



## Heavy trucks within the industry

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## Partners



## Background



Kalmar forklift DCG180, lift capacity 18 tonnes (Kalmar)

- The process industry was accounted for 25 % of the CO<sub>2</sub> – emissions in Sweden in 2014.
- Significant internal transport and handling operations that are energy intensive and costly.
- The process industry are also generating residues and by-products which consist of heat and steam as well as various gas fractions, including hydrogen.



Toyota Fuel cell forklift, lift capacity 3 tonnes (Toyota material handling, 2015)

- **2014: Demonstration of a Toyota fuel cell forklift in Sandviken**
  - Lift capacity: 3 tonnes

## Aim

- **To identify and describe** which trucks and vehicles that in the future may be **powered by hydrogen in fuel cells** and to describe how these trucks and vehicles should be adapted for this.
- **To quantify the effects of a shift to fuel cell operation** of these trucks and vehicles from an energy efficiency and environmental perspective.
- To compile a picture of, and **quantify the excess production of hydrogen gas and energy at the process industries**. This is to evaluate the process industry's future potential to produce hydrogen gas for use in fuel cells in industrial trucks and vehicles.

## Heavy industrial trucks (with combustion engines)

### Forklift



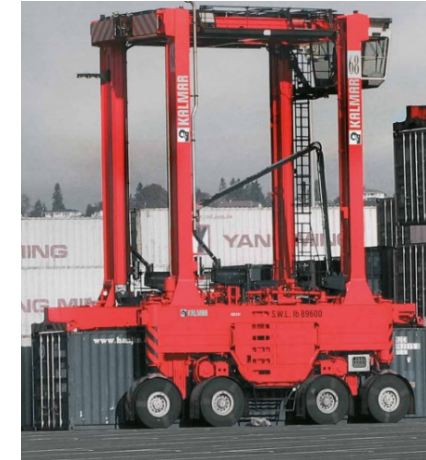
*Kalmar heavy forklift with 18 tonnes lift capacity (Kalmar)*

### Terminal tractor



*Kalmar terminal tractor with 105 tonnes load capacity (TFK)*

### Straddle carrier



*Kalmar straddle carrier with 40 – 60 tonnes lift capacity (Kalmar)*

### Tow tractor



*Volvo articulated tow tractor with load capacity of 60 tonnes (TFK)*



## Battery electric and fuel cell industrial trucks

- **Battery electric trucks:**  
Forklifts  $\leq 12$  tonnes lift capacity



*Semax EI 120 – 600 tp (ottosontruck.se)*

- **Fuel cell trucks:**  
Forklifts  $\leq 4,5$  tonnes lift capacity



*Still RX 60-45 (still.de)*

- Hybrid tow/terminal tractors  
 $\leq 50$  tonnes load capacity



*Aircraft tow tractor TBL-800 (kalmarmotor.com)*

- Hybrid tow tractors and terminal tractors  
 $\leq 60$  tonnes load capacity

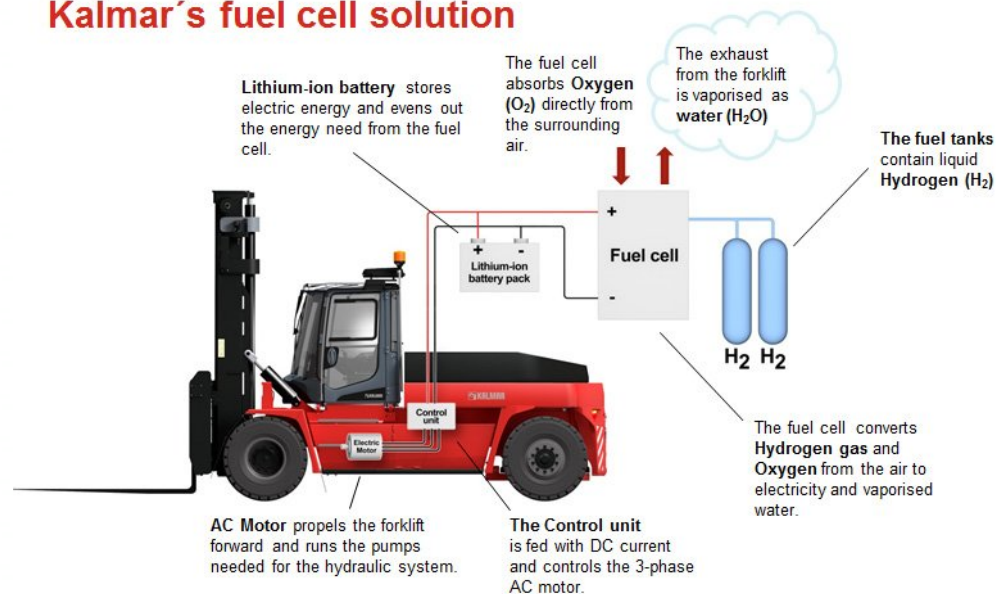


*Vision Zero-TT (fuelcelltoday.com)*

## Development of fuel cell heavy trucks

- Development of electric drivetrain
- Conversion of existing diesel truck to electric drive will be limited by the trucks design and external dimensions
- Batteries and fuel cell can serve as a counterweight
- Electric motors can be placed in wheel axles or wheel hubs

### Kalmar's fuel cell solution



## Production of hydrogen



### ■ Energy surplus in the industry:

Industry plant	Available energy surplus per year
SSAB Luleå	319 GWh residual gas ( <b>35 GWh hydrogen</b> )
SSAB Borlänge	<b>3,3 GWh hydrogen</b>
SSAB Oxelösund	239 GWh residual gas ( <b>27 GWh hydrogen</b> )
Iggesunds Bruk and Skärnäs Hamn	All energy surplus are used internal or are sold to district heating or the grid
Ovako Hofors	-
Ovako Smedjebacken	-
Uddeholms AB	-
Sandvik AB	Agreement on <b>1,2 GWh hydrogen</b> /year to the hydrogen station in Sandviken
Outokumpu Stainless AB	<b>85 GWh</b> energy surplus

→ Estimated hydrogen consumption for a heavy forklift with 3 500 operation hours/year: **0,15 GWh**



## Energy effects

### ASSUMPTIONS:

Operating hours (h/year)	3 500
Efficiency diesel truck	<b>36 %</b>
Efficiency battery electric truck	91 %
Efficiency fuel cell truck	<b>64 %</b>
Efficiency electrolysis	80 %



### ENERGY and EMISSIONS

	Diesel truck	Fuel cell truck
Energy input per truck and year	<b>270 MWh</b>	<b>190 MWh</b> energy input for producing hydrogen via electrolysis (150 MWh for operation)
CO <sub>2</sub> per truck and year	<b>74 tonnes</b>	<b>15 tonnes</b>



**~ 30 % less energy input**  
**~ 80 % less CO<sub>2</sub>-emissions**  
**0 % diesel consumption → fossil fuel free operation**

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## Interviews

### ■ **Manufacturers point of view:**

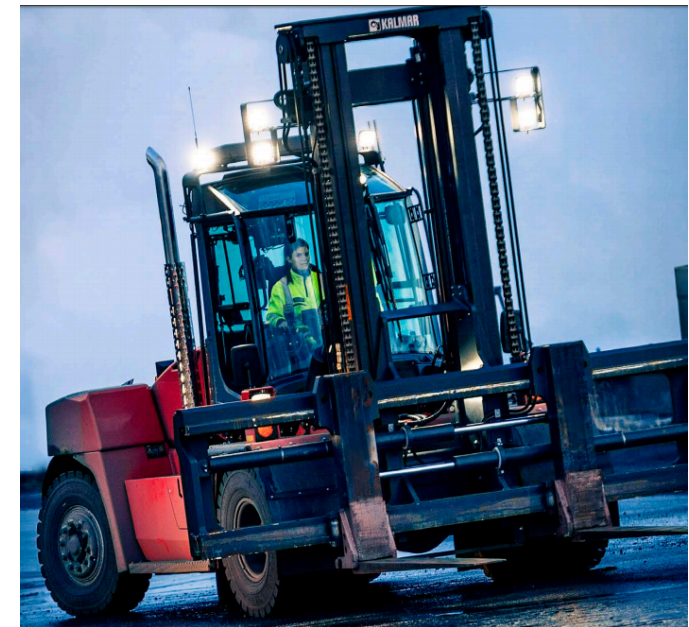
- + Good for heavy trucks in multi-shift
- + Less environmental impact
- + Allows continuous operation
- + Safe operation
- Limited hydrogen infrastructure
- High investment cost
- Dependent on price development batteries
- Few fuel cell manufacturers in Europe
- More complex system for monitoring and control
- Not sufficient technological readiness

### ■ **Users point of view:**

- + Sustainable
- + Less emissions and environmental impact
- + Less noise and vibrations
- + Reduced risk for spilling oil
- + Lower operation and maintenance costs
- + Less waste oil
- + Possible to own production of fossil-free fuel
- Not available today for heavy trucks
- High cost

## Conclusions

- Fuel cells are interesting for heavy trucks in multi-shift operation
- Need of development of electric drivetrain for heavy trucks
- Hydrogen production at the industrial plant possible
- Good environmental effects
  
- Further studies
  - Demonstration of a fuel cell forklift with lift capacity of 14 tonnes



Heavy forklift (Kalmar)

# Tack!

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