MSc Thesis proposal Volvo Group:

*Refuelling Station Queue Model for Hydrogen Fuel Cell Electric Trucks*

**About us**

Sustainability including climate change are the challenges of our generation. Our contribution is to offer leading transport and infrastructure solutions enabling societies to prosper in a sustainable way.

*Powertrain Strategic Development* at Volvo has the responsibility to explore and develop new sustainable propulsion solutions, including hydrogen-based propulsion technologies. We are focused on developing the vehicle itself, but also in ensuring that the infrastructure can support a commercially viable rollout of hydrogen vehicles. This thesis work will support us in establishing the relationship between the hydrogen fuelled vehicles and the refuelling infrastructure.

**Thesis Background**

At Volvo, we are committed to the ambitions and climate change goals of the Paris Agreement. From a lifecycle perspective, most of the emissions occur during the use phase of our products. Therefore, our priority is to develop solutions that reduce the carbon emissions from transportation. One such transport solution that we are working on today is Fuel Cell Electric Vehicle (FCEV) for demanding long-haul applications, that is to complement the Battery Electric Vehicles (BEV), which have a limited range.

Among its benefits are the low weight of hydrogen and ability to have a quick refuel. But this ability to refuel depends on the location, type, capability and queues at hydrogen refuelling stations. Hydrogen refuelling stations are also very expensive. So it is important to right-size the infrastructure solution so that it provides maximum benefits at minimum cost.

**Problem motivating the project**

Hydrogen refuelling stations can be very expensive. There is also a possibility that several trucks arriving at a refuelling station can cause long queue that could stretch into several hours. We want to understand how extensive such queues would be based on different market penetration of hydrogen fuelled trucks and also how such queues can be mitigated in a cost effective manner.

The analysis method will include developing a model of a road network where the traffic density of hydrogen trucks is varied. The road network will also have several hydrogen refuelling stations with varying capacity and cost. The simulation model will be used to analyse the build up of queues at different refuelling stations based on certain parameters that the truck use to decide where to refuel.

In the next step, we plan to introduce several mathematical models to understand how the cost of hydrogen infrastructure as well as queue times can be reduced. This will involve the use of optimization algorithms as well as potential use of machine learning or other mathematical techniques. We will also investigate the impact of traffic, price difference in hydrogen at different stations, refuelling decision making process of the drivers and other factors.
This master thesis student will also interact with other projects at Volvo that focus on driver productivity tools such as navigation, route planning and mission management.

Objective or Research Question
- Develop a mathematical model of road network consisting of different hydrogen refuelling stations and fuel cell electric trucks.
- Analyse the queues at refuelling stations under different market penetration rates for fuel cell vehicles.
- How to formulate the optimization problem to reduce the queueing time.
- Evaluate means to reduce queues at refuelling stations.

Deliverables (flexible)
- A mathematical simulation model that can analyse hydrogen refuelling infrastructure on a complex road network.
- An understanding of queueing and queue times at hydrogen refuelling stations.

Requirement on student background:
- Master students in Mathematics or Engineering Physics, Automotive Engineering, Energy Engineering, Controls or other relevant fields.
- Interest and some knowledge in computer programming for developing simulation models and solving mathematics problems. Matlab or Python is preferred but not necessary.
- Please submit your CV and motivation letter.

Supervision and examination:
Powertrain Strategic Development, GTT, Volvo Group

Chalmers University of Technology

**Thesis Level:** Master

**Language:** English

**Starting date:** Spring 2023

**Number of students:** 1 or 2

**Physical location:** Mostly at Volvo Lundby (CampX).

**Tutor:**

Volvo contact person: Parthav Desai and Erik Jonsson Holm

Academic supervisor and examiner: TBD