Electric Quarry: Pre-study

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Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

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1. Executive summary

This pre-study addresses the issues concerned with quarry electrification. The pre-study goal is to perform a pre-study for a quarry electrification project. The ultimate goal for the project is to build and demonstrate an electrified quarry that from an operations perspective can produce aggregates with zero emissions of greenhouse gases. Initial investigations show that for a typical Swedish quarry, electrification can cut energy costs with up to 65% and save almost 1.5 million kilogram of CO2. This pre-study will establish the detailed scope for such a project, including as systems perspective on a complete solution for what machines, methods, control and site management strategies as well as supporting business models that needs to be developed. To make the shift from fossil fuel propelled transport to electrical ones, several emerging technologies needs to be developed, both in terms of new vehicles, but also in quarry infrastructure and control systems.

The pre-study work has been based on site-visits on different quarries, where machines and logistics have been studied. Following this, current TCO (cost/tonne) has been calculated, and possible solutions for electrification have been calculated, including new process solutions. In parallel with the activities, the need for Site Management has been investigated, and the theory and possible applications of scheduling has been analyzed.

The main conclusions are the following:

- The TCO (i.e. customer cost for the soltion in the user phase) is favorable.
- The business potential for Volvo is acceptable.
- The technical challenge to realize the solutions is manageable

2. Background

Dealing with the threat of climate change is one of the biggest engineering challenges. The transport sector is a large contributor to the emissions of greenhouse gases into the atmosphere. By electrifying transports with renewable energy sources as power supply, big savings in terms of environmental and transport effectiveness effects can be done.

As mentioned in the summary; to make the shift from fossil fuel propelled transport to electrical ones, several emerging technologies needs to be developed, both in terms of new vehicles, but also in quarry infrastructure and control systems.

In the case of a positive outcome of the pre-study, there’s a possibility to perform a demonstrator project where the goal would be to demonstrate a quarry where gravel and macadam would be produced without, or dramatically reduced, greenhouse gas emissions during the user phase of the machines. Such a demonstrator would is assumed to be a

world first. The developed logistical solutions are assumed to be possible to use in several other applications, such as mines, tunneling and larger infrastructural project.s

This pre-study project has been conducted by Volvo CE, Volvo Trucks and Skanska.

3. Objectives

The overhead objective with the pre-study has been to increase knowledge and understanding in the transport efficiency, customer benefits and business potential for electrification of quarry transports.

4. Project realization

Project has been performed in the below stages:

Quarry Visist / Needfinding

A detailed survey of current quarry processes and operations has been carried out on 2 different quarries. Time- and production studies as well as a geometrical site measurement has been carried out to establish an as-is scenario. Current energy need has been measured / calculated to establish a level for comparison.

Development of logistic solutions for electrification

Starting from the current production need as well as current infrastructure, electrical machines models has been developed. Some are completely new concepts, others are modifications of current machines. During the pre-study, it has become evident that electrification requires both smaller and larger modifications of quarry processes and internal logistic solutions. This has also been investigated. Furthermore, the soltions and associated costs for electric infrastructure has been investigated.

Estimation of power- and energy needs

In parallel with analysing machine- and logistics concepts, calculations on power- and energy levels has been carried out. This has been a highly iterative process, where the trade-off has been between transport needs to the maximum possible electric effect.

Analysis of site management- and scheduling systems

Since many different machines on site would be forced to share a limited number of common resources (for instance chargers), there’s an apparent need for a site management system on logistical process level. By ranking machines on for instance

productivity criticality, priority could be given to different machines automatically. Scheduling has also been evaluated as a possible method.

Estimation of TCO with Electrification – the potential of Electrified Quarries

Customer benefits of site electrification has been evaluated through TCO-calculations. These calculations has been carried out for a large number of different machine combinations and logistical alternatives.

Estimation of Volvo CE Business potential

The business potential for Volvo has been evaluated, based on development-, and project costs as well as estimated market volumes.

Project plan creation

Conclusions from the work described above has been concluded in a project plan for a demonstrator. This plan contains timing and budget for a realization of the findings of this pre-study.

5. Results and deliverables

The main deliverable from the project is increased knowledge in the area of electromobility for construction equipment in quarries. This is illustrated by

- Project plan for demonstrator project
- Project application

5.1 Delivery To FFI-goals

Within the project the overhead goals of meeting the environmental and climate challenges, as well as improved business economy, have been addressed. Since the pre-study is a desktop poject, the results cannot directly be connected to the targets. However, the demonstrator project that is addressed by this pre-study focuses on:

- Increased transport volumes with minimal environmental effects, reduction of transport related exhausts of CO2 with 50% up until 2020 as well as emissions of NOX. The pre-study points at large potentials in terms of increased transport efficiency and thereby on decreased emissions of green-house gases

- Improved competiveness of the Swedish vehicle industry. This target is addressed both from the possibility to offer environmentally supreme transport solutions, as well as the possibility to sell gravel and macadam produced with lower green-house gas emissions.

6. Dissemination and publications

Apart from internal communication within Volvo and Skanska, no distribution nor communication of project results has been made. This depends mainly on the short project time (February to june 2014).

7. Conclusions and future research

The main conclusion from the pre-study is that electrification of quarry transports is possible, both from a customer as well as a machine/solution supplier perspective. However, large changes in machines and logistics needs to be done. To realize the demonstrator project, a lot of work needs to be done both in the industry as well as in academia. This work also include substantial changes in the quarry logistics process.

During Q3 2014, Volvo, Skanska and possibly other interested parties will make the decision on whether the demonstrator project will be realized. If so happens, it would be a large step towards improved climate effect from quarry transports.

Within the project the simulation software developed through the Vinnova financed project TCO Simulation Tool (ref nr 2009-04127) has been further developed and used for electrification studies. This work will continue during 2014 together with KTH.

8. Participating parties and contact person

Volvo Group

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