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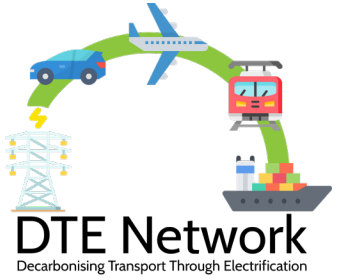
Intermittent Electrification with Battery Infill

Intermittent Electrification Webinar

2022-01-27

Project Overview



RSSB

- Funded by the DTE Network+
  - (Building on work funded by RSSB)
- Background:
  - Electrification is expensive and is only done in fits and starts
  - **But** it's the best way to decarbonise the railway
- Motivation
  - How do different methods of intermittent electrification affect the amount of CO_2 that can be saved?
  - How big do the batteries need to be?
  - What is feasible?

Model Overview

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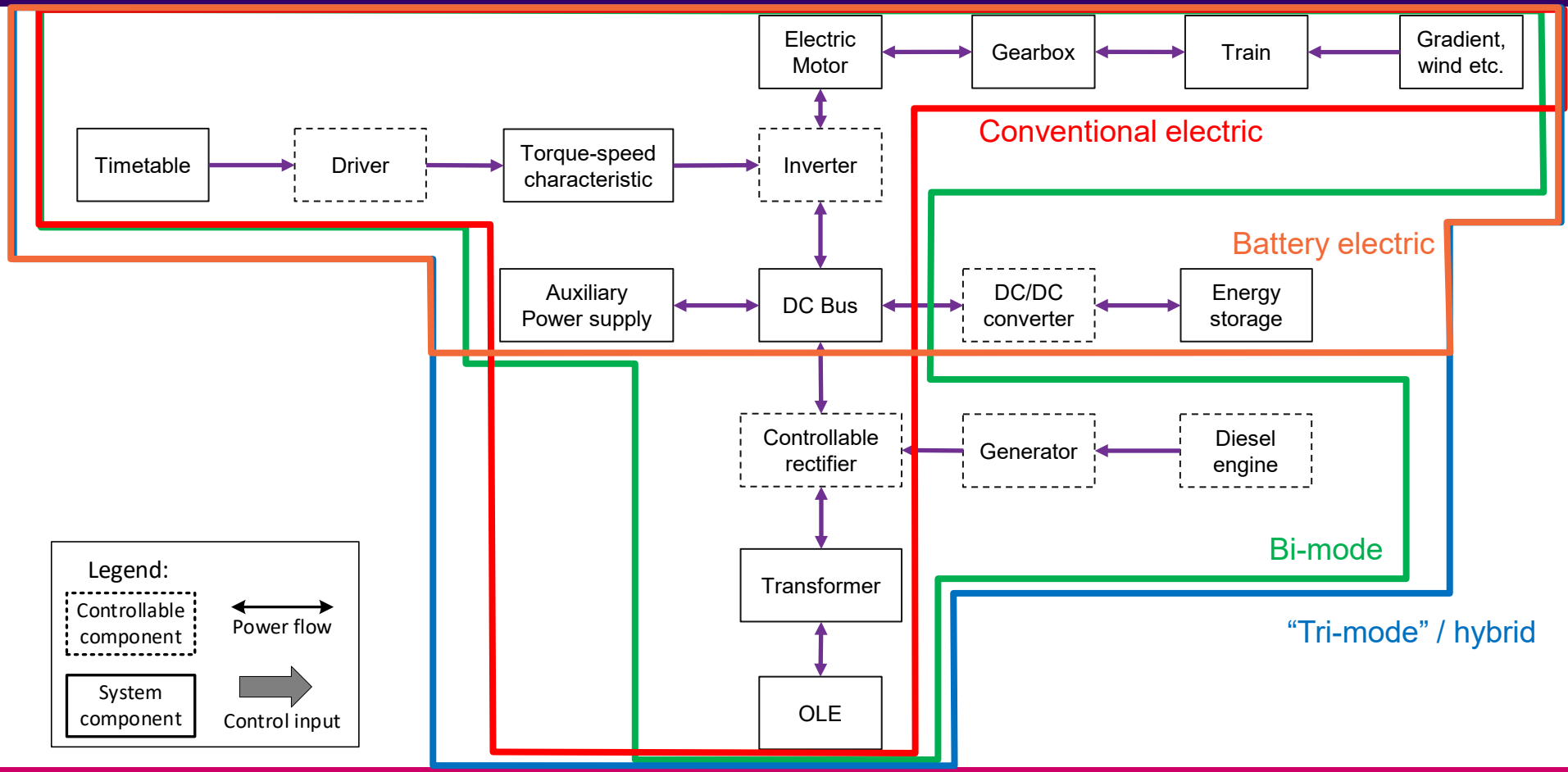

Model Validation

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- The model of the vehicle (vehicle speeds and behaviour) were validated using data collected in 2020
- For more information, see our previous work:

Continuous Electrification

257g/kWh

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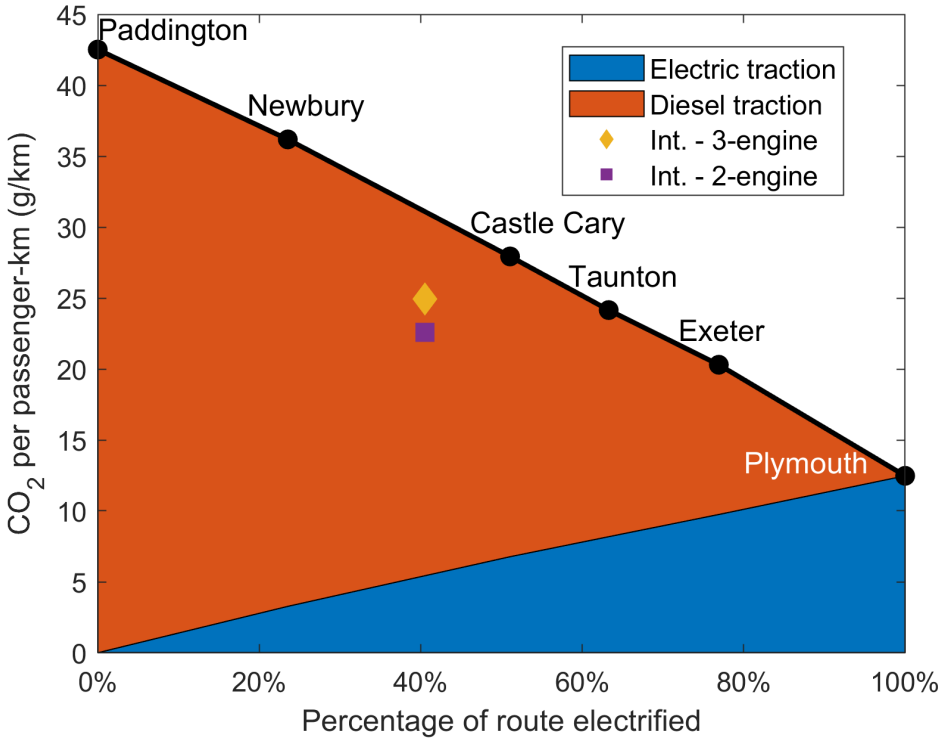
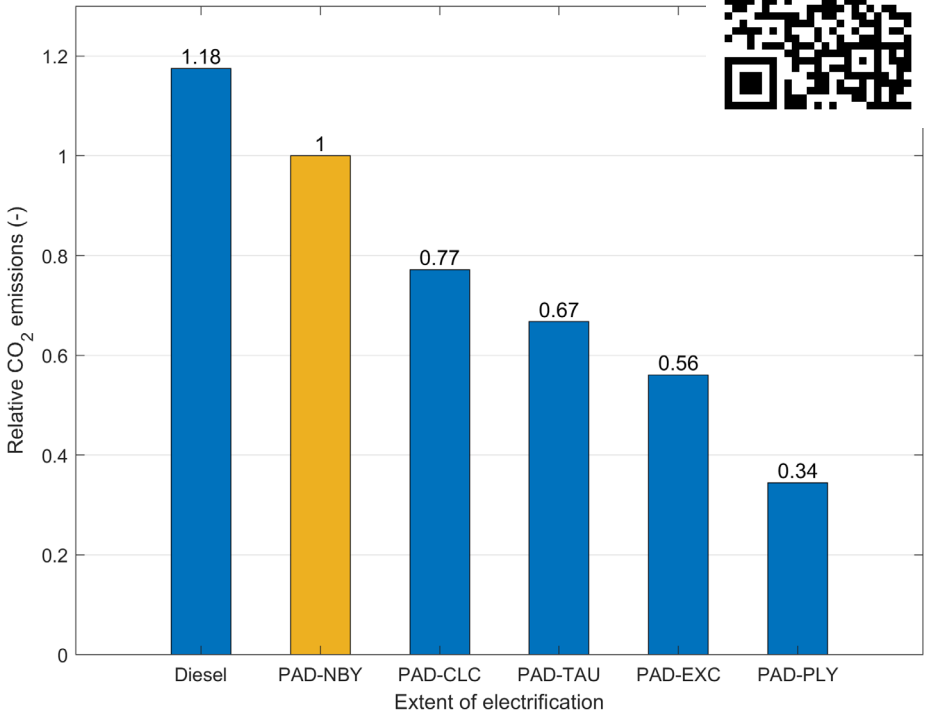
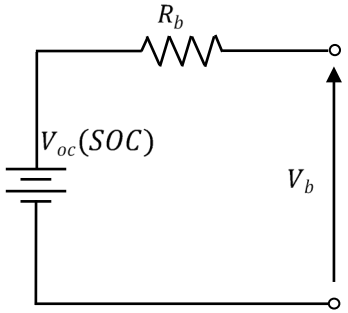
More detail:

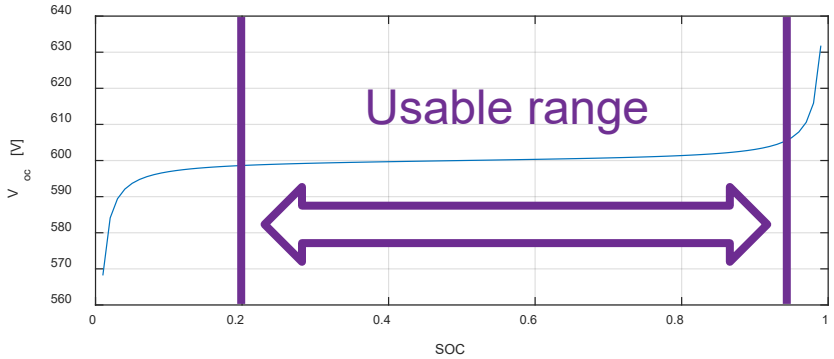




Battery Model

- Simple battery model, using series resistance:





- State of charge (SOC) kept between $0.2 \leq SOC \leq 0.95$
- Lithium-titanate (LTO) battery with good charge/discharge performance

Electrification

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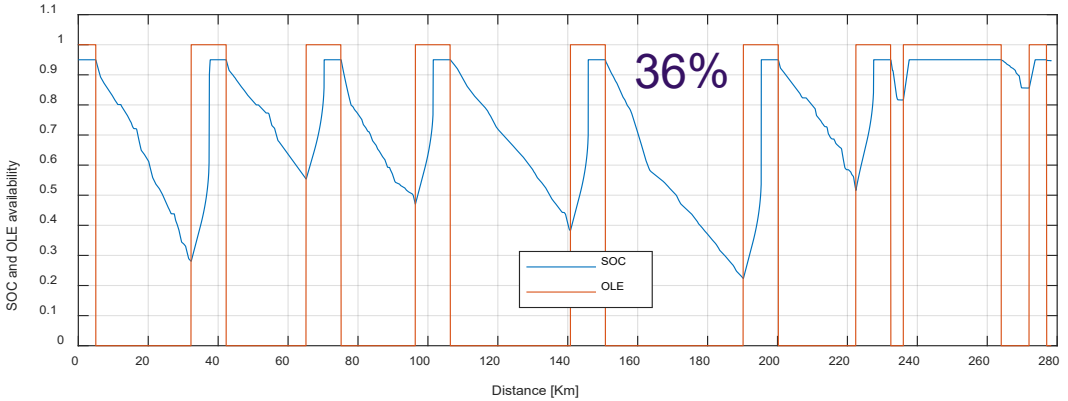
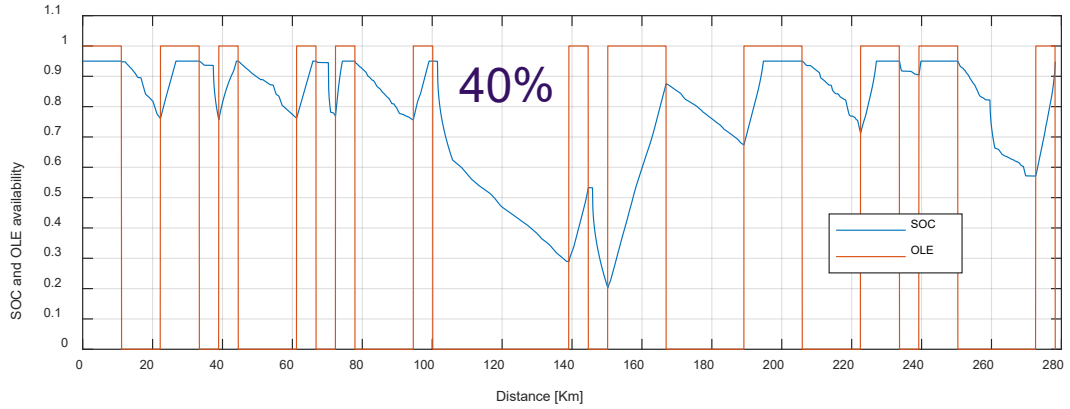
1. ‘Common-sense’ – electrify in 10-km sections around stations and hills



2. ‘Optimal’ – split route up into 5.6-km sections and electrify the highest-energy sections



Comparative masses

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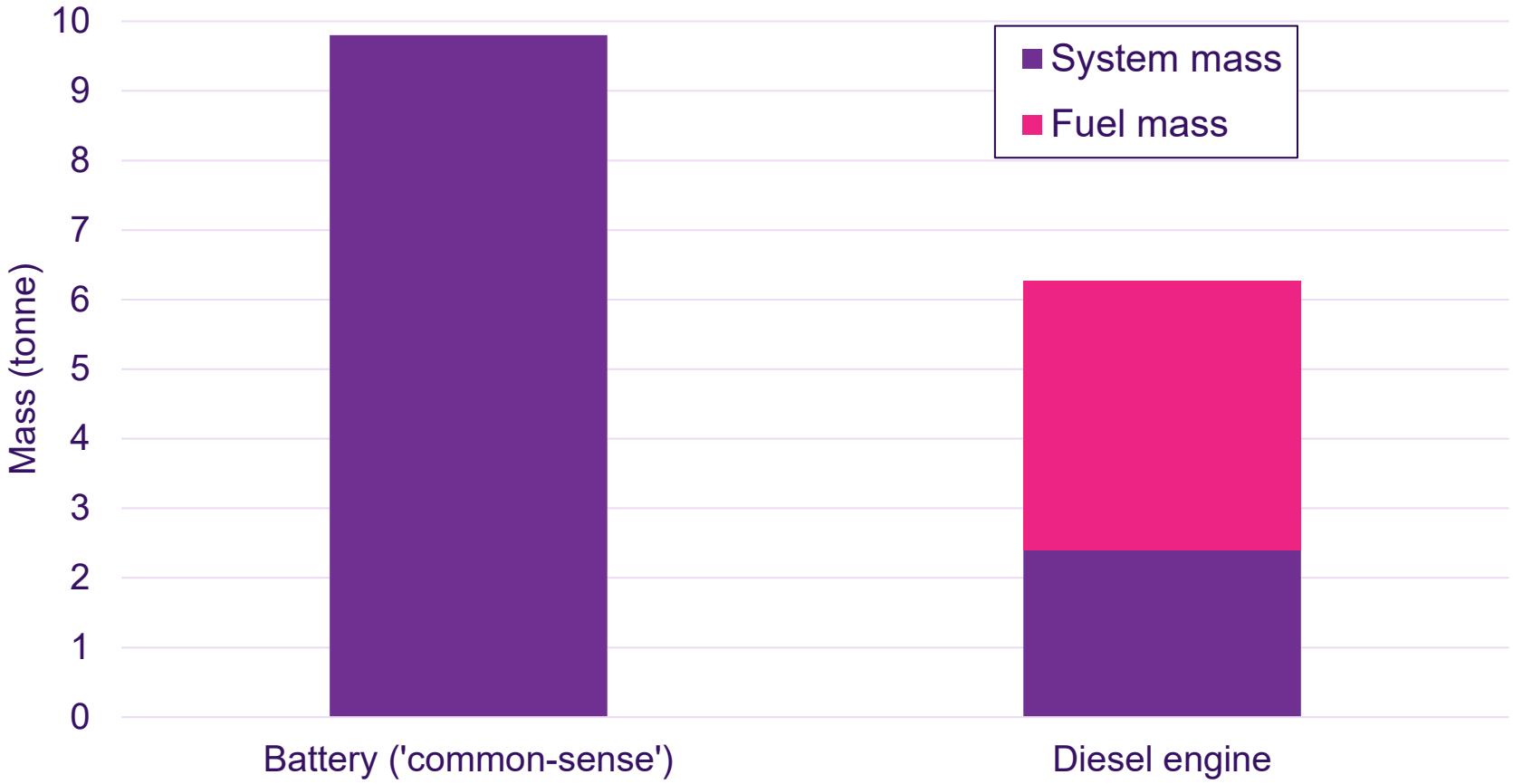

Battery mass vs electrification

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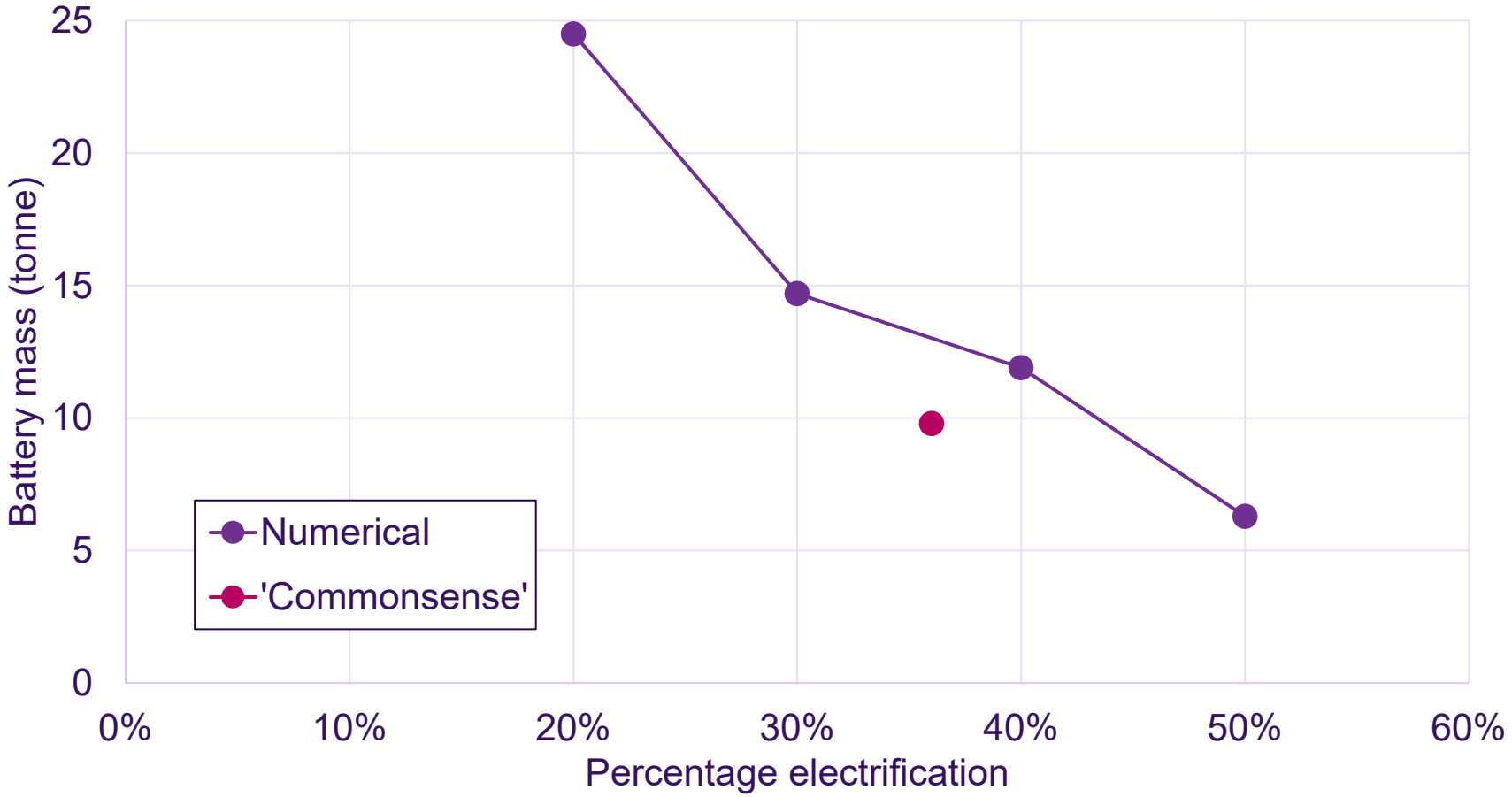

Battery Lifecycle

- Used ‘rain flow’ model – cumulative wear over a return journey to/from Plymouth – Newbury
- Expected lifetime of 1.44 years to 80% capacity if the battery is kept at 55°C
- Extended to around 6 years if the battery is kept at 25°C
  - **Thermal management is important!**
- Expected that spent batteries would be used for e.g. lineside storage or recycled

CO_2 Emissions

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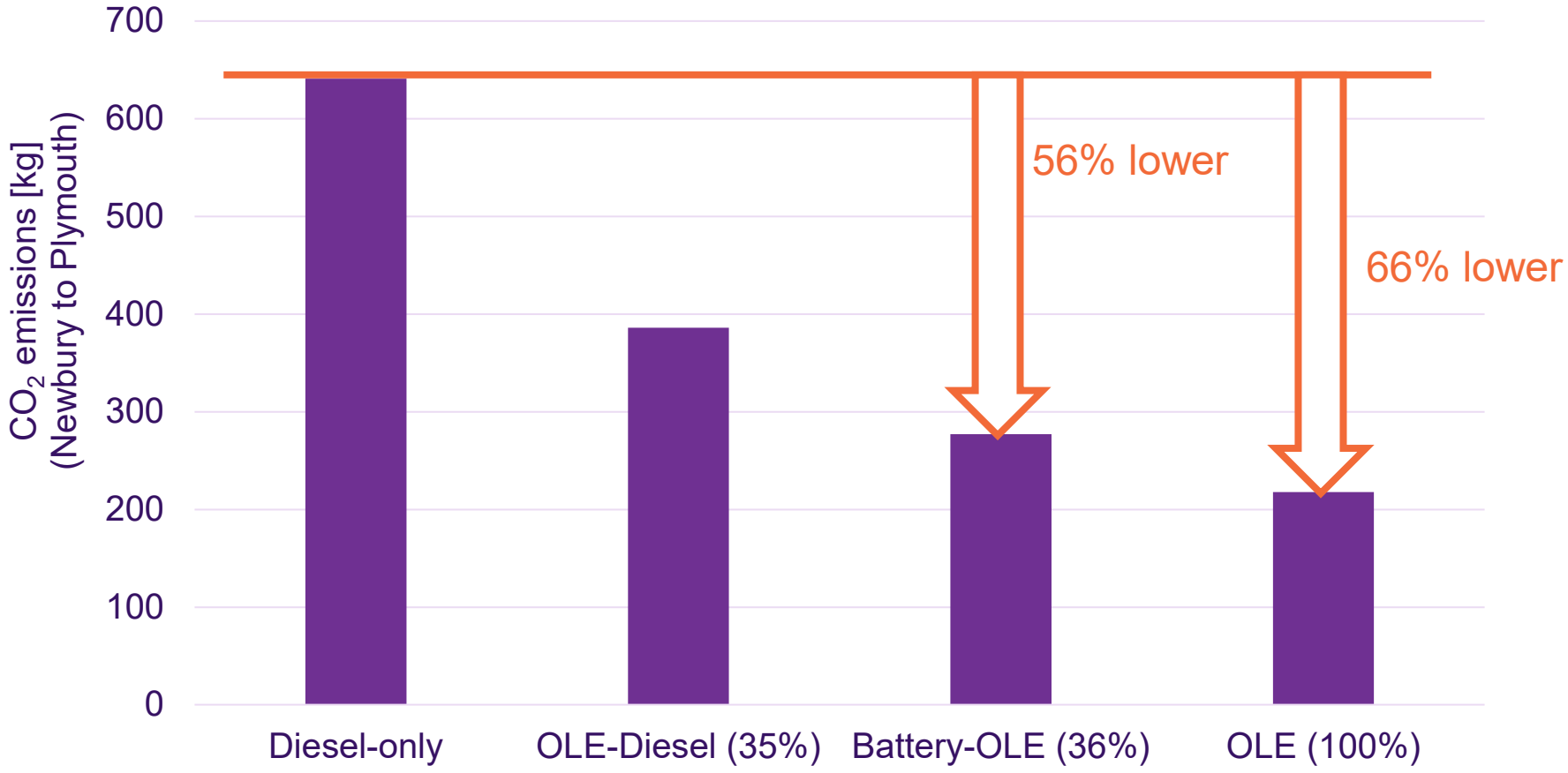

Conclusions

With ‘common-sense’ intermittent electrification:

- Battery weighs ~10 tonnes
- Battery will last ~6 years (if kept at 25°C)
- 56% lower CO_2 when compared to diesel for the same journey

Could be a viable route to full electrification …

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The carbon case for intermittent electrification

Detailed rail vehicle model development