Fuel cell technology adapted for cargo pedelecs

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E-commerce has disrupted Trade related Supply Chains ...
Growth of the CEP-Market

2016: More than 3 bn Consignments

2016: +7,2%

In Germany:
- 3,16 bn Shipments 2017
- Delivered by 60.000 Vehicles

Until 2028:
- 11.400 Fuel Cell Cargo Pedelecs
- (22.800 in Europe)


Source: KEP-Studie 2016, Befragung der KEP-Unternehmen 2017, KE-CONSULT Marktanalyse
... and caused several logistic related Challenges

Growing Emissions
~50% of air pollutant emissions are related to transport activities¹

More Traffic Jams
~30% of vehicle kilometers stem from transportation¹

Delivery Delays
~70% of all deliveries get stuck on the last mile¹

¹. In major German cities
Alternatives for Last Mile Delivery already being explored by CEP Providers

- Parcel delivery robots
- Car trunk delivery
- Unmanned aerial vehicles (UAVs)
- Parcel stations
- Cargo pedelecs (CPs)
Cargo Pedelecs bear the Potential to address the identified Challenges

- **Zero (local) emissions**
  - Pedaling power supported by electric propulsion system instead of combustion engine

- **Reduced congestions**
  - Broader utilization of urban infrastructure (bike/bus lanes, parks, pedestrian areas)

- **Faster delivery**
  - Higher average speed of CPs on the last mile compared to vans

**Key to success of Cargo Pedelecs are a suitable energy source and a tailored logistic concept**
FCREX - A compact Fuel Cell Module for Cargo Pedelecs

- **FCREX** fuel cell system provides 5 kWh electric energy
- **Twice the range** vs. battery at same size due to higher energy density

- **FCREX** can be refueled within minutes
- Hydrogen **infrastructure available** in key markets and steadily growing

- **FCREX** equipped with **modular pre-heater**
- System can be operated **down to -20°C** without performance losses

- **FCREX** emits **thermal energy for heating**
- Heat stems from **exothermic reaction** - No impact on range
What is inside the box? FCREX – Basic Set-Up
What is inside the box? FCREX – Fuel Cell Stack

- Compact FC system for light electric vehicles (LEVs), **max output ~ 750W**
  - **Metallic bipolar plates** ensure high durability in tough operating conditions
  - Stack consists of *20 cells* with ~ *60 cm² active area* per cell
  - Stack **dimensions ~ 215 x 120 x 117 cm**, stack **weight ~ 2000 g**
  - Minimum **output voltage 13 V**, maximum **current 60 A**
  - **Liquid-cooling** to extend life span and improve **cold starting** capabilities
Special feature: **FCREX** pre-heating system with no extra H₂ consumption

- Pre-heating system **enables frost / cold start and reduces degradation**
  - Based on **metal hydride powder** material - no extra H₂ consumption
  - Starts immediately from -20 °C, preheating to 5 °C in < 3 minutes
  - Integrated heat transfer structure and minimal amount of fluid
  - Aluminum **one-piece-design, additive manufacturing, patent pending**
  - Performance | \( P_{\text{peak}} = 1 \text{kW/kg}_{\text{MH}} \) or 0.3 kW/kg\(_{\text{Sys}}\)

Photos/drawings: C. Kretschmer, MA, 2019
What is inside the box? – Battery & Controlling System

**Infrastructure electric:**
- Battery: LiFePO4 36V/2,3Ah incl. BMS
- Control system: Controllino Automation, industry-grade PLC with Arduino compatibility
- DC/DC-Converter: Compact onboard charge controller for different fuel cells and hybrid batteries incl. constant main voltage

**Infrastructure process engineering:**
- Air supply: blower, filter
- Hydrogen supply: Pressure reducers, valves, connectors
- Fluid cooling supply: fluid pump, thermostat-valve, deionizer filter
FCREX is our Solution to power the next Generation of Cargo Pedelecs

- Cargo pedelecs feature a payload up to 400 kg
- Freight compartment provides storage space of 0.5 - 1.5 m³
- FCREX can be easily fitted into any cargo pedelec designs
- FCREX compatible with existing H₂ pressure tanks
- FCCP lightweight tank (Under preparation)
Interreg Projekt FCCP (Fuel Cell Cargo Pedelec)

I. Technology Validation

Validation of the FCREX (Fuel Cell Range Extender) with 50 cargo pedelecs under different commercial, topographic and climatic operating conditions

II. Logistic Concept

Development of logistic concepts which are specially adapted to the performance characteristics of the FCREX-powered cargo pedelecs

III. Measure Catalogue for Municipalities

Categorisation and assessment of municipal actions for supporting the integration of FCCP into local supply chains
Acknowledgment FCCP

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Thank you for your Attention!

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