(I DON'T) MIND THE GAP (extended mix)

Discontinuous Electrification as part of the Railway System

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AtkinsRéalis

AGENDA

1. BEMUs - the Great Traction Shift
2. Flattening the hype cycle
3. What is Discontinuous Electrification?
4. New traction types
5. Deadly sins or Wonders of the World? The seven modes of DE
6. DE: temporary or permanent?
7. DE system integration
8. Feasibility and compromises of DE
9. DE and the forgotten customer - freight
10. Appropriate use cases for DE

BATTERY TRAINS - DISRUPTIVE CHANGE

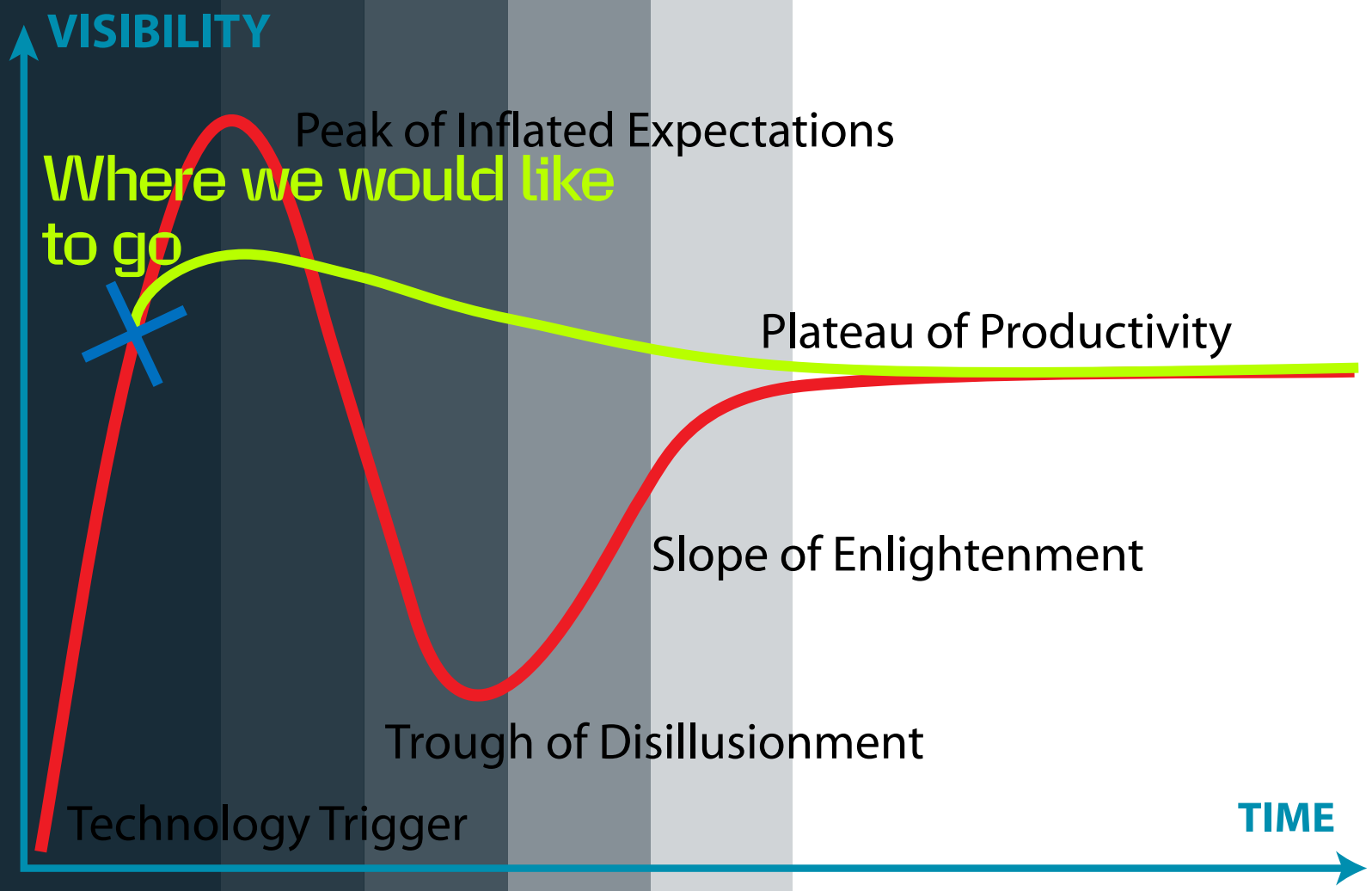
Current Battery Train Procurement:
Northern Trains
GWR
East West Rail
Chiltern
South Western Railways
Scotrail

BEMUs are the biggest change to UK traction policy since the end of steam

Novel technology carries huge opportunities – but also big risks – dieselisation in 1960s refers

We must learn the lessons from history and treat battery trains as a system-level change

THE HYPE CYCLE: WHERE ARE WE?



WHAT IS DISCONTINUOUS ELECTRIFICATION?

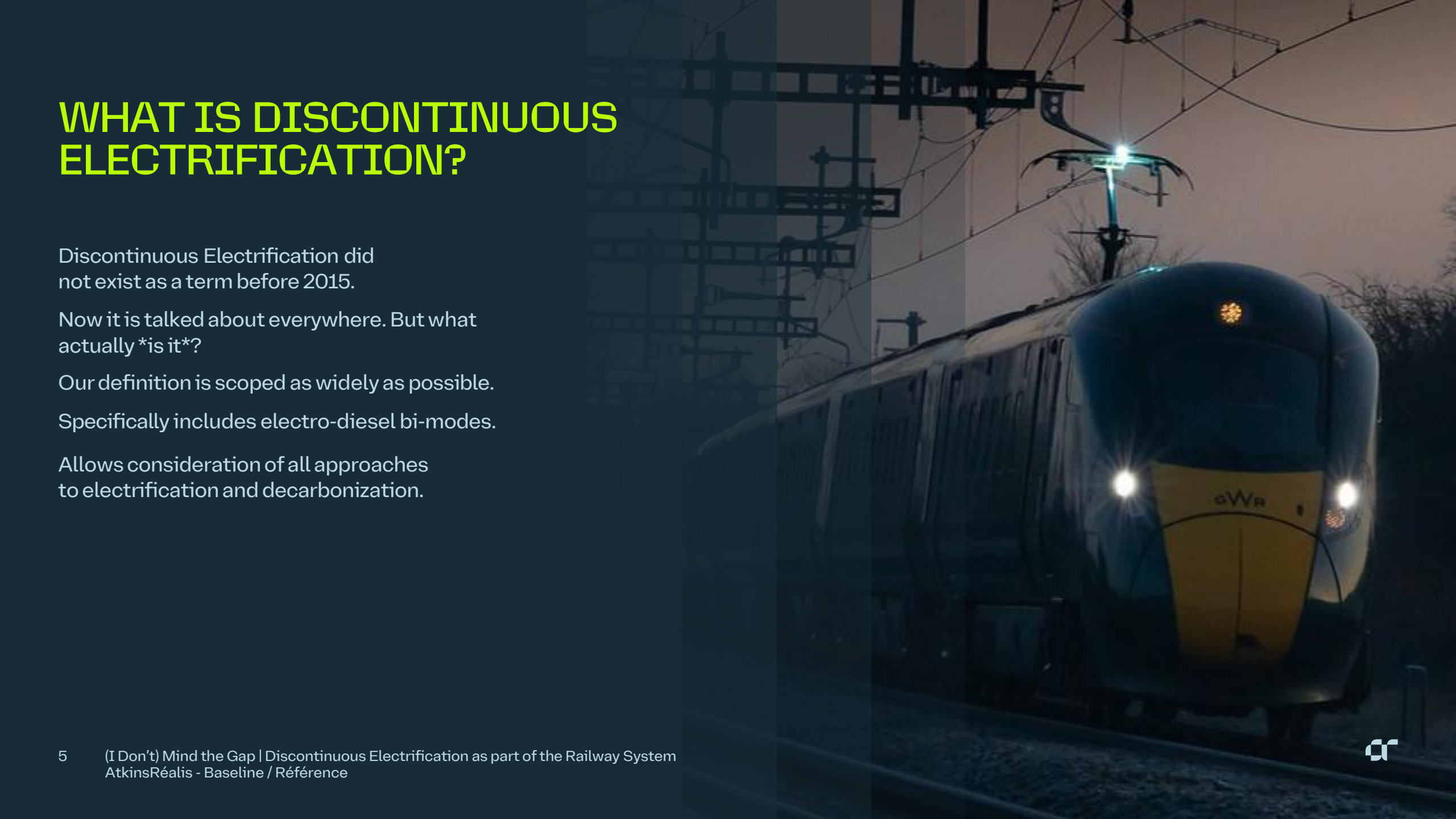
Discontinuous Electrification did not exist as a term before 2015.

Now it is talked about everywhere. But what actually *is it*?

Our definition is scoped as widely as possible.

Specifically includes electro-diesel bi-modes.

Allows consideration of all approaches to electrification and decarbonization.



DISCONTINUOUS ELECTRIFICATION:

THE ATKINSRÉALIS DEFINITION

"A railway traction system where there is not a continuous live contact system above or below an electric train for the whole length of its journey; and where electric power is provided to the train via current collection equipment[1] for the purpose of propulsion[2] and/or energy storage when the train is moving[3] and/or when the train is stationary[4]."

1.This could be a pantograph, trolley pole, shoegear or plug-connector
2.And auxiliary loads
3.In-Motion Charging (IMC)
4.Static Charging (SC)

THE NEW JARGON – TRACTION TYPES

- DMU – Diesel Multiple Unit (MU)
- EMU – Electric MU
- DEMU – Diesel Electric MU (electro-diesel, bi-mode) – e.g. class 80x
- BEMU – Battery Electric MU (bi-mode) – e.g. class 798
- BMU – Battery MU – e.g. class 230
- BDEMU – Battery Diesel Electric MU (tri-mode) e.g. class 756

BREAKING THE PROBLEM DOWN

These definitions show how complex the picture is

How can we simplify things?

THE SEVEN MODES OF DISCONTINUOUS ELECTRIFICATION

Mode 0:
Conventional electrification.

Mode 1:
Continuous electrification with non-electrified diverging branches or sidings.

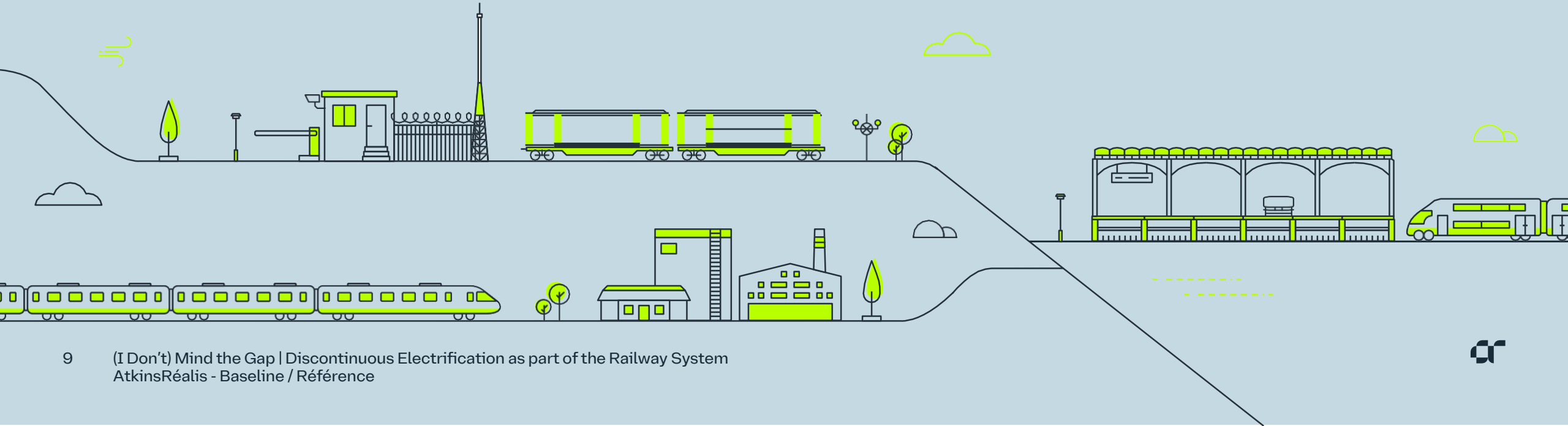
Mode 2:
One short discontinuity within an otherwise continuous system.

Mode 3:
Many short discontinuities, but still a mostly continuous system.

Mode 4:
Islands of electrification with multiple long discontinuities.

Mode 5:
Static charging facilities at stations, with no contact system in between.

Mode 6:
No electrification.



DE: TEMPORARY OR PERMANENT?

Temporary Uses:

- Part of a rolling programme of electrification
- Because a remodelling scheme is due to be undertaken in the gap.

Permanent Uses:

- As an end state, with no plan to close the gap.

The first scenario is the most effective way to roll out Continuous Electrification - and is needed for freight.

Scenario two is increasingly proposed, and the rest of this talk will focus on the idea of DE as a permanent state.

CORE VALLEY LINES – THE RISK OF COMPLACENCY

- CVL is mode 3 – relatively low risk, battery sections quite short
- Mode 4 is significantly higher risk
- Industry cannot risk another botched electrification programme

SYSTEM INTEGRATION

DE requires a fundamentally different approach to specification, procurement and design.

Rolling stock, infrastructure and operations are part of a single system in a way that is not the case with Continuous Electrification.

Sponsors, operators, rolling stock manufacturers, infrastructure managers, programme delivery and supply chain need to be tightly integrated and working to a common goal.

Requirements need to be clearly set out and agreed before the project starts.

SYSTEM INTEGRATION

- Operations
- Rolling Stock
- Static Charging
- In-Motion Charging
- Power Changeover
- Driver Authority System

OPERATIONS

Essential factors to define for DE:

- Service pattern
- Dwell times for static charging
- Power availability
- Stabling and overnight charging
- Service disruption
- Battery lifecycle
- Battery warranty
- Low temperature performance
- End-of-life performance
- Power changeover locations

ROLLING STOCK COMPROMISES

- Higher rolling stock capex
- Higher rolling stock opex
- Potentially lower reliability
- Bi- and tri-mode vehicles complexity
- Cost of conversion provision
- Diesel maintenance requirements
- Manufacturer reluctance on diesel
- Limitations on cascade

STATIC CHARGING

Static Charging (Mode 5) is more challenging than other modes because:

- Charge time is minimised
- Charging current and battery degradation is maximised
- Risk of contact patch damage if currents are too high

The golden rule: infrastructure constraints (charging availability) should not be constraining operational needs (dwell times)

IN-MOTION CHARGING

In Motion Charging is less demanding than SC (lower currents, no dwell time constraints), **BUT**

- OCS currents are higher: traction current + charging current
- OCS system needs to be designed (or upgraded) to allow for total current
- Existing traction power supplies may need to be upgraded to allow for additional power

CHARGING STANDARDISATION

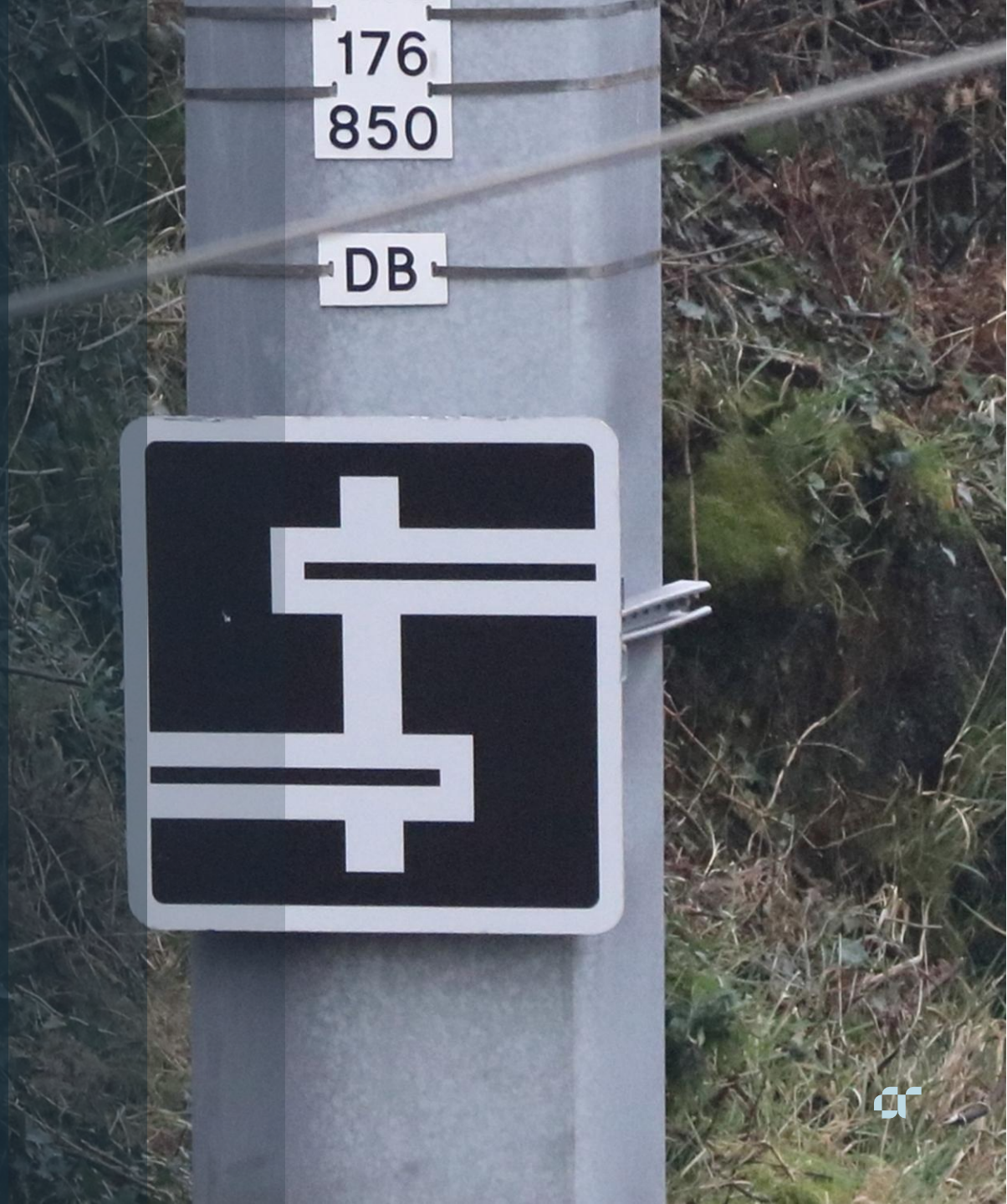
How do we avoid proliferation of charging systems? The railway is built on common standards

Industry needs to standardize on:

- Current GB pantograph design for AC in-motion charging
- Current third rail pickup design for DC in-motion charging
- GWR/Vivarail system for static charging?

POWER CHANGEOVER

- Power changeover between modes is complex and must be planned from the start
- At higher speeds a considerable length of track is needed
- Must be away from signals, bridges and other features
- Power changeover can in some circumstances require more OCS to be built, increasing costs



DRIVER AUTHORITY SYSTEM

Driver will not know whether they have sufficient charge to get to next charging opportunity

Range will depend on:

- Battery capacity
- Length of unwired section
- Ambient temperature
- Wind speed and direction
- Level of disruption on route

All multi-mode trains will need to have a DAuS (as opposed to a DAS) to give them permission to move. Complete integration with signalling and traffic management system needed

THE FORGOTTEN CUSTOMER - FREIGHT

- DE, with the exception of Modes 1 and 2, is not an option for freight, now or for foreseeable future
- Power demand is simply too high
- DE as a permanent solution risks locking freight out of decarbonization
- Freight electrification has other benefits - increased capacity on busy lines

APPROPRIATE USE CASES FOR DE

- A single discontinuity to deal with a problem with no practical engineering solution
- Last-mile branch line capability in coordination with continuous electrification on the mainline
- Temporary discontinuities as part of a staged and coordinated rolling programme of electrification
- Short, self-contained routes with no freight where island charging can be provided
- Multiple discontinuities on a self-contained passenger-only network
- Multiple discontinuities on a mixed use passenger and freight railway, as part of a longer term strategy to close the gaps for freight

THANK YOU
Q&A