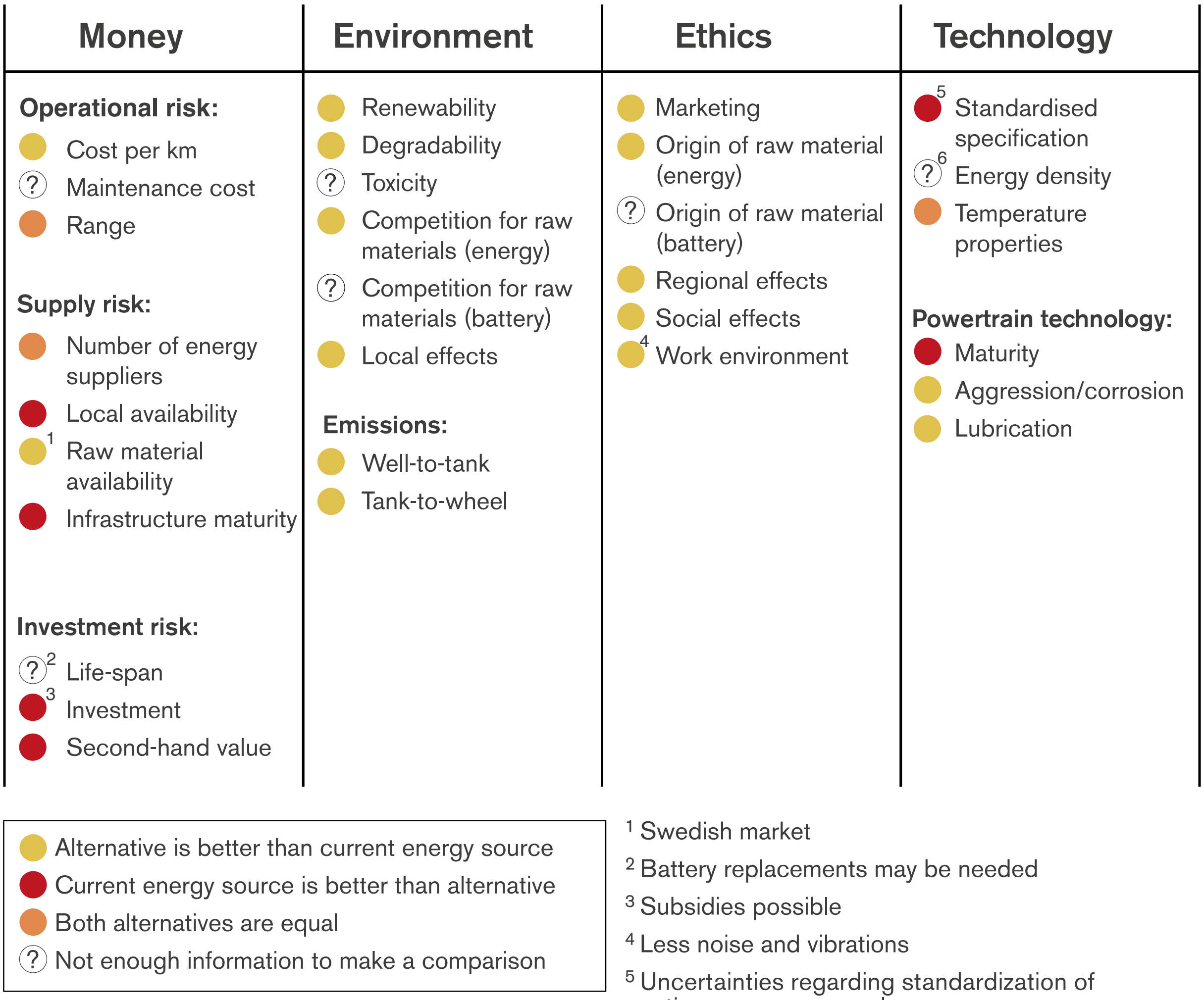
The first example is an ERS which is a technology option for the propulsion of long haul trucks.[14] The principle is to transfer electric energy from the road to the vehicle and use an electric engine for propulsion. The continuous charging could be conductive or inductive (see Chapter 2 and 3). The main strategy is to develop the system in steps. First start with closed localised systems, such as transport from mines or bus systems, and then continue with highways. For long haul the main idea is to use a hybrid vehicle. Where no electric power infrastructure is built into the road the vehicle can use a diesel engine for propulsion. There are several on-going or planned demonstrations in the world. The most known is Pajala (Sweden), KAIST (Korea), LA Harbour and Siemens (Germany).

ERS could have a major impact on the cost of electric trucks. In particular, the size of the battery could be drastically reduced.

13 On the other hand there are other factors that push towards standardisation. Currently, diesel trucks are used in a great variety of applications.

14 ERTRAC Research and Innovation Roadmaps Implementation of the ERTRAC Strategic Research Agenda 2010.

Electric roads vs conventional diesel
Assessment example for long haul road transport



[1] Swedish market
[2] Battery replacements may be needed
[3] Subsidies possible
[4] Less noise and vibrations
[5] Uncertainties regarding standardization of continuous power supply
[6] Smaller diesel tank but increased weight of powertrain. Could depend on vehicle usage.

Figure 14.1 Example of how a long-haul freight company can assess the alternative of electric roads in relation to conventional diesel.

The assessment example above shows the complexity in choosing alternative energy. All of the different parameters are compared to conventional diesel and some of them are (in this example) better and some are worse. The drawbacks of electric roads as an alternative for this haulage company is mainly focused on the supply and investment risks involved. According to this assessment, the transition to electric roads will be expensive and risky, also when looking at the as of yet immature engine technology.[15]

The second example is battery electric city distribution trucks. Several municipalities around the world restrict access to trucks with engines with high emission

15 Initially, the availability of ERS is limited to roads where power is available. This will decrease the number of freight companies that can choose this alternative.

rates. Some cities are even discussing the possibility to only accept zero-emission trucks. Battery electric city distribution trucks with a range of 180 to 200 km could be a feasible solution. They do not emit pollutants in the city, make less noise and could use renewable electricity.

BEV vs conventional diesel
Assessment example for city distribution truck

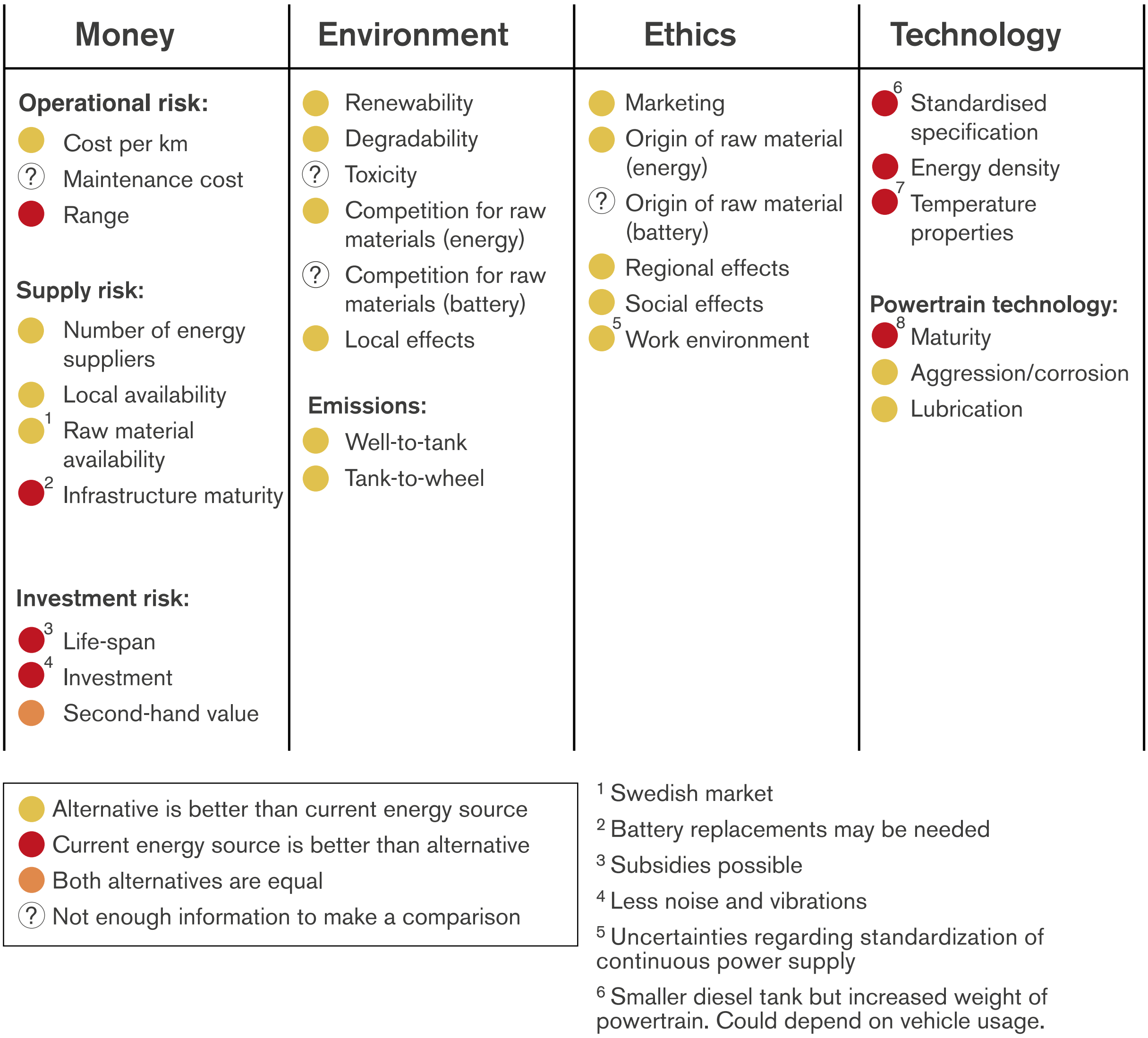


Figure 14.2 Example of how a city distribution freight company can assess the alternative of a battery powered electric vehicle (BEV) in relation to conventional diesel.

In the above example, the negative aspects of the BEV alternative are found to be both economic and technological. The battery technology is clearly a problematic area here, where range, life-span, price, standards and temperature sensitivity are the main arguments against BEV. This is just an example, however, and another transport company may well have a different opinion on what is considered good or bad compared to diesel.

CONCLUSION

Freight companies are part of a low-margin and high-investment industry that is extremely competitive. There is little or no room for investments that do not generate profit (preferably directly). In spite of this, there are frequent demands for the use of alternative fuels and energy carriers. These demands come from customers as well as from society as a whole. The choice of fuel or energy carrier is however quite complex. There are many factors that need to be taken into consideration and the new options will be compared to the existing mature diesel-based system.

There is a need for system models that take various aspects into account. In this chapter, one such model was presented. The MEET model is a checklist encompassing the dimensions Money, Environment, Ethics and Technology. A model like this can be used to construct a subjective "map" of arguments that in turn can be used to guide a decision. The model can also be used as a basis for communication with stakeholders such as customers, suppliers, authorities, trade organizations and competitors. Because of differences in individual preferences and situations, the generated maps will differ between firms.