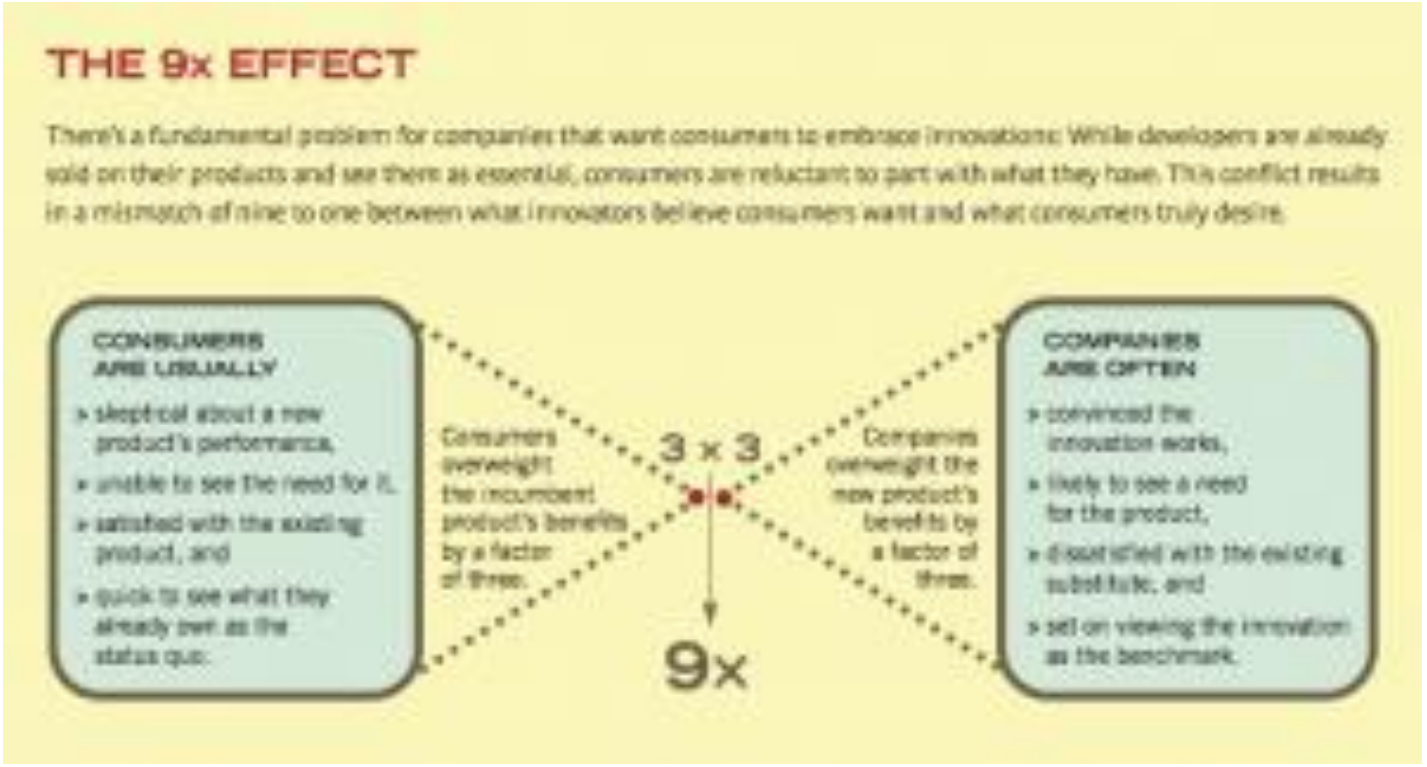
accutrein

Waarom doen we het niet allang ?

Innovatie

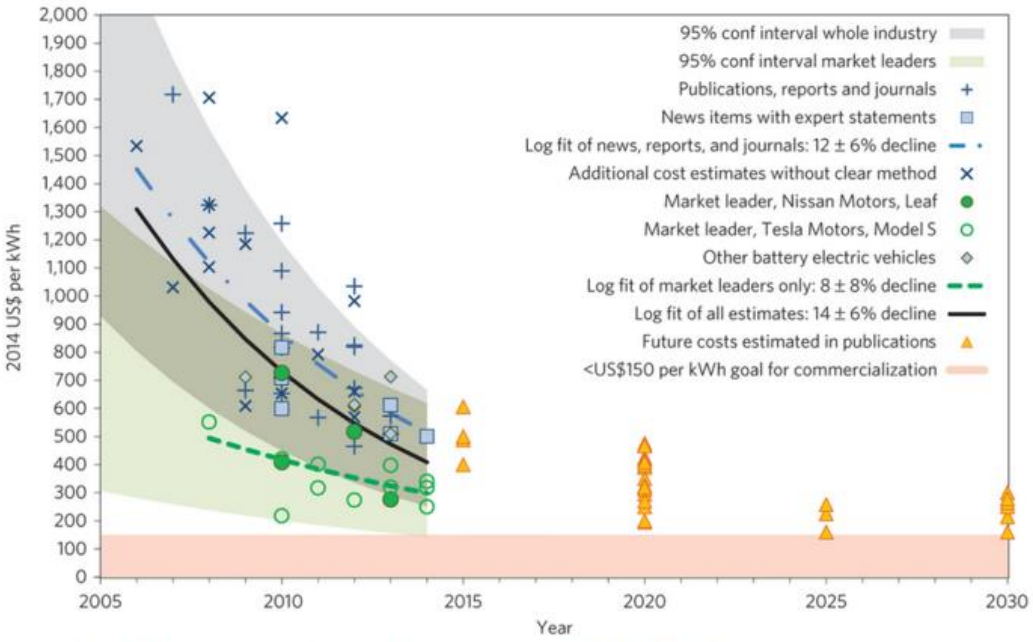
- *Voor innovatie: Het kan niet en het mag niet.*
- *Na: Waarom hebben we het niet veel eerder gedaan.*



(N)iets nieuws ?

Ontwikkeling prijs

- Opslag capaciteit
- Kosten



Gegevens van de accu-industrie en van de koplopers. De $ 150/kWh-lijn geldt als drempel voor commerciële doorbraak

Welke batterij ?

	LA *lead acid*	LFP *lithium-iron-phosphate*	LTO *lithium titanate*	Ultracap
Charge Rate	0,12	2-3	6 -20	> 20
Discharge Rate	1-3	10	6-20	>20
max. SOC	80%	90%	95%	99%
min. SOC	5%	20%	15%	0%
energie density (cel) Wh/kg	30-40	110-180	85	10
kg / kWh	28,6	6,9	11,8	100,0
volume density Wh/dm3				
cycles 80 % DOD	700	2500	20000	500.000
temperature tolerance	+	+	++	+
chemistry safety	-	0	+	mechanical
price (€ per kWh)	€ 200	€ 300	€ 1.200	€ 5.000
real price (per kWh/cycle)	€ 0,29	€ 0,12	€ 0,06	€ 0,01

Proven technology

https://www.youtube.com/watch?v=EyRKM08bf1M

Waarom LTO-batterij en snelladen ?

- 50 -100 km per rit , 800 km per dag.
- 3 kWh/km
  - 150 kWh -300 kWh per rit laden
  - 2400 kWh per dag laden
- Massa & volume
  - Snelladen: 300 kWh * 12 kg/kWh (LTO) = 3.600 kg
  - Dagelijks : 2400 kWh * 7 kg/kWh (LFP) = 16.800 kg
- Prijs batterijgebruik per kWh (/ cyclus)
  - LTO: € 0,06
  - LFP: € 0, 12

Nog een proven technology

Laadstroom = ongeveer gelijk aan stroom vertrekkende trein (vol vermogen)

RailBaar

Furrer+Frey Overhead contact lines

Opbrid

RailBaar is a rapid charge station for battery powered trains. It takes existing proven technology from Bus, Tram and Lorry rapid charge stations

RAILBAAR ANATOMY

Railbaar post

Hood for ADDED safety and weather protection

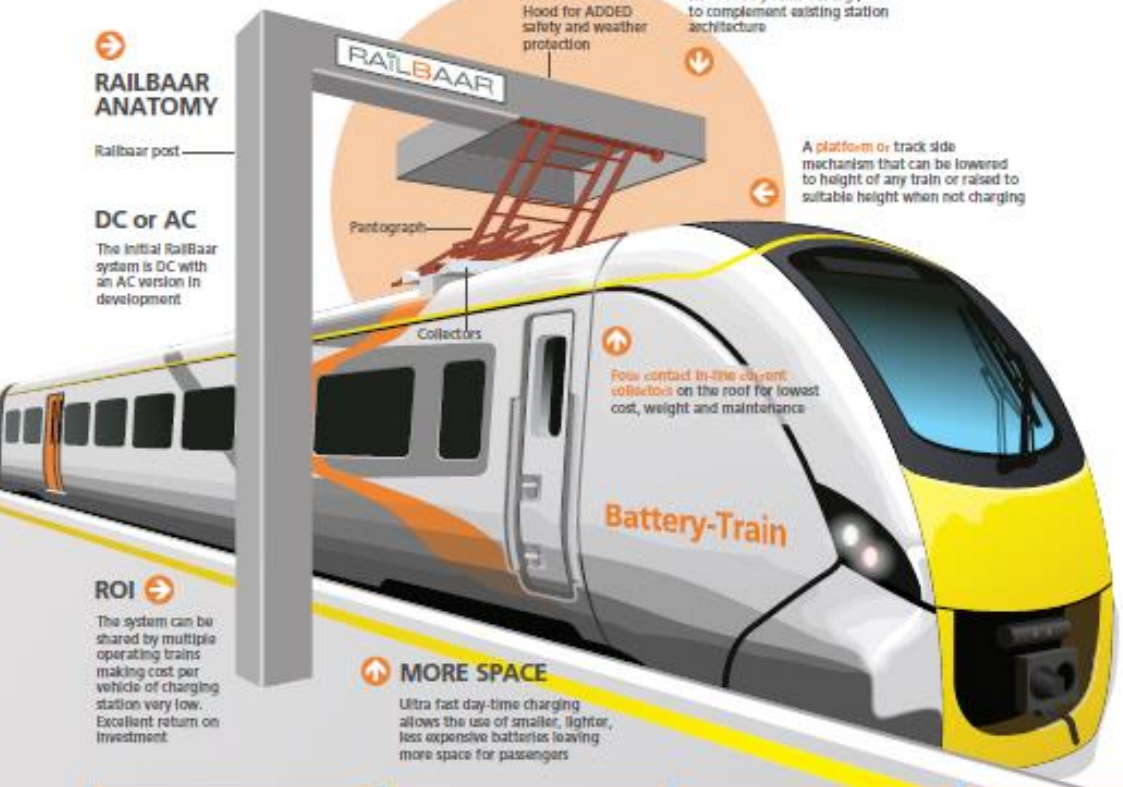
Compact overhead unit reduces visual impact and allows use of a wide variety of mounting posts to complement existing station architecture

A platform or track side mechanism that can be lowered to height of any train or raised to suitable height when not charging

Pantograph

Collectors

Low contact in-line current collectors on the roof for lowest cost, weight and maintenance



DC or AC

The initial RailBaar system is DC with an AC version in development

ROI

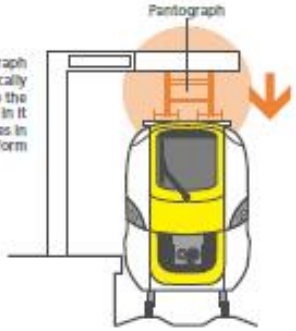
The system can be shared by multiple operating trains making cost per vehicle of charging station very low. Excellent return on investment

MORE SPACE

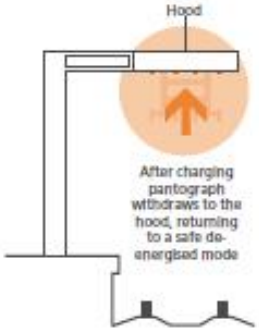
Ultra fast day-time charging allows the use of smaller, lighter, less expensive batteries leaving more space for passengers

CHARGING MODE

Pantograph automatically drops to the train when in it arrives in platform

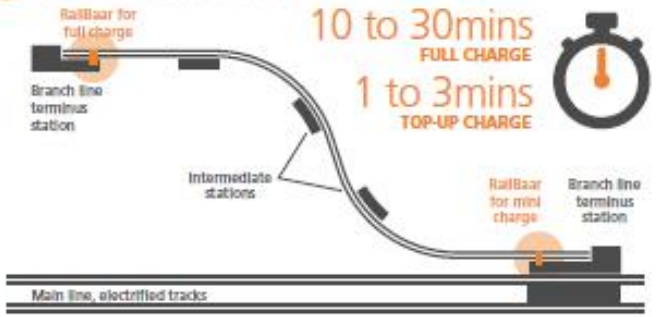


DE-ENERGISED MODE



After charging pantograph withdraws to the hood, returning to a safe de-energised mode

BRANCH LINE APPLICATIONS



+ PROVEN TECHNOLOGY

The RailBaar design is rooted in proven technology which is already successfully in use across Europe with rapid charge systems for buses, trams, and lorry transport

1,000,000
Expected number of charge cycles

+ INNOVATIVE DESIGN

A safe design composed of four contacts which ensure correct connection to collectors and fit almost any train due to their small rooftop footprint. Designed for very large standstill current and power

20 years
Design life

+ AUTO CONNECTION

Mechanical lowering contacts automatically drop to the train collectors when the train is in platform. The contacts raise to the hood once the charge cycle is complete, returning to a de-energised state

<5 secs
Lowering time

+ CHARGING

Charging capacity is 120kW to 650kW with a full charge taking 10 to 30 minutes and top-up charging taking 1 to 3 minutes. (Charge times are dependent on battery size)

1000V DC
Max voltage

+ WHERE

RailBaar is an ideal solution for a number of situations, particularly for none cost viable or hard to reach areas of electrification, branch lines and airport shuttle routes with multi-battery operated trains

24/7
Depot charger applications

+ BENEFITS

The benefits of RailBaar are many, it is versatile and easily integrated with existing railway infrastructure providing a sustainable mode of travel. It has Lower system costs, higher capacity, better ROI and increased safety, these are all reasons the RailBaar will be an important part of future rail projects and decarbonising railways

Find out more... www.furrerfrey.ch

Verbruik, rijden

- Rolweerstand
  - $F_r = m * g * C_r$ m= 87000, g=9,81 Cr = 0,002 ; 1 kWh/km = 3,6 kN
  - 0,47 kWh/km

- Aerodynamische weerstand
  - $F_d = c_d * A * (1/2 * s.g._{lucht} * v^2)$ c_d=0,6 ; A = 12 m^2; sg =1,25 kg/m^3 ;

- Totale weerstand : energieverbruik / km. Vermogen P = F * v
  - V = 100 km/u : F_d = 0,97; F_{total} = 1,45 kWh/km 145 kW
  - V = 120 km/u : F_d = 1,39 ; F_{total} = 1,86 kWh/km 223 kW
  - V = 140 km/u : F_d = 1,90 ; F_{total} = 2,37 kWh/km 332 kW

  (Lengte: aerodynamische weerstand per 10 m + 7%)

- Versnellen : 600 kW (diesel) – 1200 kW (elektrisch)

Regeneratief verbruik: halten en heuvels

- Heuvel :
  - E = m.g.h hoogteverschil (87 ton GTW 2/8)
  - 500 m hoogteverschil: 120 kWh .
  - 3% helling : 850 kW (120 km/u)

- Halte : ½ $m*v^2$
  - 120 km/u = 33 m/s
  - Energieverbruik per stop : 13, 4 kWh
  - 1200-1500 kW (piek)

Hoe groot moet de batterij zijn ?

Verbruik

- rijden 2,2 kWh / km
- 100 % regeneratief remmen, 100% regeneratief heuvels
- 50 km -100 km traject: 110 kWh -220 kWh

Batterijpakket

- 80% snelladen : niet eerste 15% en laatste 5 %
- 80% end of life capacity
- Capaciteit: 50 km – 100 km traject: **170 kWh – 340 kWh**
- **Max vermogen (6C) P = 1020 – 2040 kW.**

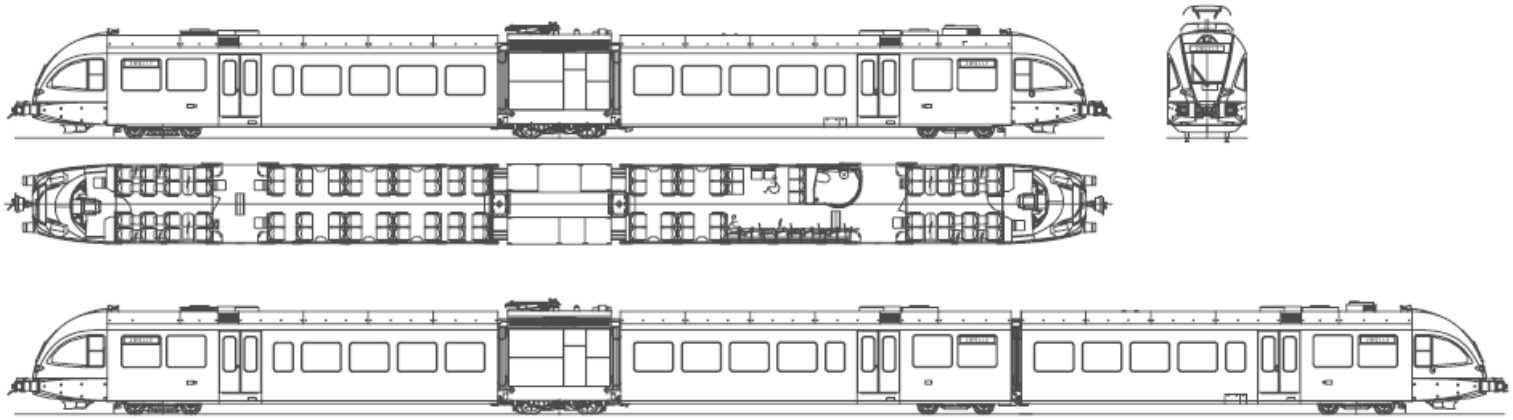
Afmetingen en gewicht

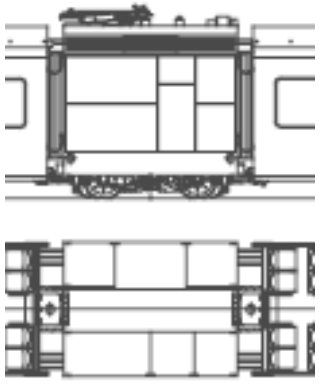
- Cell 85 W/kg; sg = 2 kg /dm^3 ; Systeem ca. 50 W/kg sg = 1,3 kg/dm^3
- 50 km : 3400 kg; 2,6 m^3 - 100 km : 6800 kg ; 5,2 m3

- *(ter referentie: trein 65-87 ton; akkupakket baureihe 515: 12 -18 ton, dieselmotor 5 ton)*

Waar laten we batterij ?

(vb. Stadler GTW 2/6 of 2/8)





Aandrijfeenheid: 20 m^3

2,95 m. 2 * ca1m *hoogte 2,5m * lengte 4m

Vloer trein : 17 m3

10 cm * 56 m* 3 m = 16,8 m^3

Vergelijking diesel, bovenleiding, waterstof

Voorbeeld Zwolle Wierden, jammer

Maaslijn, besparingen tov elektrificatie

3. Power curve for a Stadler GTW DMU 2/8 on the Northern Netherlands driving cycle