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OFF Wire & ZEMU  
Latest developments in Catenary Free Operation

by



American Public Transportation Association  
Streetcar Subcommittee  
2019 APTA & TRB LRT & Streetcar Conference



## About Us

Primary Locations:



### Services

Engineering



Design



Manufacturing



Support



### Segments



Aerospace



Transport



Industrial



Telecom



Medical



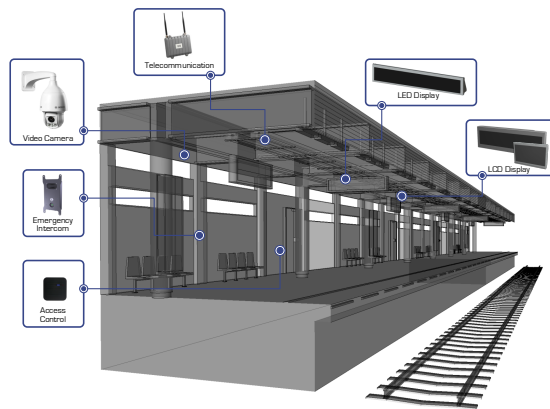
2,200 Employees



150 M\$

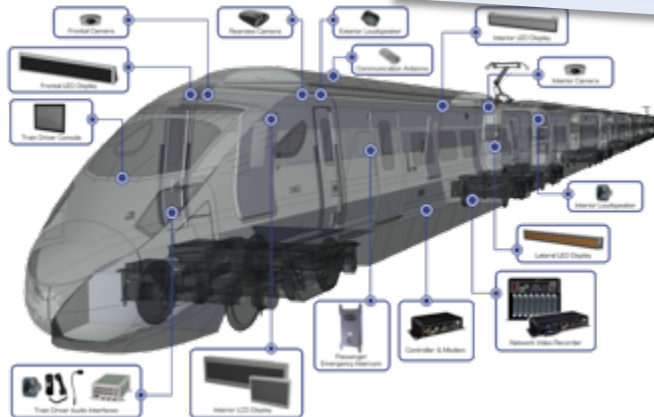


## About Us – Expertise in Rail



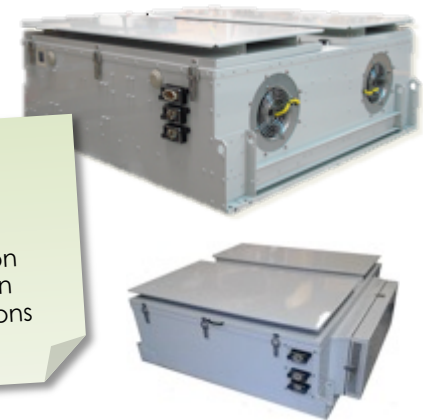
### Passenger Information

- PIS
- PA
- PEI
- CCTV
- WiFi
- APC
- Network
- MDS
- Radio

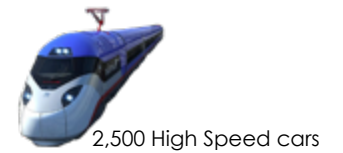


### Energy Systems

- APC
- LVPS
- Battery Charger
- Regen Storage
- Power Stabilization
- Power Conversion
- Autonomy Solutions



## About Us – Global Experience



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***Powering Light Rail Vehicles  
... the future ... is now***

## Powering Light Rail Vehicles

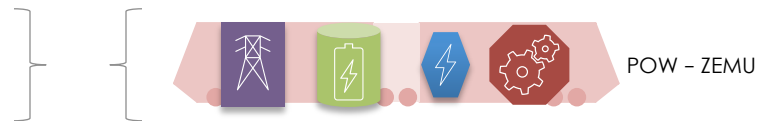
### Conventional Infrastructure based:

- ☉ **OCS**: Overhead Catenary System
- ☉ **GLPS**: Ground Level Power Supply



### Infrastructure based / Battery Hybrid:

- ☉ **POW**: Partial Off-Wire
- ☉ Battery Technology



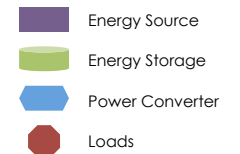
### Onboard Power Generation System

- ☉ **DE-DMU**: Diesel-Electric
- ☉ **BDEH**: Battery-Diesel-Electric Hybrid
- ☉ **HFC**: Hydrogen Fuel Cell

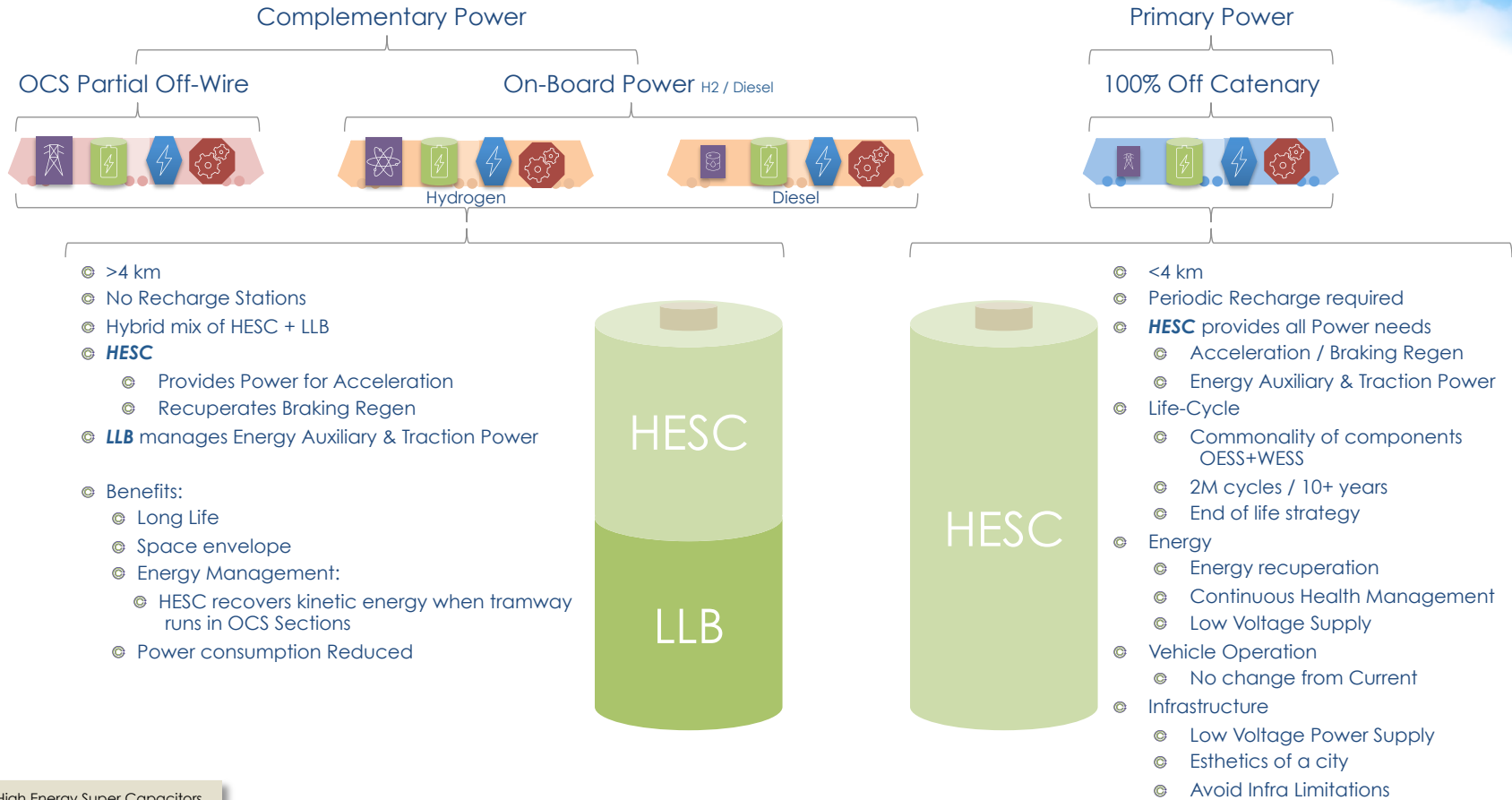


### OESS/WESS: Onboard/Wayside Energy Storage System

- ☉ 100% Off Catenary

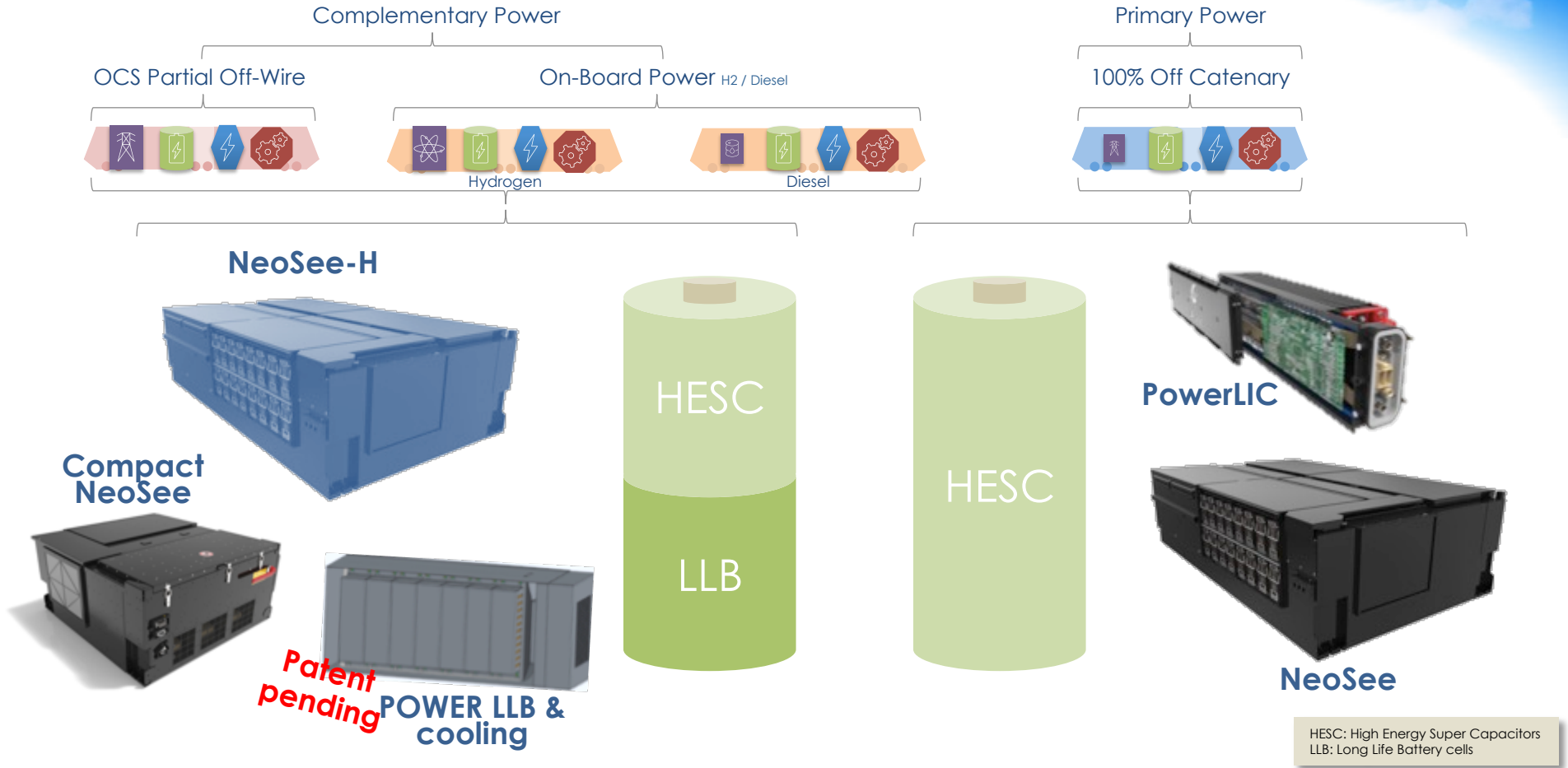


## Powering Light Rail Vehicles – OESS: Side by Side



HESC: High Energy Super Capacitors  
LLB: Long Life Battery cells

## Powering Light Rail Vehicles – Product Portfolio





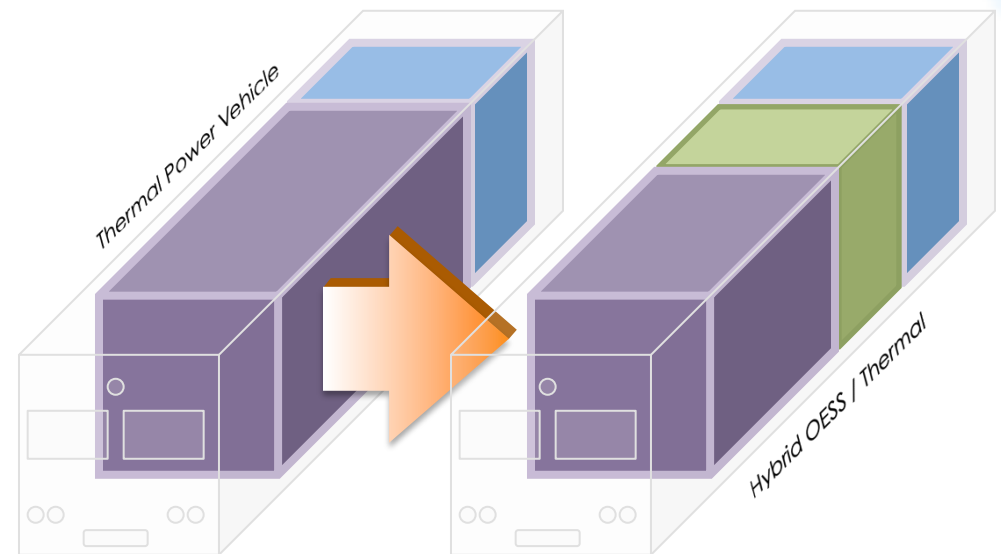
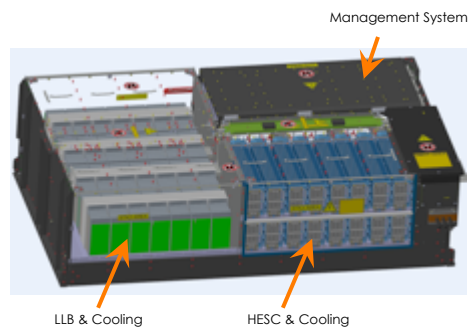
## Complementary Power: On-Board Power (Hydrogen / Diesel Electric)

- © OEES aboard a DE or HFC MU
- © Improve Equipment Availability



- © Advances in Energy Storage Technology allow a shift from Mechanical to Mechanical/Chemical

### NeoSee-H

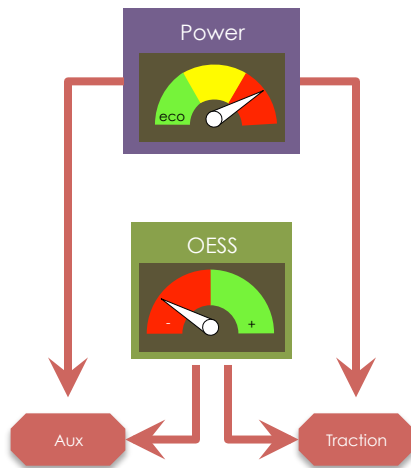


- Diesel/HFC Power-Pack
- Power Conversion
- OEES

## Complementary Power: On-Board Power (Hydrogen / Diesel Electric)

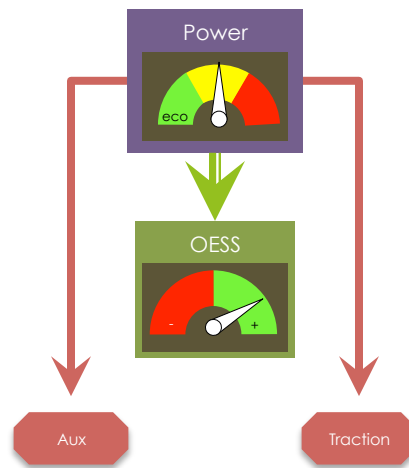
### Power Phase

- ⦿ High Power Demand
- ⦿ Start Assistance
- ⦿ Slope Assistance



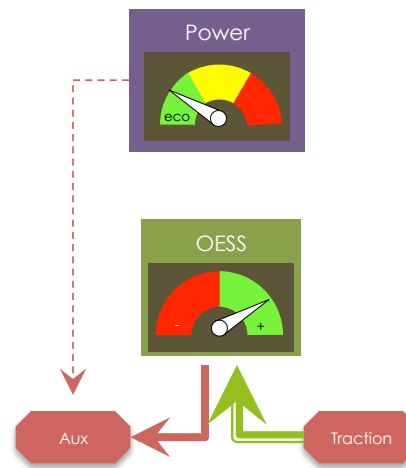
### Running Phase

- ⦿ Recharge Between Stops



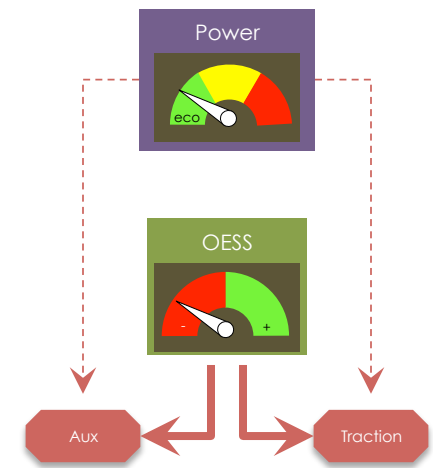
### Braking Phase

- ⦿ 100% Regen.
- ⦿ Engines Optional

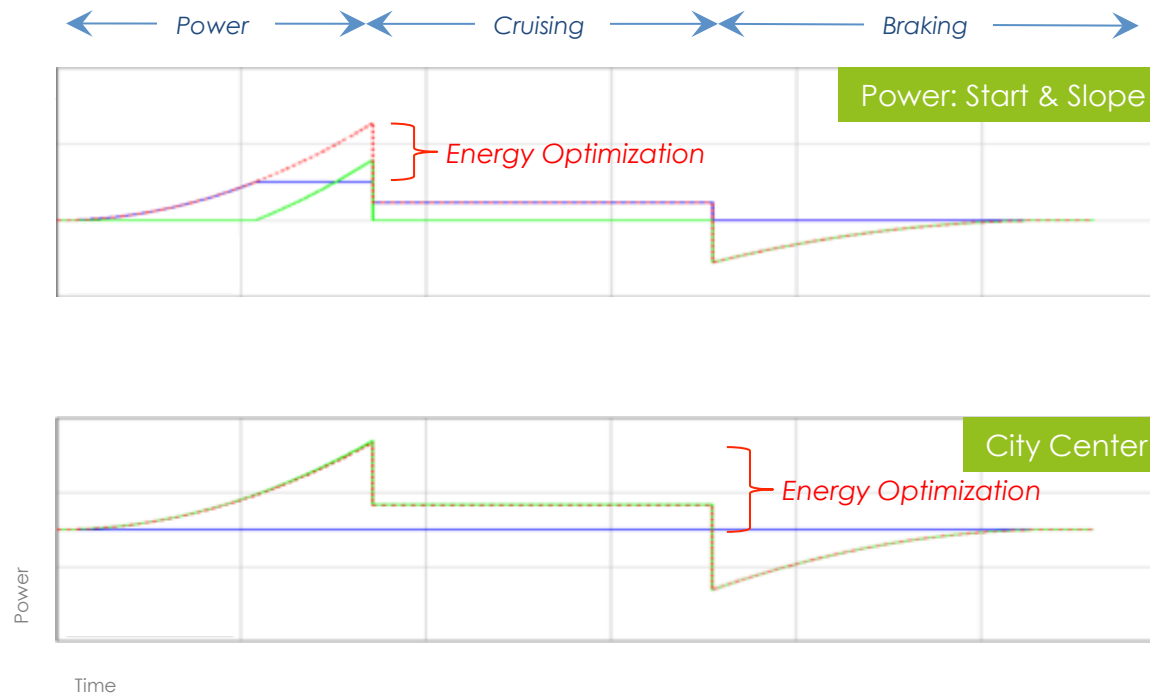


### City-Center / @ Station

- ⦿ Engines OFF
- ⦿ Full Autonomy



## Complementary Power: On-Board Power (Hydrogen / Diesel Electric)



--- Total Energy Req.  
— Diesel Power Out  
— ESS Power

Primary Power: 100% Catenary-Free

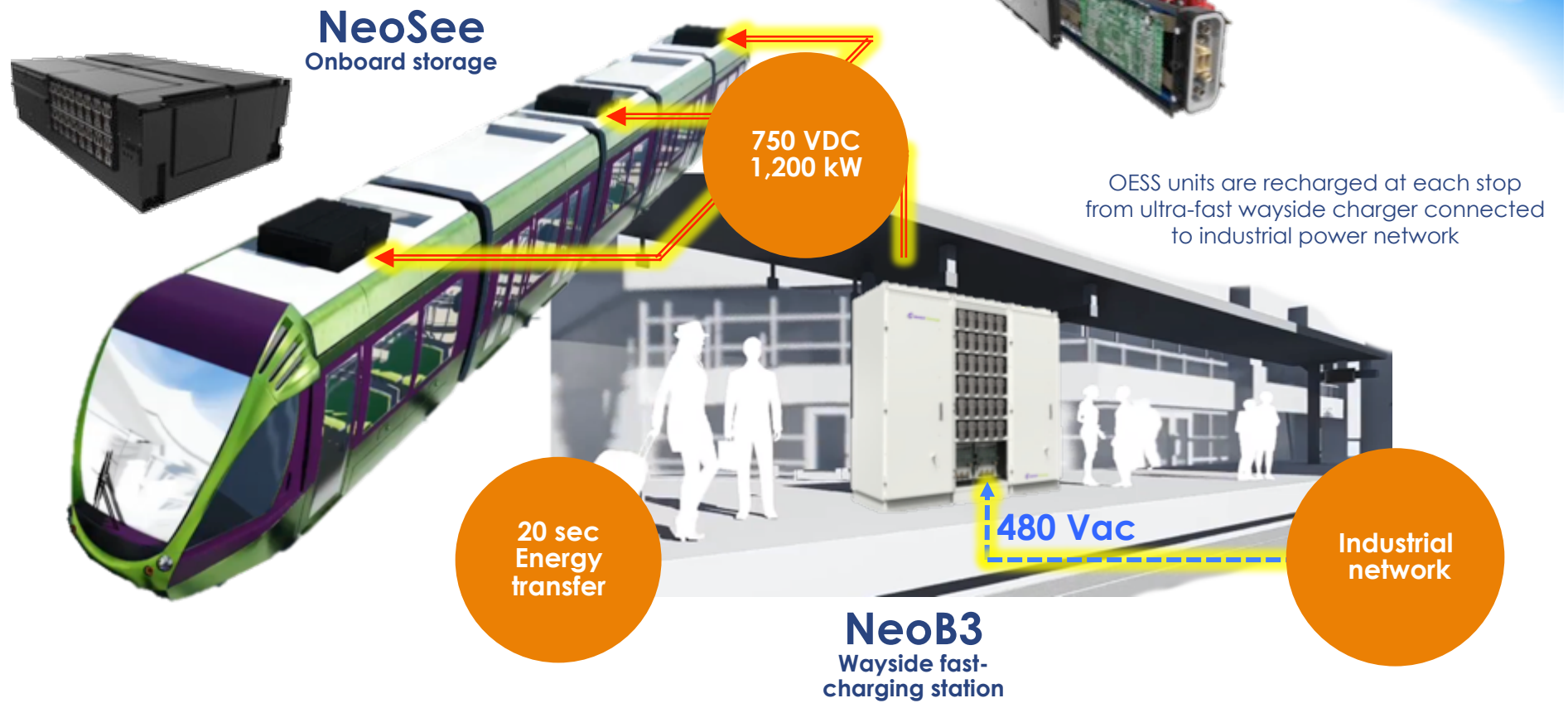


Primary Power: 100% Catenary-Free





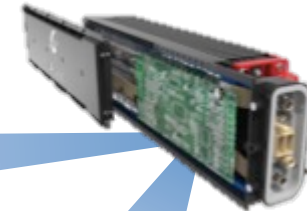
## 100% Catenary-Free Solution – Onboard



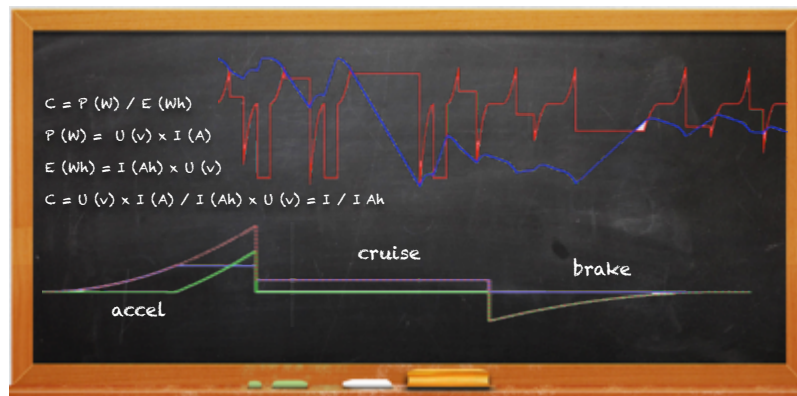
## 100% Catenary-Free Solution – Criteria for Configuration



- On-Board**
- Dwell time
  - Vehicle Weight
  - Acceleration
  - Speed Profile
  - Consist / Trainset Arrangement
  - Topology
  - Downgraded Modes
  - Contingencies
  - Go/NoGo
  - Towing Capability
  - Local Operational Rules
  - ...

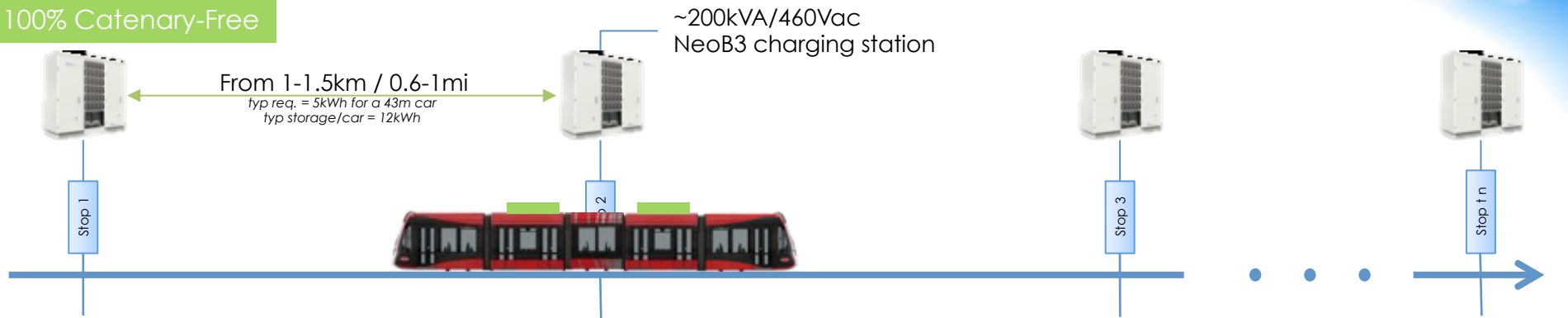


- Wayside**
- Headway
  - Frequency of Trains
  - Contingencies
  - Real-estate design
  - Architecture
  - Additional Uses
  - Local Operational Rules
  - ...

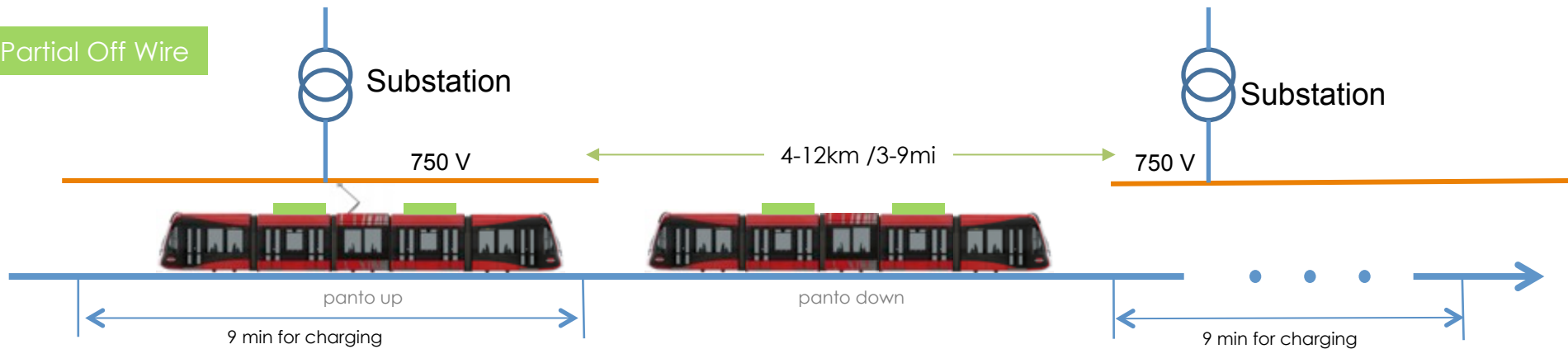


## 100% Catenary-Free & POW – System Views

### 100% Catenary-Free



### Partial Off Wire





## 100% Catenary-Free Systems in Operation – France - Taiwan



Alstom Copyright



Kaohsiung, Taiwan



Video Courtesy of:  
<https://www.youtube.com/watch?v=QrHc44isXh8&feature=youtu.be>



Alstom Copyright



Nice, France



Video Courtesy of:  
<https://www.youtube.com/watch?v=GXeu1CnUr5U&t=38s>

## 100% Catenary-Free Systems

### ☉ Truths & Myths about Off-Wire

#### ☉ Advantages

- ☉ Improved aesthetics
- ☉ Reduction in conflicts with other users of the street space
- ☉ Potential for infrastructure simplification
- ☉ Elimination of single point of failure (OCS failure)

#### ☉ Disadvantages

- ☉ Vehicle becomes more complicated
- ☉ Weight, space and performance trade-offs
- ☉ Onboard Energy Storage
  - ☉ unknown life expectancy of energy storage elements

Partially, enhancements in all areas are increasing

5% Weight increase, NO performance trade-offs

Experience so far in France and Taiwan shows no failures, high reliability, high availability

- ☉ Ground Level Power
  - ☉ high cost / proprietary

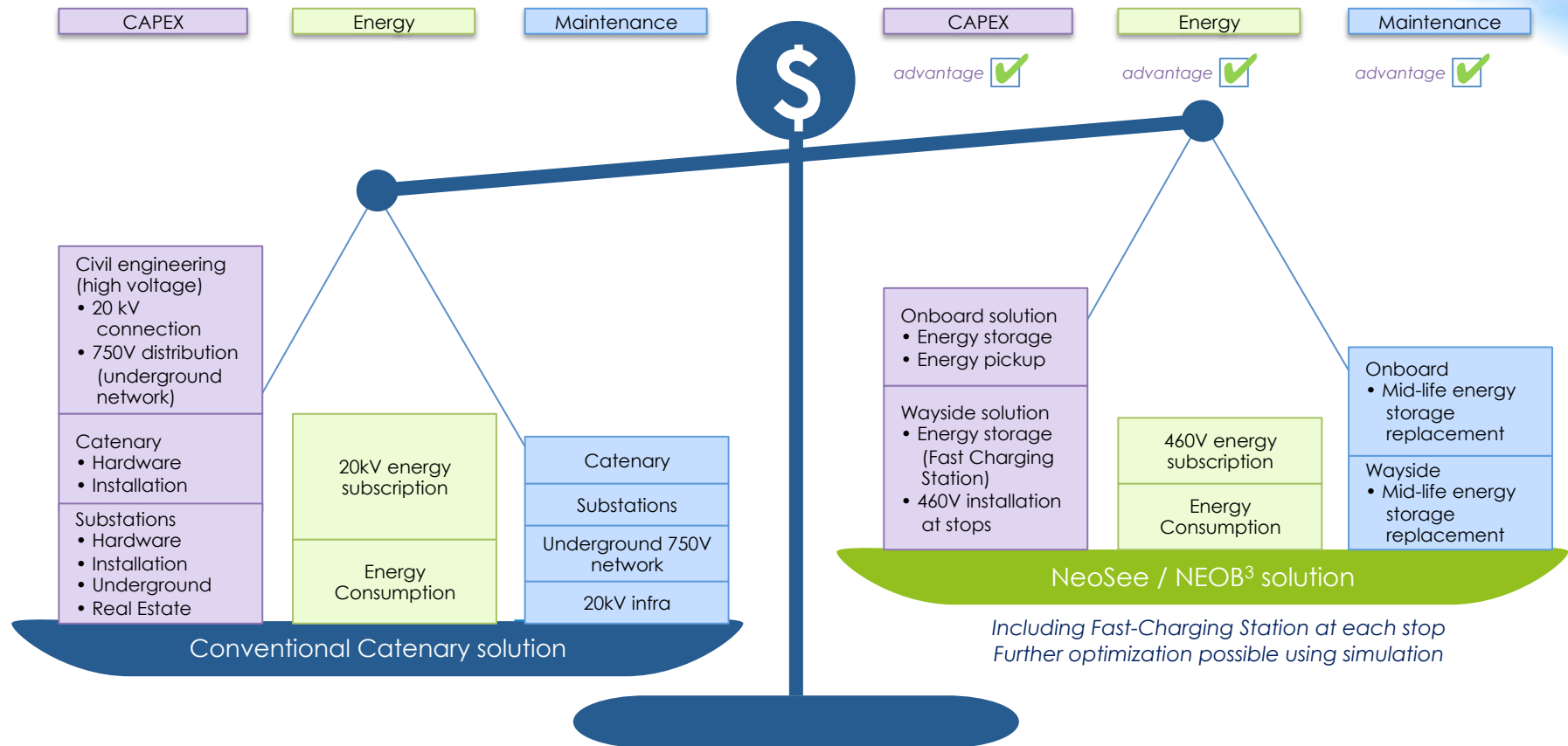
Significantly lower cost than conventional substation network  
Technology is open-source

#### ☉ Onboard Power Generation

- ☉ fuel cell technology expensive, requires fueling

ZEMU benefits are significant

## Business Case: Cost Effective Innovation - 30 years Total Cost of Ownership





**CUSTOMER CENTRIC** innovation  
embedded energy teamwork recharge  
stations technology TRUST **STORAGE**  
**LIFETIME** lifecycle cost