STADLER ZERO EMISSION MULTIPLE UNITS

HOW ALTERNATIVE PROPULSION PRODUCTS MAKE U.S. TRANSIT MORE SUSTAINABLE

Martin Ritter | 05/16/2023 | Stadler US

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STADLER
RECENT DEVELOPMENTS AND INNOVATIONS

Stadler Rail Group

Revenue:	**3.6 billion USD**
Employees:	**13,400+**
Locations:	**15 all over the world**
Established:	**1942**

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Employees:	**440**
Facility Size:	**400,000+ sq ft**
Established:	**2016**
Projects in progress:	**3 (Caltrain, DART, MARTA)**

Over 9,300 trains sold all over the world

STADLER'S APPROACH TO INNOVATION

Market Needs + **Customer Perspective**

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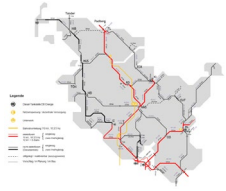
Trains not ADA accessible and complicated for travelers and families with strollers		1995	GTW (Multiple-Unit-Train) with level boarding	
Caltrain needs two different access heights and bicycle access/space		2016	KISS EMU with two different entrance level	
Nah.SH in Germany with partly electrified routes and need for zero-emission solution		2019	BEMU FLIRT AKKU 15kV charging through catenary, brake energy and external charging stations	
California leads climate change ambitions by reducing greenhouse gas emissions to below 40% of 1990's level by 2030		2019	SBCTA and Caltrain – Two solutions for zero emission transportation	

STADLER FLIRT CONVERSION IN THE US
BASED ON THE FLIRT EMU

FLIRT DMU SBCTA	
Speed	80 mph
Seats	116
Cars	2 + Power Pack
Vehicle Length	163ft
Propulsion	Diesel Power Pack

FLIRT H2 SBCTA	
Speed	80 mph
Seats	116
Cars	2 + Power Pack
Vehicle Length	169ft
Propulsion	H2 Power Pack

FLIRT Battery USU	
Speed	80 mph
Seats	116
Cars	2 + Power Pack
Vehicle Length	169ft
Propulsion	Battery Power Pack DC Fast Charging

FLIRT – MAIN LINE TRANSIT
FOCUS ON MODULARITY IN CONFIGURATION

Different Propulsion Systems

EMU	Electrical
DMU	Diesel
BEMU	Battery
H2	Hydrogen

Range
138 miles

Different Sizes (examples)

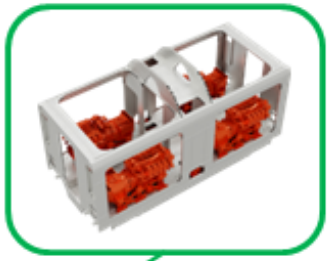
2 passenger cars	≈ 116 seats
4 passenger cars	≈ 272 seats
6 passenger cars	≈ 388 seats
Double traction	≈ 544 seats

Combination of any kind of propulsion system with any kind of size

PROPULSION
THE FLIRTS PROPULSION OPTIONS

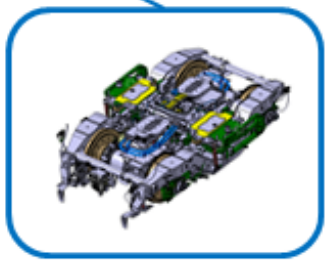
Converters

A traction converter in each cab car controls the traction motors on the respective car, and has in addition a integrated auxiliary converter.



Power Pack

Where the energy is generated or stored to propel the vehicle and power the auxiliary systems. Three possible systems are diesel, hydrogen, and batteries.



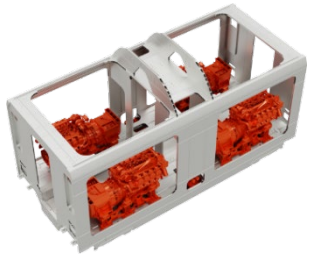
Traction Motors

2 traction motors are installed per motorized truck. The standard FLIRT³ US has two motorized trucks for a total of 4 traction motors.

One train concept for multiple traction technologies

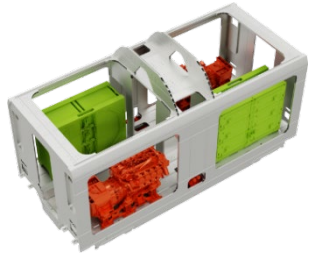
PROPULSION
THE FLIRTS PROPULSION OPTIONS

Diesel



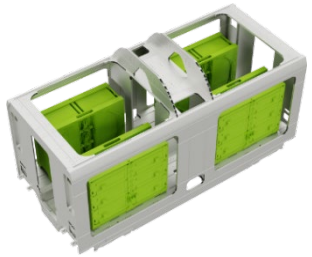
- Long Range
- Combustion produces environmentally damaging by-products
- High energy density

Diesel – Battery Hybrid



- Long Range
- Improved efficiency through energy recuperation

Battery



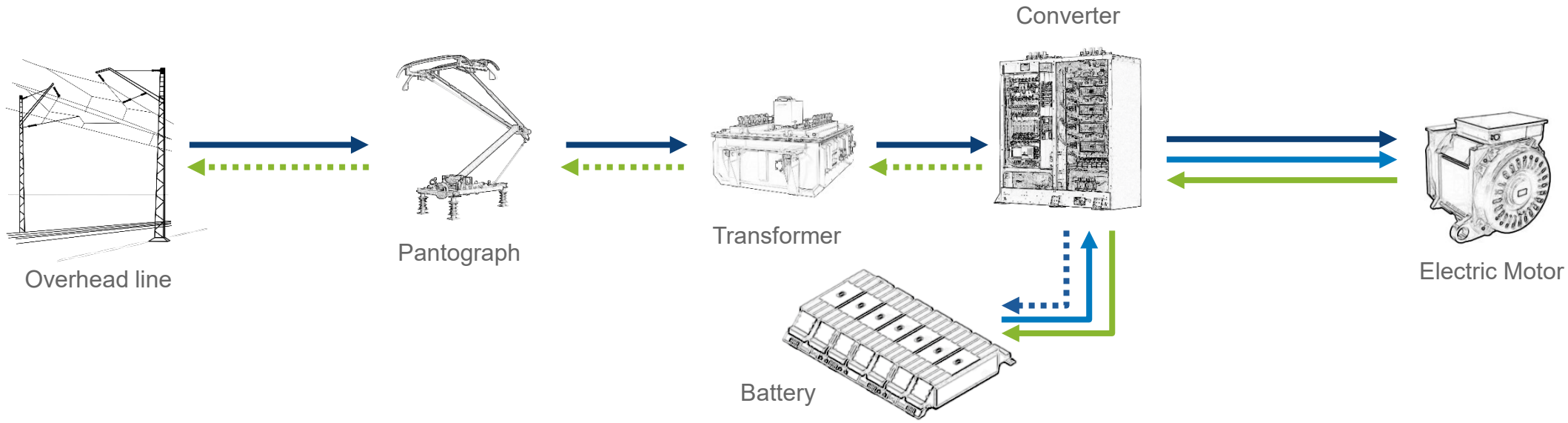
- Short Range
- Optimal for short lines or reduce investment cost to electrify parts of a line
- High power output

Hydrogen

- Long Range
- Hydrogen serves as range extender to the roof installed batteries
- Low constant power output

High propulsion flexibility through the Power Pack design

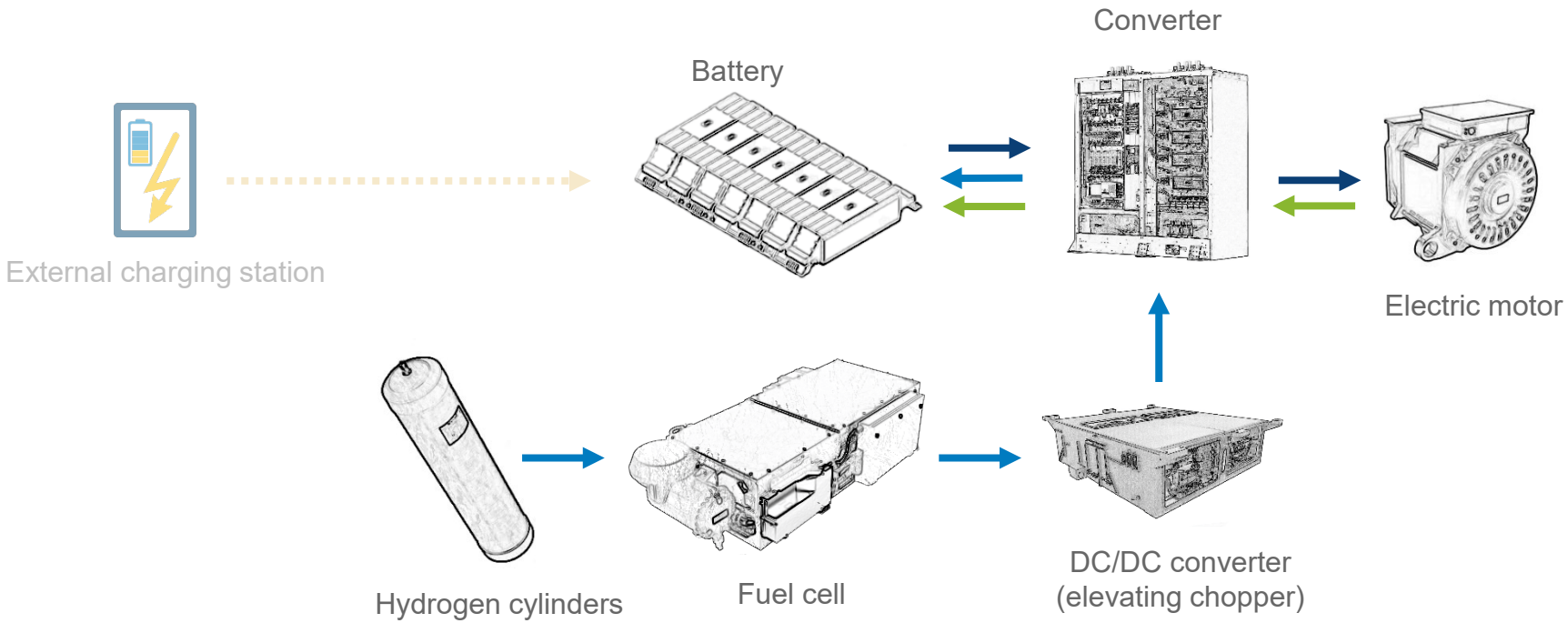
BEMU
TRACTION CHAIN TOPOLOGY



Technical Information

- The FLIRT BEMU has a demonstrated range in battery up to 138 miles.
- Depending on the operation profile, NMC, LTO, or LFP batteries are used.
- Tractive Effort / acceleration and Power at wheel is scalable.

H_2 FUEL CELL
TRACTION CHAIN TOPOLOGY



Energy flow in drive mode

Energy flow in braking mode

Continuous energy flow from the fuel cells

Energy flow during charging from external source (if planned)

CHALLENGES AND LIMITATIONS OF ALTERNATIVE PROPULSION

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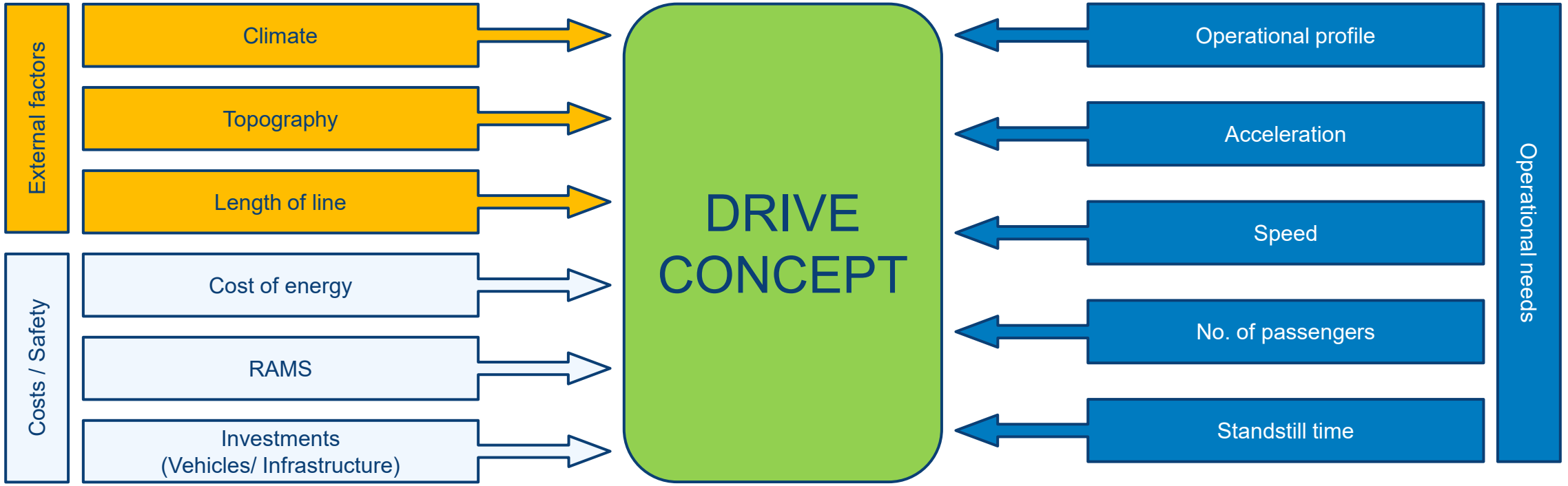
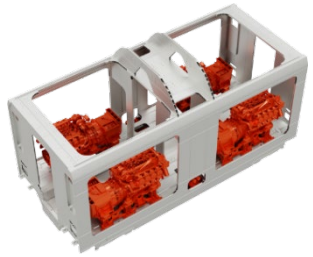
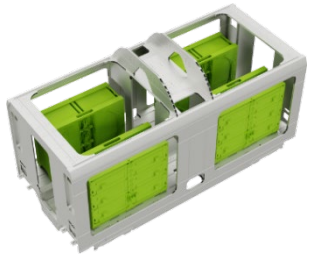
FLIRT WITH ZERO EMISSION
FACTORS INFLUENCING THE CHOICE



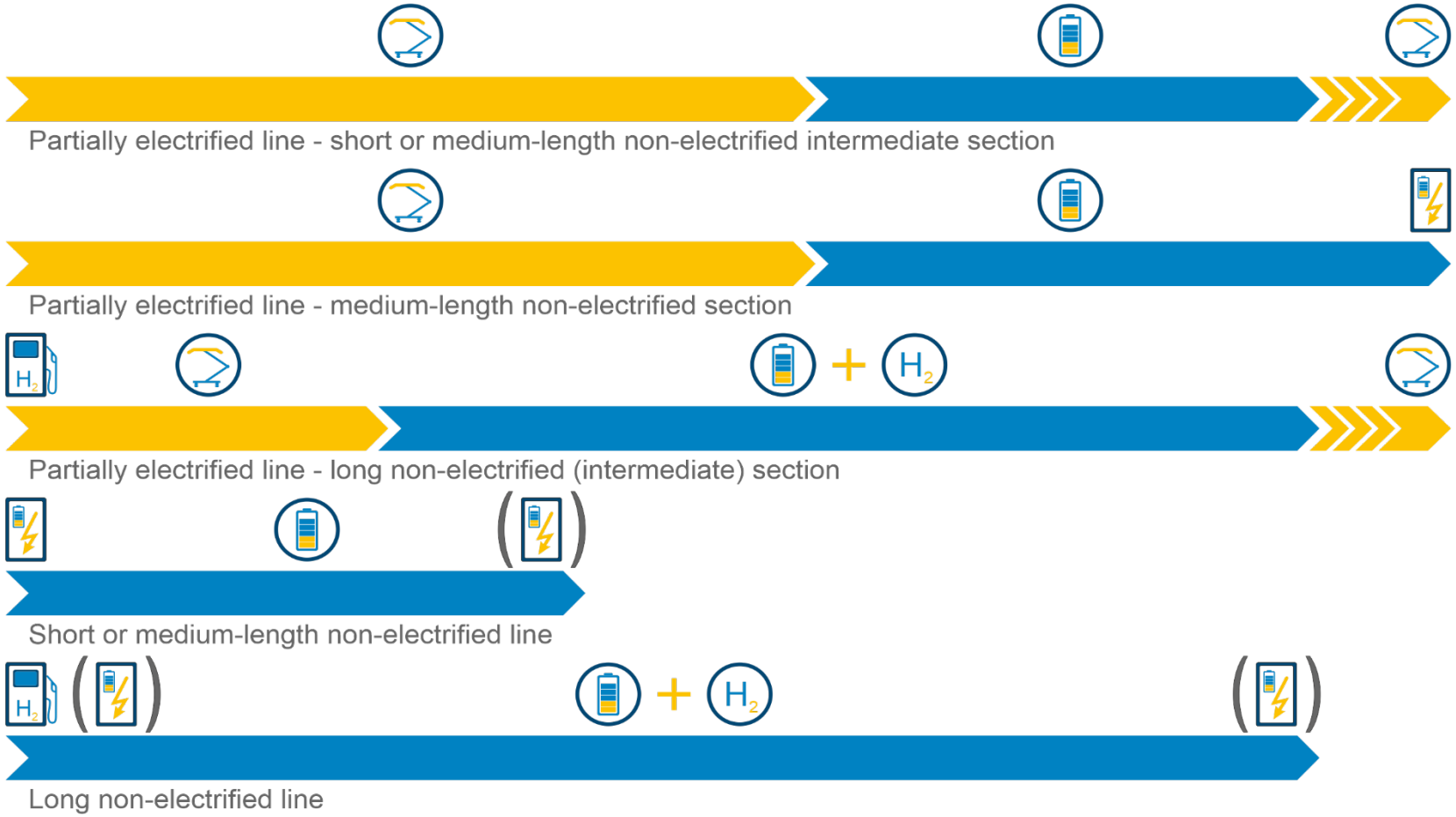
Transition from Diesel to Green Technology requires specific operation profiles

PROPULSION
WHAT IS THE BEST ALTERNATIVE TO DIESEL?

Diesel	Battery	Hydrogen
		
↑ Power Available	↑ Power Available	↓ Power Available
↑ Range	↓ Range	↑ Range

Battery powered trains provide high power output while hydrogen provides range

FLIRT ZEMU
CONFIGURING ECOLOGICAL DRIVES



The batteries may be recharged

– en-route (partial electrification)

– .. stationary (charging station)

– .. or on-board (fuel cells).

PROJECT PROGRESS
FLIRT H2 FOR SBCTA & FLIRT BATTERY FOR USU

FLIRT H2 FOR SBCTA

- **2019** – Contract Signed
- **2021** – Start production
- **2022** – First International Presentation (InnoTrans)
- **2023** – **Testing Train**
- **2024** – First H2 train in service

FLIRT Battery FOR USU

- **2023** – **Contract Signed**
- **2024** – Final Design with USU & Start Production
- **Early 2025** – Testing Train
- **2025** – Proof of Concept for ZEMU Battery Train

THANK YOU
FOR YOUR ATTENTION

Martin Ritter | 05/16/2023 | Stadler US

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