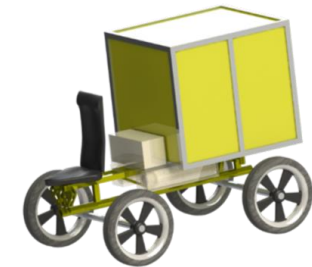




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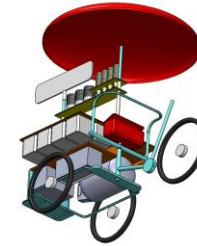
# **FUEL CELL POWERED CARGO BICYCLES - A FEASIBILITY STUDY**



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# Outline

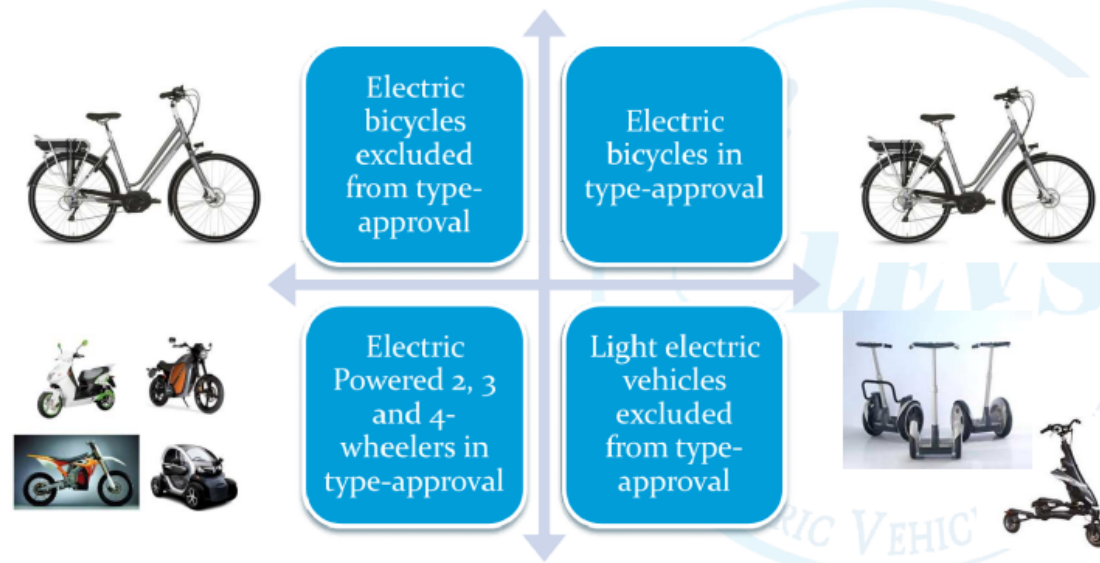


- **Why this project?**
- **LEVS, Pedelecs and Cargo bikes**
- **Fuel cells and hydrogen solution**
- **Design of fuel cell powered bicycle**

# LEVs, Light Electric Vehicles

1<sup>st</sup> Light Electric Vehicles Summit, LEVS 2016, Barcelona

LEVs groups determined by L-category



(Annick Roetnyck, AVERE, LEVS 2016, Barcelona)

# Electric bicycles - Pedelecs

Pedelecs (Pedal Electric Assisted Cycles) or EPACS (Electronic Power Assisted Cycles)

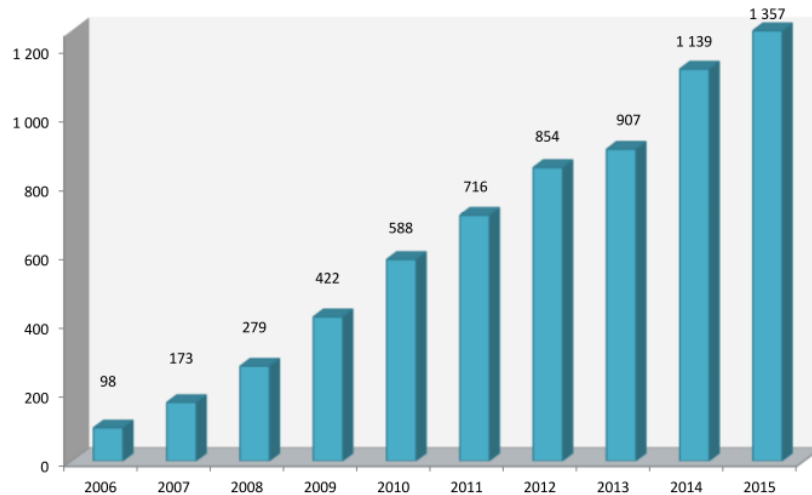
## Classifications:

- "Normal" Pedelecs: electric motor max 250W, pedal assist up to 25 km/h, no classification.
- "Speed" Pedelecs: electric motor max 4 kW?, max speed 45 km/h, class: L1e-B, Moped class 1.
- "Speed bike" example: STROMER ST2, 45 km/h, 500W, .
- "Moped class 2", electric motor max 1kW, pedal assist up to 25 km/h, class: L1e-A, intended for cargo-bikes.



# Electric bicycles - pedelecs

European sales: more than 10x increase in 10 years – 2016: 1.9 M.  
 Swedish EV-bicycle sales increase with 50% every year – 2016: 45 k.



Country	E-bikes sold in 2015	Change compared to 2014	Market share
Germany	535,000	+11,5%	12%
The Netherlands	280,000	+25,5%	28,5%
Belgium	125,500	+25%	28%
France	102,000	+32%	3,5%
Austria	77,200	+54,5%	19%
Switzerland	66,300	+15%	20,5%
Italy	66,000	+10%	7%
Sweden	est. 30,000	+50%	6%
Czech Republic	est. 25,000	n.a.	8%
Norway	est. 20,000	n.a.	5%

Chinese sales 2016: 37 M

(Annick Roetnyck, AVERE, LEVS 2016, Barcelona and <http://www.ebwr.com/>)



# Cargobikes

Bicycles for heavy loads, up to 500 kg!

51% of city transport could be replaced by cargobikes!



Examples of cargobikes: bicycle taxi (HejhejStockholm), bicycle café (Wheelys) and transport (Velove bikes, Movebybike)

# Other pedal-assist LEVs

TWIKE ( 1986)



ELBIBI



ARMADILLO



EVOLO



# Fuel cell powered bicycles

PEM fuel cells, hydrogen in metal hydride, chemical hydride or pressure tanks, battery hybrid



Examples of early (left, ENEA, 2002) and more recent (right, Linde, 2015) fuel cell powered bicycles.



# Need for extrapower?

Interviews with: Manufacturers, developers and users of cargobikes.

No!



...but if long range and cannot recharge.

No!



...but in winter range can be reduced 50%.

Yes!



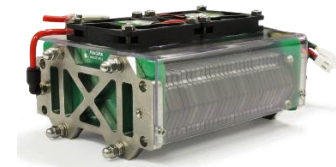
Yes!



# Available fuel cell market?

The market for stacks in the range 50-500 W is small:

- Stacks: Horizon Fuel Cells and Pragma industries
- Systems: Genport (300W), BOC (200W)
- 



Pragma Industries, 70W



Horizon Fuel Cells, 200 W



Hymera from BOC, 175 W

# HYMERA sold in Sweden by Safex Systems

**Safe X System Scandinavia AB, Falun**  
Road security solutions.

**Hymera:**

150 W nominal, 175 W peak,  
450 x 180 x 200 mm, 7,4 kg.

Output: 10-30 V DC, IP43



# How to get the hydrogen?

Pressurised hydrogen can be purchased at over 200 distributors all over Sweden in 5 and 20 liter bottles, 200/300 bar, 9 and 38/23 kg.



# Designing a fuel cell powered cargo bike

## Potential partners:

- Cargobike developer: Velove bikes, Göteborg
- Fuel cell provider: Safe X System, Falun
- Hydrogen gas provider: Aga/Linde

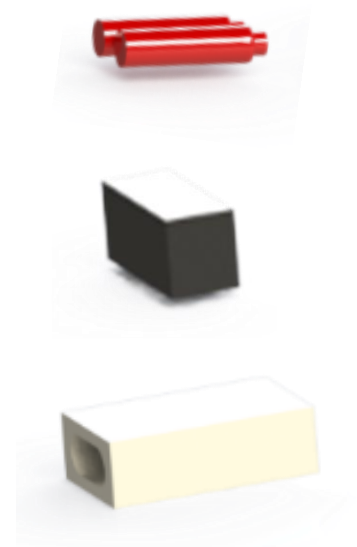




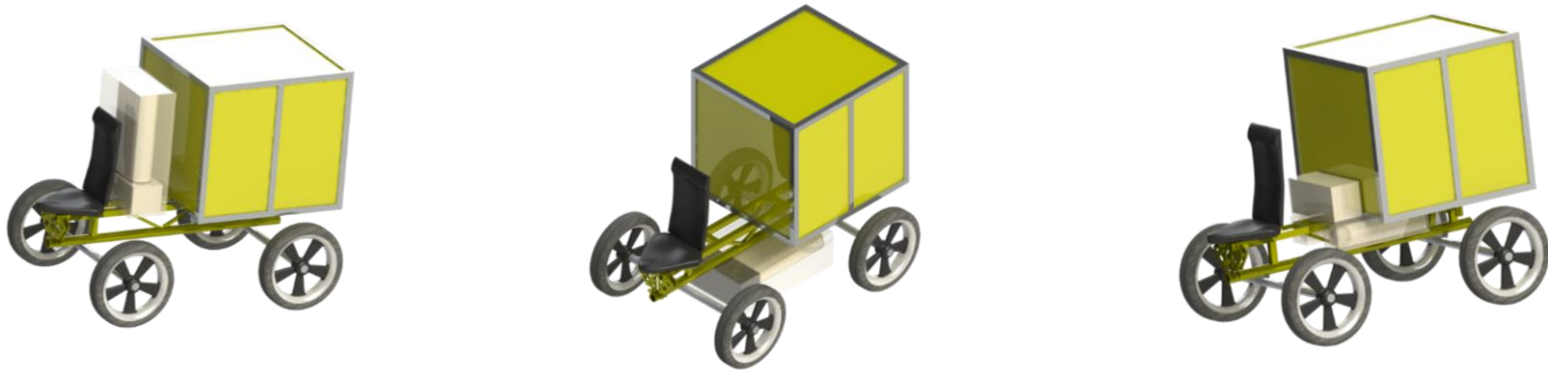
# Designing a fuel cell powered cargo bike

On-going diploma work Master Program  
Innovation and Design, MDH, Eskilstuna  
(completed end of Jan 2017).

- Dimensioning
- Practical and cost-effective integration
- Safety considerations



## Present status: first CAD drawings



### **Next step: Safety considerations.**

- Fuel Cell Road vehicles – safety standards, ISO 23273
- Failure Mode and Effects Analysis, FMEA  
(start/stop, change of gas bottles, traffic accident, etc)
- Communication with MSB, Transportstyrelsen



# Thank you!