Delivering economical solutions to drive industry's transition towards decarbonized operations

PICEAHOA

Electrification of Refuse Trucks

Case Study October 2019

Our Client, Recycle BC, wanted to understand the feasibility of operating electric refuse trucks within British Columbia (BC), Canada. Waste collection companies currently use diesel or CNG internal combustion engines to power their refuse trucks. We analysed the current and future market for electric refuse trucks, infrastructure requirements, environmental impacts and economics to provide an overall comparison between the different technologies.

Our analysis showed

- Battery electric refuse trucks are **feasible** and **available** now.
- Charging infrastructure and **smart charging** strategies can be deployed relatively easily to meet refuse truck utilisation requirements and **reduce peak electricity** demand / costs.
- Electric refuse trucks result in significantly **lower greenhouse gas** (GHG) emissions relative to diesel or CNG refuse trucks within BC.
- Battery electric refuse trucks have **competitive life-cycle costs** over a 10-year operating life and are better suited over diesel or CNG when accounting for future economic trends.

RECYCLEBC™

Recycle BC is responsible for residential packaging and paper product recycling throughout British Columbia.

In 2018

- Over 183,900 tonnes of paper product was collected
- Over 1.85 million BC households received curb side multi-family and depot service
- 98% of households had access to depots

Zero-Emission Trucks

Diesel and CNG refuse trucks require much more input energy to achieve the required outcome relative to electric refuse trucks

Diesel and CNG refuse trucks are approximately 5 and 5.8 times less efficient than battery electric (BE) refuse trucks respectively, while hydrogen fuel cell electric (FCE) trucks are approximately 1.8 times less efficient. This is because:

- **Internal Combustion Engines** (ICEs) are **much less efficient** than electric motors in converting input energy to output motion.
- ICEs use energy when the truck is **idling, coasting** or **braking**. Electric motors not only **don't use energy** during these operations, they can act as a generator when coasting or braking, generating energy in a process known as **regenerative braking**.
- The **heavier** the refuse truck load, the **greater** the **energy produced** from regenerative braking. Depending on the topography of the collection zone, an **optimised route** can be analysed to further increase the energy efficiency of electric refuse trucks.

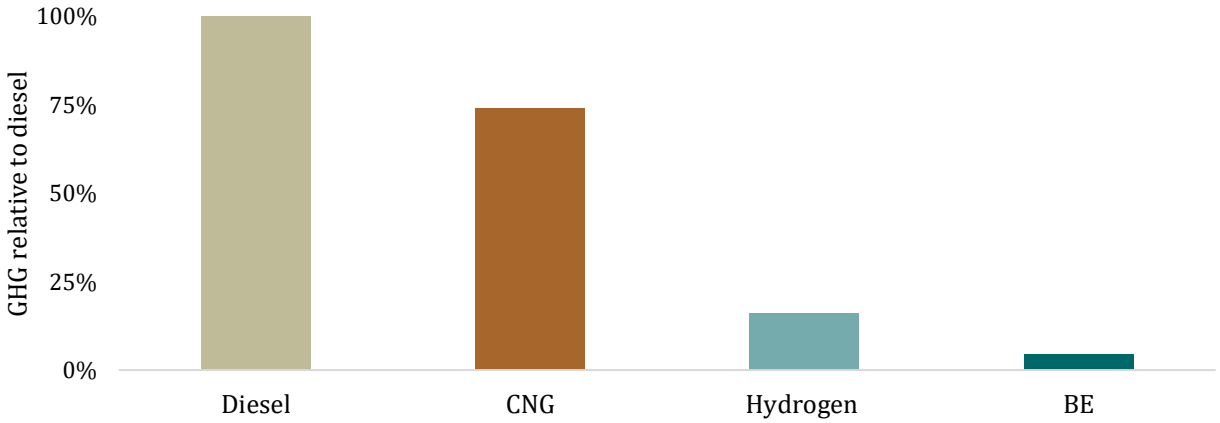
There is an existing and growing market for electric refuse trucks

- Several car manufacturers have battery electric refuse trucks on the market (Volvo, Mack, BYD, Lion Electric, etc.). While other companies have converted existing refuse trucks to battery electric (Motiv, Emoss, etc.).
- Battery electric refuse trucks are or are planned to be operated across several cities around the world. These include Hamburg (GE), Auckland (NZ), Wellington (NZ), Christchurch (NZ), Sacramento (US), Seattle (US), Palo Alto (US), New York (US) and York (UK).
- A hydrogen fuel cell electric refuse truck is being developed by Scania for operation in Sweden in 2020.
- Vehicle age, condition, remaining value and utilization are some of the parameters that should be considered when developing a **fleet decarbonization strategy**.

Environmental Impact

Greenhouse Gas (GHG) emissions are significantly lower for electric refuse trucks within BC

- British Columbia enjoys clean renewable electricity production. Studies indicate that Battery Electric Vehicles are also an opportunity to support additional renewable energy production around the world.



The impact from battery manufacturing can be mitigated

- **Batteries** come to the **end of their useful life** in electric vehicles when the battery is at 80% of its original capacity. However, the battery can potentially be used for **stationary storage** for shaving grid demand and smoothing out renewable energy supply, which prolongs the life of the battery.
- **New recycling processes** are being developed that can recover higher proportions of the battery materials. Lithion Recycling, based in Quebec, has a process that can recover 95% of battery components.
- **Regulations** are being put in place around the world to drive the recovery and recycling of batteries at the end of their life (i.e. Directive 2006/66/EC in Europe and an Extended Producer Responsibility program for batteries in China).

Hydrogen production

- Hydrogen can be produced by either steam methane reforming, coal gasification or electrolysis.
- Within BC, ‘green’ hydrogen can be produced in an electrolyser with a **relatively low environmental impact**.
- The Government of Canada, through Natural Resources Canada (NRCan), has already provided investment support for 15 ‘green’ hydrogen fuelling stations across Canada.

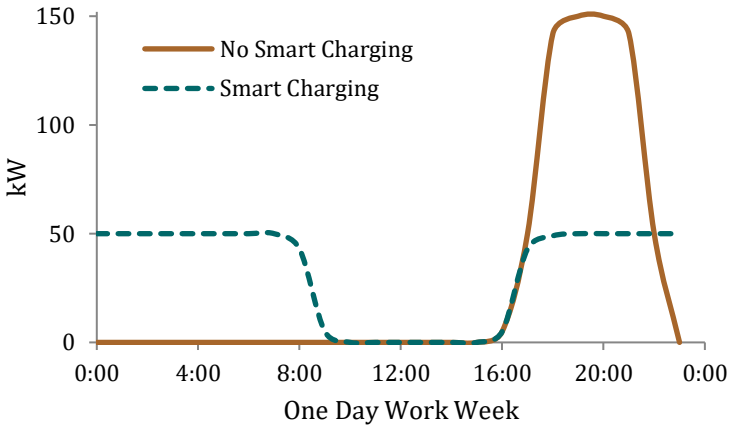
Battery Charging Infrastructure

There are two different levels of charging infrastructure that can be deployed to optimise utilisation of battery electric refuse trucks

- **Level 2** chargers supply AC power between 208V and 240V, which can be **sufficient** for some **day time operations** where the truck is parked in the **yard overnight**.
- **Level 3** 'fast' chargers can supply DC power up to 400kW, which will be required for **higher utilisations** or if day and night time operations are allowed and therefore the truck has **limited downtime** in the yard.

A smart charging strategy can reduce peak electricity demand and costs

- Utilities can have different electricity rates and prices depending on the size of the service, peak energy consumption, peak power demand and time of the day. Therefore, **fast charging** is usually **not the most economical** option and can result in faster **battery degradation**.



- The best option requires **smart chargers** to **avoid peak demand**. Depending on the operation activity of the fleet owner, chargers will communicate between each other, to a central system or a building management system if the building load is significant.

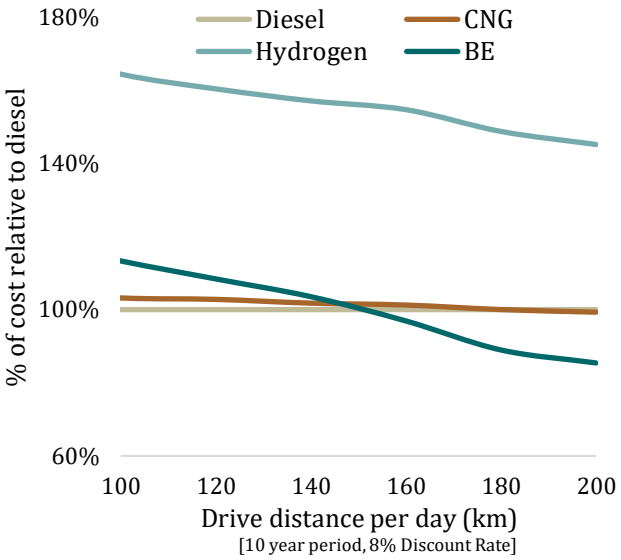
Electricity storage can complement smart charging and add value to the operation

- If the fleet operates daily and electrical demand is low at the yard, there may be a business case to **lower operating cost** using electricity **storage**.
- Over the long term, **old batteries** from refuse trucks can be used as **stationary storage**, **increasing** the battery **asset life** and economic value.

Life-Cycle Cost Comparison

With sufficient utilisation, battery electric refuse trucks are more competitive than fossil fuel based trucks

- There is an **opportunity** with electric refuse trucks to **increase** the **allowable operating times** due to the lower noise they make. This will allow for higher utilisation of the trucks.
- **Carbon credits** can be generated, which would further **decrease the cost** of battery electric refuse trucks by 4-9% to what is shown in the adjacent graph.



Battery electric refuse trucks are better prepared to account for economic trends

- The **capital cost** of battery electric refuse trucks could **drop in the future** due to **lower battery costs**, technological improvements and larger economies of scale.
- Although an 8% discount rate was used above, there have been historically low interest rates over the last several years resulting in **'cheap' capital** that **drive** more **capital intensive projects**. Therefore a 4% discount rate may be more reasonable.