What is the judicious mix?

David Shirres, Editor

RailEngineer

Minister’s challenge and industry response

February 2018 – Jo Johnson’s call

“I would like to see us take all diesel-only trains off the track by 2040”

“Alternative-fuel trains powered entirely by hydrogen are a prize on the horizon”

“I want to see options like lighter rolling stock and alternative sources of power considered and analysed”

July 2019 – Rail industry response

- Significant decarbonisation by 2050 can only be achieved with a judicious mix of electrification, battery and hydrogen technology
- The Traction Decarbonisation Network Strategy should identify preferred combinations of electrification, hydrogen and battery traction options. This will report in October 2020.

Minister's challenge and industry response

- Government rightly concerned at unacceptable electrification cost overruns
- (UK) Transport Minister convinced that innovative traction can avoid the need for costly and disruptive electrification
- He doesn't want to be told otherwise!
- So the producing an acceptable report with a 'Judicious mix' that 'follows the science' is a challenge

Written statement to Parliament

Rail update: bi-mode train technology

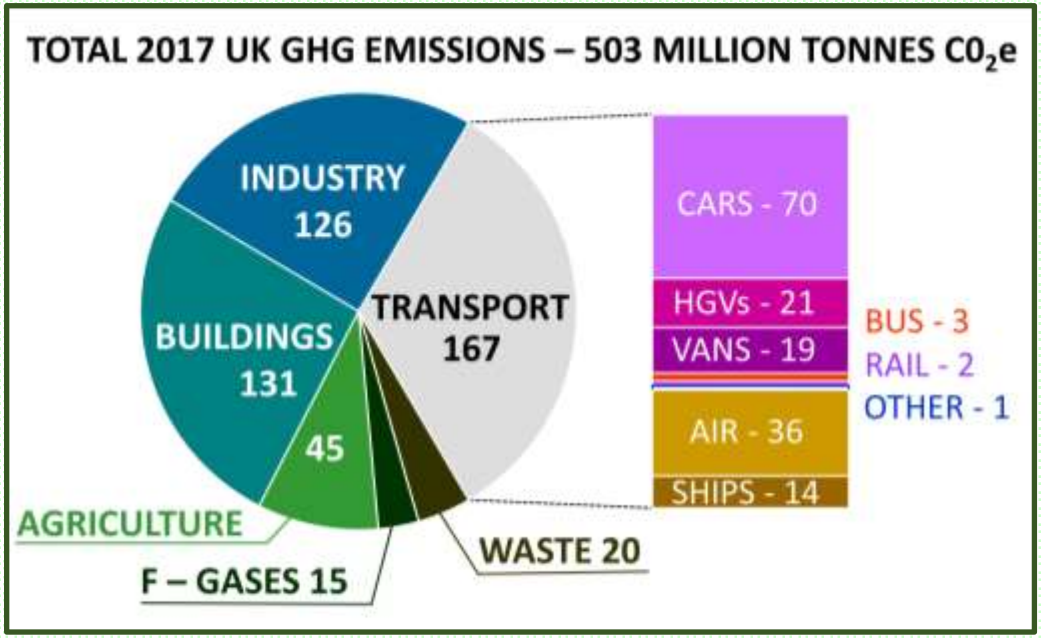
Modernising rail services and infrastructure on the Great Western Main Line, Midland Main Line and in the north.

Published 20 July 2017
From: Department for Transport and The Rt Hon Chris Grayling MP

"New bi-mode train technology offers seamless transfer from diesel power to electric that is undetectable to passengers. The industry is also developing alternative fuel trains, using battery and hydrogen power. This means that we no longer need to electrify every line to achieve the same significant improvements to journeys."

The big picture

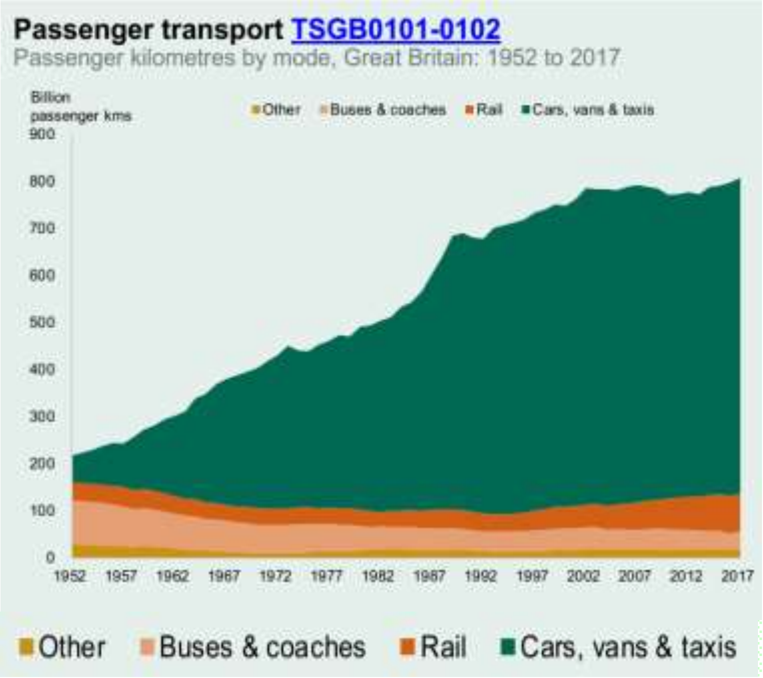
- Transport – 33% of problem and, perhaps, the most difficult challenge
- Rail is easiest to decarbonise as it has existing technology offering high-speed, high-powered transport that does not need fossil fuels
- Rail is only 1.2% of transport emissions and has lowest emissions per passenger/tonne mile
- Modal shift from road and air to rail could give emissions savings far greater than rail's total current emissions. This could be rail's greatest contribution to UK emission reduction.

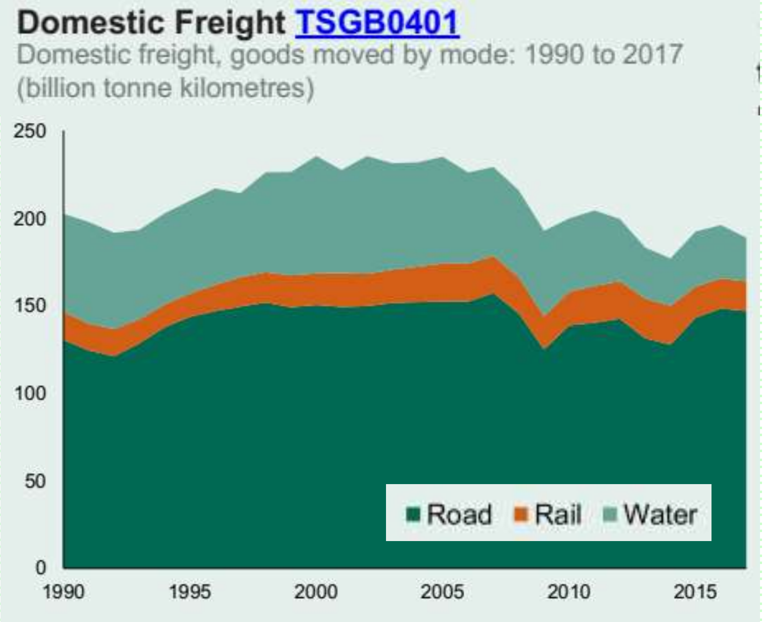


Modal share

UK Passenger transport 2018			
	Billion pass km	Emissions $MtCO_2e$	kg CO_2e /km
Car	678	70.7	**0.10**
Cycle	4.9	0	**0**
Bus / Coach	35	3.4	**0.10**
Rail	81	2.5	**0.03**
Air	9.4	1.5	**0.17**
Total	808	78.1	

UK Freight transport 2018			
	Billion tonne km	$MtCO_2e$	Kg CO_2e / tonne km
HGV	152	20.8	**0.28**
Van		19.4	
Rail	17	0.5	**0.03**
Total	169	40.7	





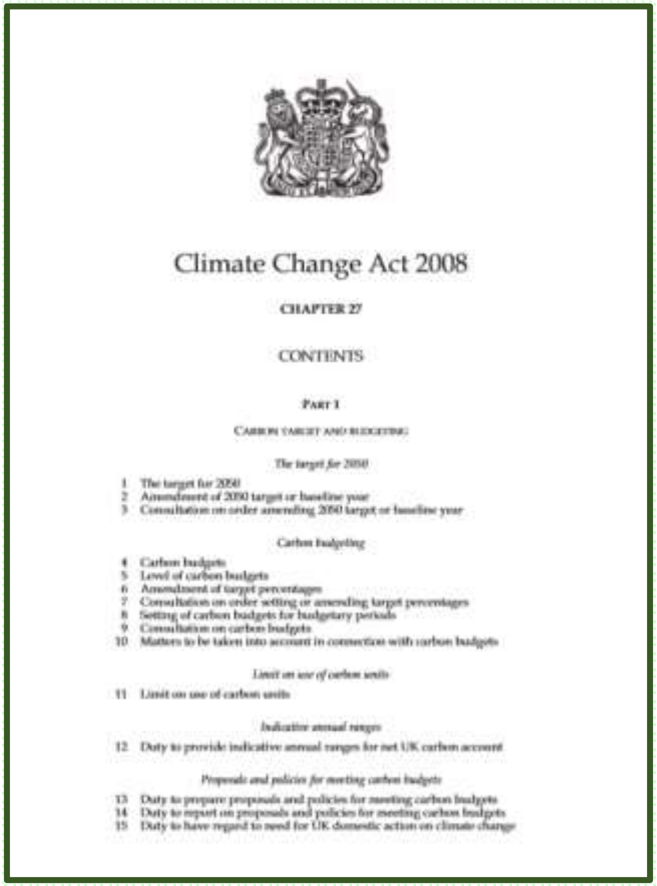
Modal shift – Rail's biggest contribution

UK Passenger transport 2018			Modal Shift to Rail: From Road - 5 %		From Air - 25% %	
	Billion pass km	Emissions $MtCO_2e$	Billion pass km	% traffic change	Emissions $MtCO_2e$	Change in emissions
Car	678	70.7	644	95%	67.2	-3.5
Cycle	4.9	0	4.9	100%	0.0	0
Bus / Coach	35	3.4	35	100%	3.4	0
Rail	81	2.5	117	145%	4.2	1.1
Air	9.4	1.5	7.1	75%	1.1	-0.4
Total	808	78.1	808		75.3	
				Passenger Modal shift saving		2.8

UK Freight transport 2018			5 % Modal Shift to Rail			
	Billion tonne km	$MtCO_2e$	Billion tonne km	% traffic change	Emissions $MtCO_2e$	Change in emissions
HGV	152	20.8	144	95%	38.2	-2.0
Van		19.4				
Rail	17	0.5	25	145%	0.7	0.2
Total	169	40.7	169		38.9	
				Freight Modal shift saving		1.8
				Total Modal shift saving		4.6

2008 Climate Change Act

- A world first
- 80% reduction of 1990 GHG emissions by 2050 – amended to net zero in June 2019
- Requires short term targets to be set and monitored
- Requires Government to set policies to ensure targets are met
- Established **Committee on Climate Change** to monitor progress and advise action required



Climate Change Act 2008

CHAPTER 27

CONTENTS

PART 1

CARBON TARGET AND BUDGETING

The target for 2050

Carbon budgeting

Limit on use of carbon units

Indicative annual ranges

Proposals and policies for meeting carbon budgets

"It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is 100% lower than the 1990 baseline"

CO2 reduction blueprint

Committee on Climate Change report published May 2019

"Net-zero is only credible if policies are introduced to match."

"The technologies and approaches that will deliver net-zero are now understood and can be implemented with strong leadership from government."

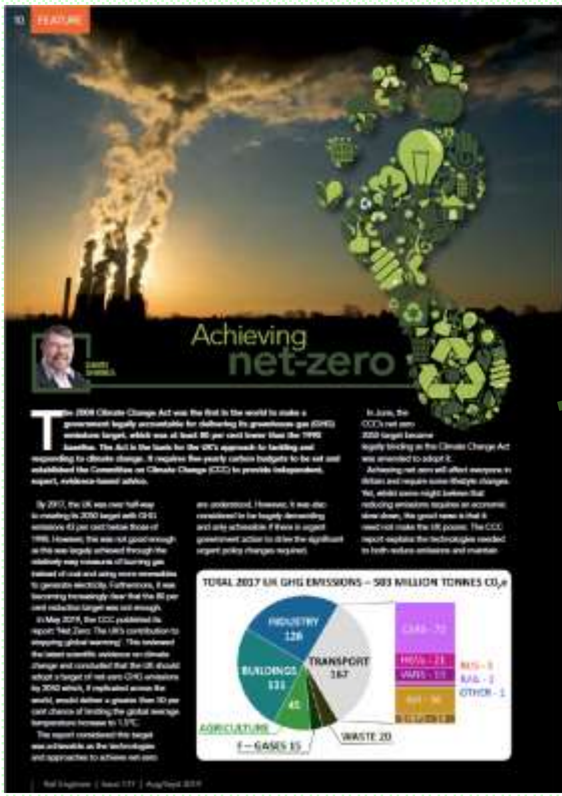
"HM Treasury should ensure the appropriate policy levers are in place to incentivise low-carbon initiatives."

CCC net-zero report

Main report – 277 pages

Technical report – 304 pages

Summary in Rail Engineer, September 2019


FEATURE

Achieving net-zero

TOTAL 2017 UK GHG EMISSIONS – 503 MILLION TONNES CO_2e

INDUSTRY 126

TRANSPORT 167

BUILDINGS

AGRICULTURE

F-GASES 15

WASTE 20

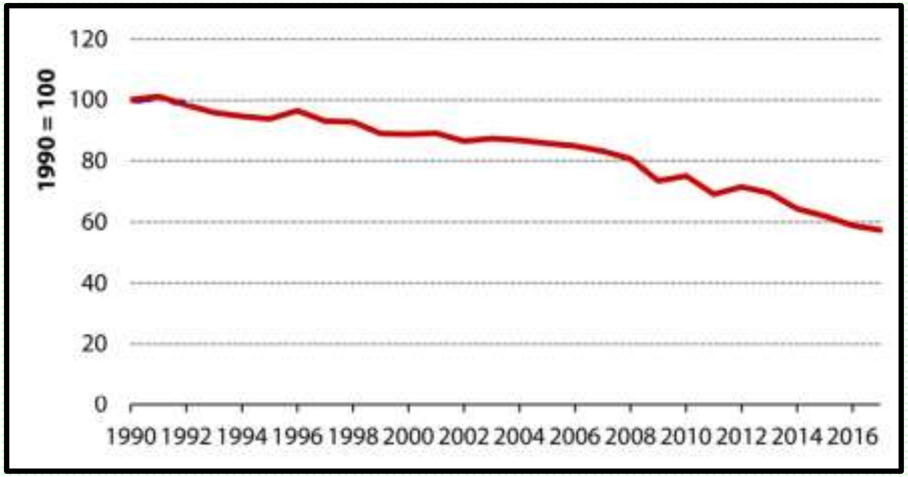
Electrify everything

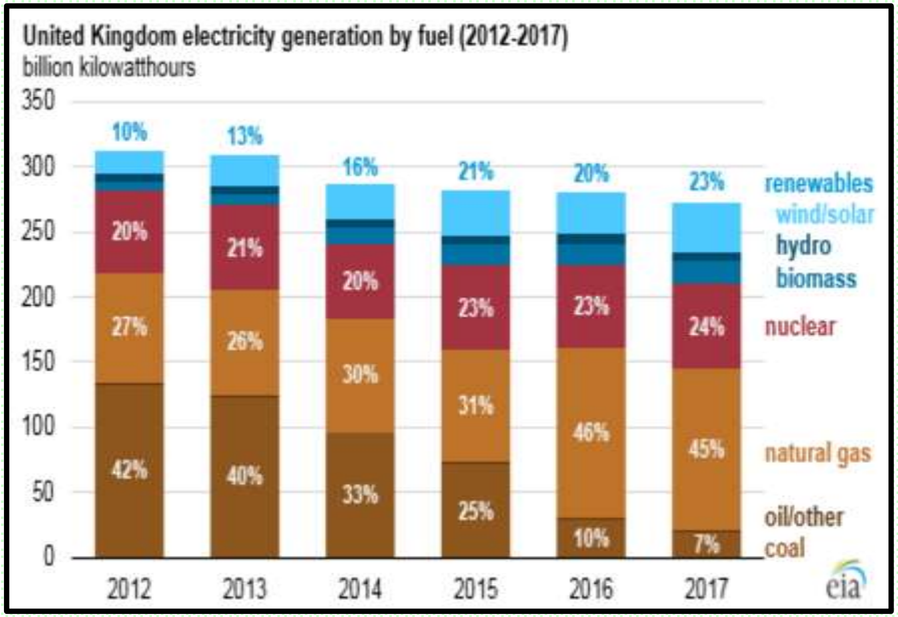
Modern world is utterly dependant on fossil fuels which have a high energy density and can be readily stored and transported.

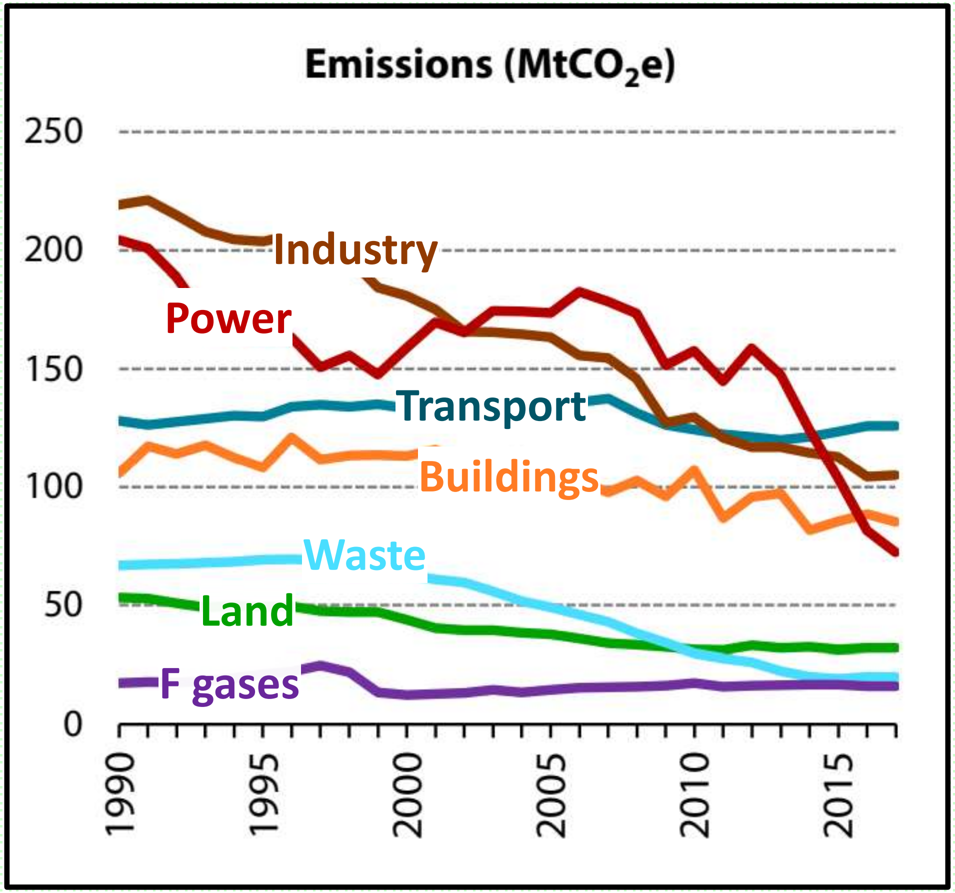
To achieve net zero we must be weaned off them. To do this, the **CCC report stresses the need for extensive electrification, particularly in respect of transport and heating**.

Electricity can also readily transport huge amounts of energy, albeit only to fixed locations. An exception to this is **electric trains, which are the only form of high-speed and mass transport that offers potentially zero emissions**. No doubt for this reason, the report recommends a rolling programme of railway electrification.

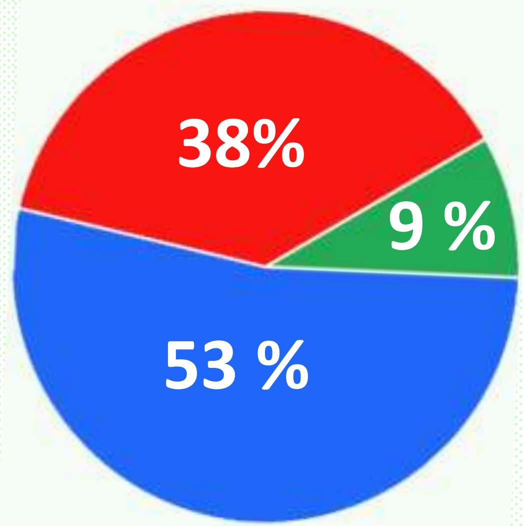
Progress to date







CCC net-zero report – lifestyle changes required



NONE - low carbon technologies and fuels not requiring societal or behavioural changes

ENTIRELY dependant on behavioural changes required e.g. less flights and consuming less meat / dairy products

MIX of new technologies and consumer changes, e.g. buy an electric car, install a heat pump

compare and contrast with


BBC Sign in News Sport Weather iPlayer Sounds

NEWS

Home UK World Business Politics Tech Science Health Family & Education

Science & Environment

Climate change: Big lifestyle changes are the only answer

By Justin Rowlatt
Chief Environment correspondent

11 October 2019

Share

Climate change

CCC net-zero report

	2020s	2030s - 2040s
ELECTRICITY	Largely decarbonise, Renewables, coal phase out	Expand system, decarbonise peak generation
HYDROGEN	Start production with CCS	Widespread industry deployment, HGVs
BUILDINGS	Heat networks, heat pumps	Widespread electrification, expand heat networks, hydrogen gas grids
ROAD TRANSPORT	Ramp up electric vehicles, HGV decisions	End sale petrol/diesel vehicles, Zero - emission fleets
INDUSTRY	Initial CCS clusters, efficiencies	Further CCS, widespread hydrogen use, electrification
LAND USE	Afforestation, peatland restoration	
AGRICULTURE	Healthier diets, reduced food waste, tree growing, low-carbon practices	
AVIATION	Operational measures, new plane efficiency, constrained demand, limited biofuels	
SHIPPING	Operational measures, new ship fuel efficiency, use of hydrogen/ammonia	
WASTE	Reduce waste, increase recycling	Limit emissions from combustion of non-bio waste
FRIDGE GASES	Move completely award from F-gases	
GREENHOUSE GAS REMOVALS	Develop options and policies	BECCS deployment, direct air capture of CO2
INFRASTRUCTURE	Industrial CCS clusters, expand vehicle charging and electric grid	Hydrogen for industry, more CCS, hydrogen/electric HGV infrastructure, expand electric grid

2018 UK energy flow chart (million tonnes oil equivalent)

INPUTS
284 mt

CONSUMPTION
151 mt

Oil refineries

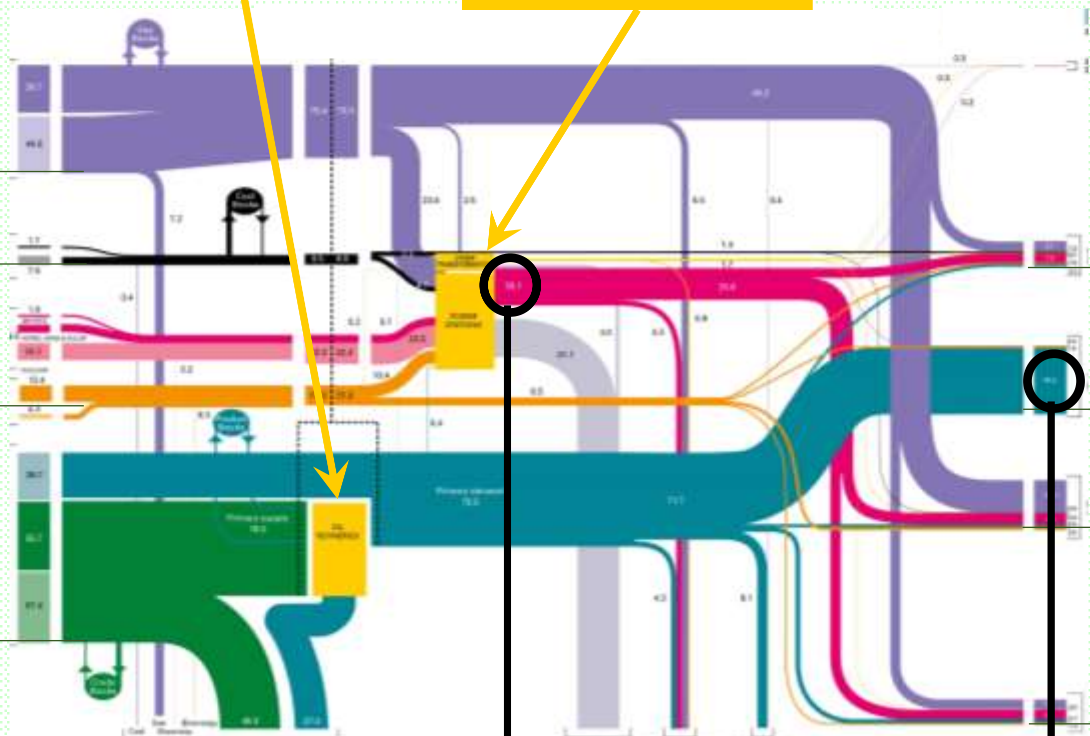
Power Stations

Natural Gas

Coal

Nuclear,
Renewables

Petroleum



Industry

Transport

Domestic

Other

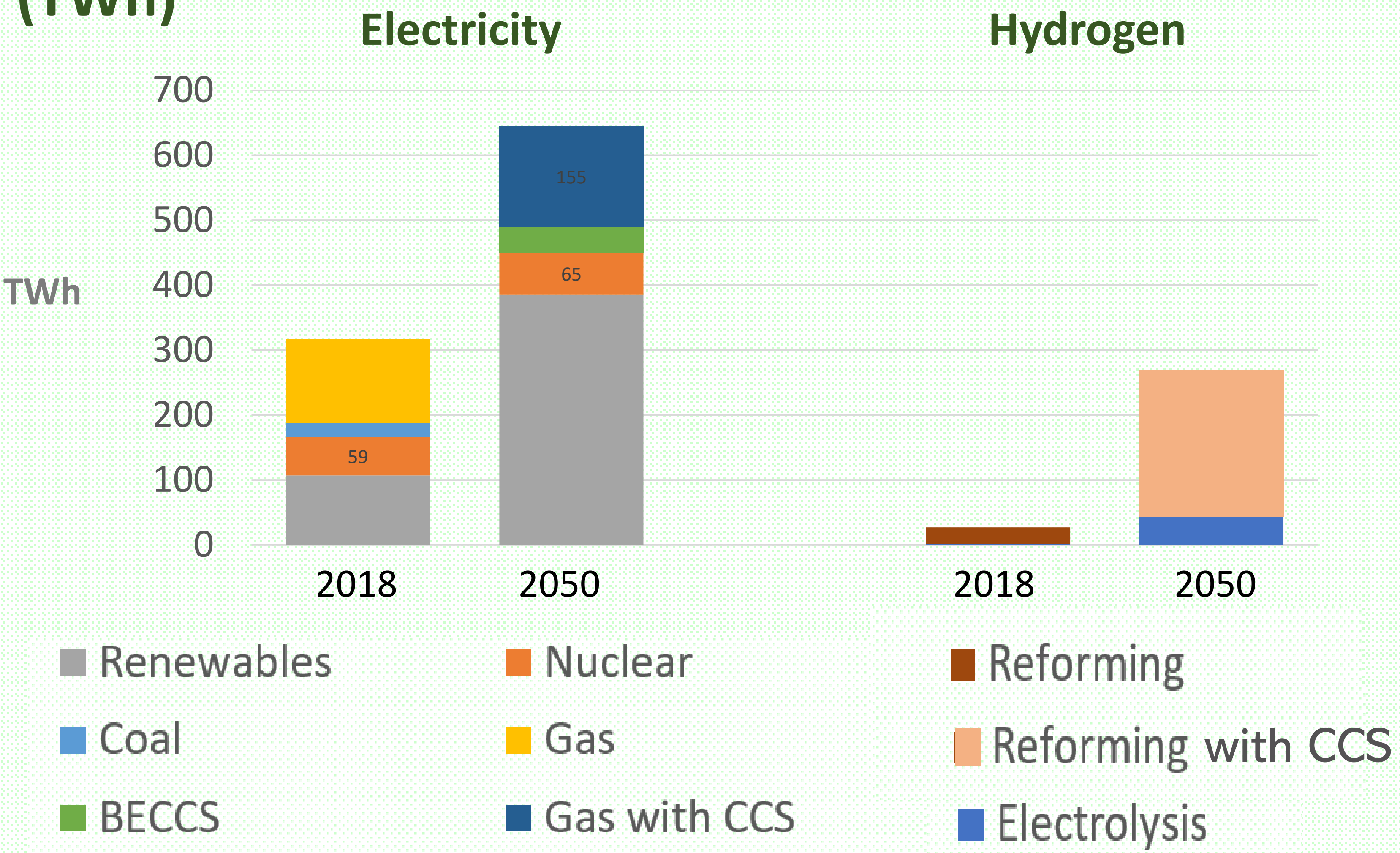
Exports, Marine bunkers

Losses

Electricity production = 30.1 mt

Petroleum for transport = 55.2 mt

CCC projected electricity and hydrogen consumption (TWh)

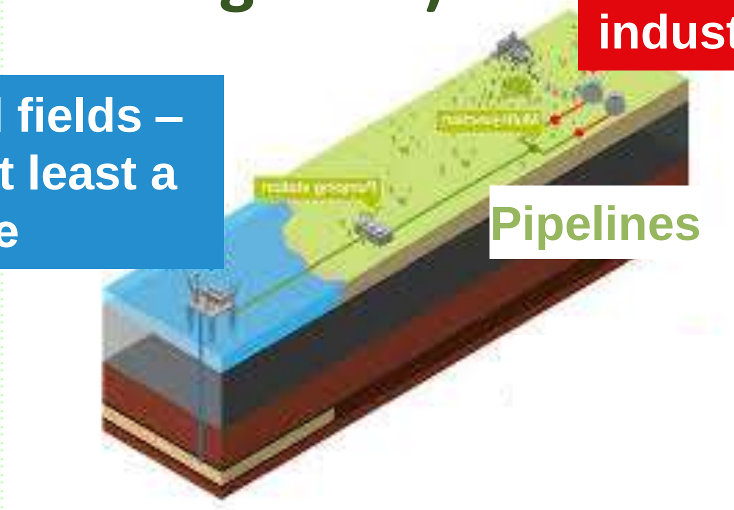


Hydrogen for transport: HGVs - 22 TWh, Buses - 3 TWh; Trains 0.3 TWh

CCC net-zero report – technologies

Carbon Capture and Storage CCS)

Storage in depleted oil fields – estimated to provide at least a hundred year's storage



Carbon capture from industrial processes

Pipelines

To achieve net-zero CO2 emissions UK will need to store 171 million tonnes of CO2 per year (i.e. 34% of current emissions)

Currently the UK has no carbon capture

2050 UK CCS requirement 171 Mt CO2e	
Power generation	57
Hydrogen production	46
Biofuels	44
Industry	24


If diesels are to be eliminated, what is the judicious mix?

- Power, range, efficiency and cost of each type of traction
- What does each type of rail service require


Electrification

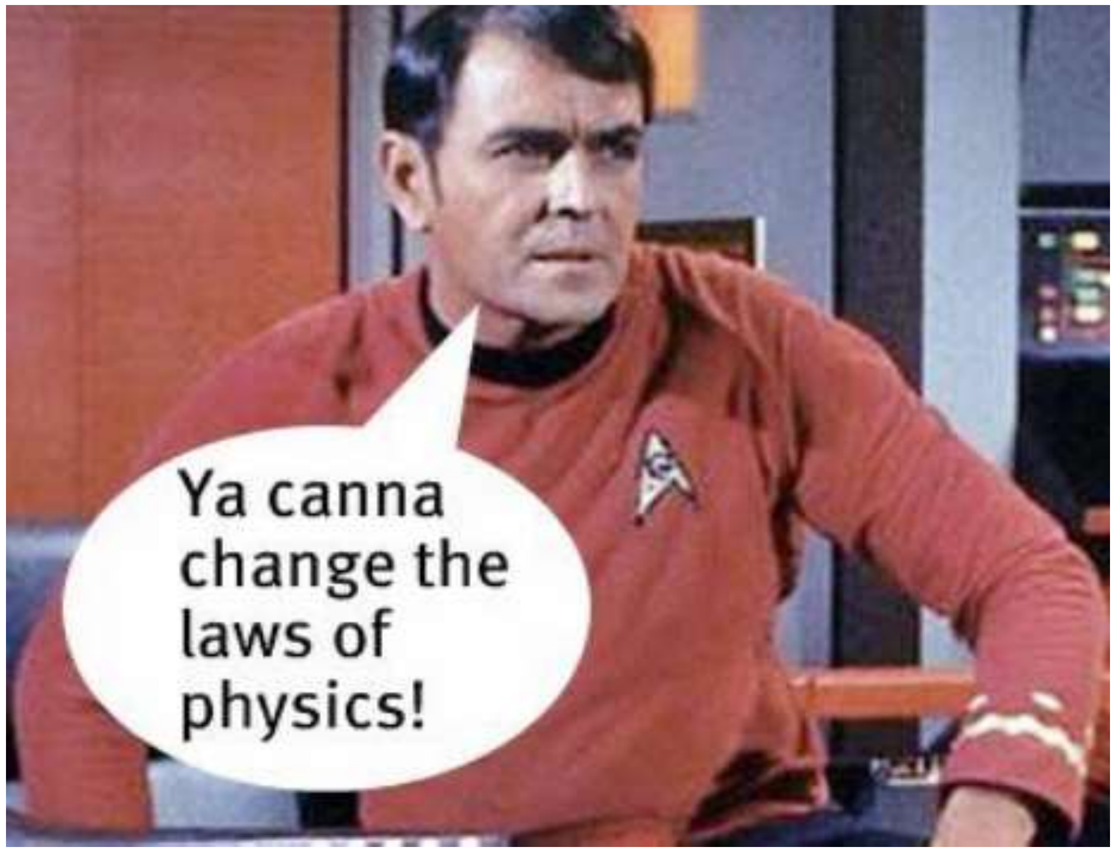
Electrification and the First law of thermodynamics

- **The First Law -** Energy can neither be created nor destroyed; energy can only be transferred or changed from one form to another.
- Most vehicles convert chemical or electrical energy into kinetic energy to make them move. Their power and range is limited by the amount of energy they can store.
- The challenge for decarbonisation is that nothing comes close to amount of energy in fossil fuels. Hydrogen and batteries have about 14% and 7% the energy density of diesel
- Electric trains get around this limitation as they can receive a very large amount of energy whilst in motion. Thus they are unique in offering high-speed passenger and heavy freight transport with potentially net-zero carbon emissions

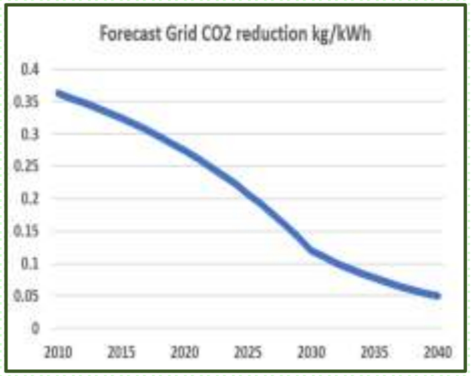
Electrification and the First law of thermodynamics

- **The First Law -** Energy can neither be created nor destroyed; energy can o … n to another.
- A vehicle's k … ical energy. The … by the amount …
- The challeng … close to amount o … es have about …
- Electric trai … they can receive … hus they are uni … transport w …

Captain Montgomery Scott born Linlithgow, 2222



Electric trains – carbon emissions



		2013-14	2018-19
Passenger CO_2e emissions (ktonnes)	Diesel	1431	1394
	Electric	1483	1071
	Total	2914	2465
Freight CO_2e emissions (ktonnes)	Diesel	586	454
	Electric	35	22
	Total	621	476
Grand Total		3535	2941

Comparison diesel and electric passenger vehicles			
Number passenger vehicles	Diesel	3904	3800
	Electric	8751	11,000
Average CO_2e per vehicle (tonnes)	Diesel	0.37	0.37
	Electric	0.17	0.10
Carbon intensity of the grid (grams/kWh)		461	204
Diesel to Electric CO_2 emission ratio		2.2	3.7

Electric trains - performance

- Power limited only by current through pantograph (max 300 amps @ 25kV = 7.5 MW)
- High efficiency. Self powered trains have power plants with unavoidable energy losses

Modal shift requires high performance trains yet:

- Acceleration not mentioned in rail decarbonisation report which categorised trains by speed
- "Electric trains not needed for a low-speed trains" DFT official

Significant passenger benefits from increased acceleration

Acceleration from 0 to 60 mph before and after EGIP:

Class 170 DMU – 100 secs
Class 385 EMU – 40 secs

Grayling defends Cardiff-Swansea electrification cancellation

Mr Grayling said the scheme would have enabled "the same trains to travel on the same track, at the same speed, at the same timetable".

He misled parliament as electric trains save four minutes by faster acceleration from the route's four stops

Electric trains

Costs

Significant capital costs

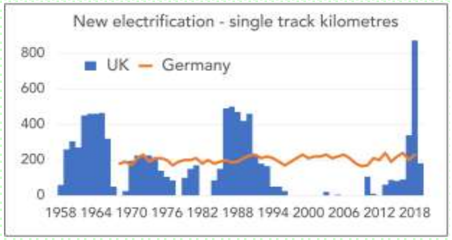
Government and DfT understandably concerned at recent cost overruns e.g. GW scheme cost rose from £1.6 to £2.6 billion

RIA report explains why and shows how electrification can and is now being delivered in a cost effective manner.

GW cost £2.2 million per single track km

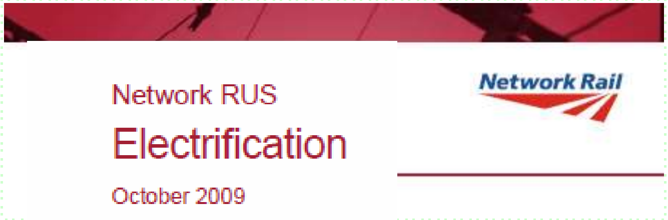
Recent Scottish schemes are half this cost.

Key cost factor is historic stop start nature of UK electrification



Benefits

Higher performance trains attract more passengers



Maintenance, Fuel, Track wear and lease cost savings are around £2 to £3 million per passenger vehicle

Typical operating costs

	Diesel car	Electric car
Maintenance per mile	60p	40p
Fuel per mile	47p	26p
Lease per annum	£110,000	£90,000
Track wear per mile	9.8 p	8.5p

No harmful particulate pollution

Potential zero-carbon emissions – investment appraisals do not currently considered this

Bi-mode trains

Diesel bi-mode trains

- Much less power in diesel mode than in electric mode
- LNER class 800/1 in diesel mode have less power than HSTs they replace.

	Weight	Power (MW)		Kw/tonne	
Train	tonnes	Diesel (A)	Electric	Diesel	Electric
9 car HST	**445**	**3.0**		**6.7**	
9 car Azuma	**438**	**2.5**	**4.5**	**5.7**	**10.3**
A. Assumes 10% for auxiliaries and hotel load, not an issue for electric trains					

Carbon pros and cons	
Reduced diesel running under wires – Class 800/1 units on London to Inverness route have 33% CO2 emissions of the HSTs they replace.	9 coach unit has 5 engines weighing 7 tonnes each (8% weight of train). This incurs a significant carbon cost over the train's lifetime
Traction flexibility facilitates a rolling programme of electrification	With their diesel engines, they cannot be part of a zero-carbon railway

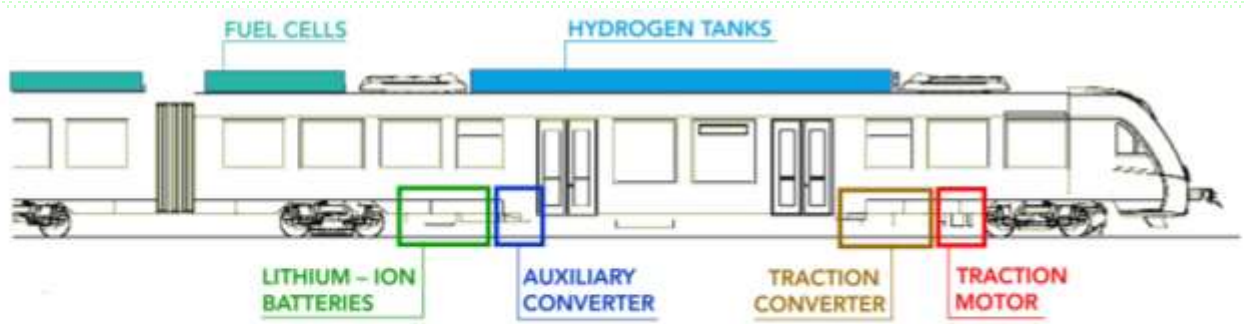
Hydrogen

Hydrogen trains - development

July 2012 – Birmingham University's Hydrogen loco with 1kW fuel cell at the IMechE's Railway Challenge

Fuel cells	2001	2011
Power (kW)	25	33
Mass (kg)	290	75
Volume (L)	365	125
Efficiency %	c42	c52

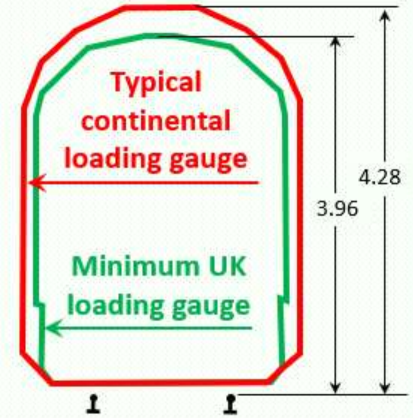
September 2018 - Alstom 2-car unit hydrogen iLint enters service in Germany.
Tanks hold 178 kg hydrogen @ 350 bar to give ~700 km range; Max speed 140 km/hr; A hydrogen / battery hybrid; each car's has 200 kW fuel cell and 22kW traction battery.
Peak power to weight ration 7.9 kW/tonne (25% more than class 170)



January 2019 - Alstom announce their hydrogen Breeze concept with a 1,000 km range. Due to UK loading gauge hydrogen tanks inside train

Hydrogen trains – energy storage and efficiency

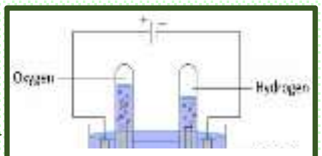
Substance	By volume (MJ/L)	By weight (MJ/kg)
Uranium	1,500,000	80,620,000
Diesel	35.8	48.0
Hydrogen (at 350 bar)	**4.6**	**71**
Lithium-ion battery	2.6	0.9

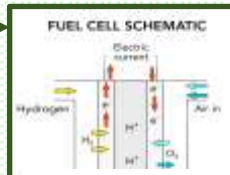


Energy Storage	Total kg	kg / KWh	MWh	Coaches	MWh / coach
Alstom iLint - 2 x 89 kg H_2 at 350 bar	178	71	12.6	2	6.3
Inter city HST - 2 x 3741 litres diesel	6225	48	299	9	33.2

Efficiency - on site hydrogen production from renewable energy

Electricity from grid 3.4 kW → **Electrolysis** → **Compress to 350 bar** → **Fuel Cell** → **Converter and Drive** → **Wheel 1.0 kW**





Efficiency 68% 94% 52% 89% **Overall 29%**

Hydrogen in Aberdeen

Busiest hydrogen refuelling station in Europe

£1 million hydrogen production and refuelling station consisted of:

- 3 x Hydrogenics electrolysers (each size of 40ft container
- 2 x hydrogen compressors
- 2 x hydrogen dispensers
- & hydrogen storage, control systems and cooling plant

Required a 1 MW electricity supply for an installed capacity of 300 kg/day (actual requirement 150 kg/day), 99.9% availability achieved since 2015

Fleet of 10 hydrogen buses
Total cost of ownership £169,000 per bus per year, comparable with battery buses but £62,000 more than diesel buses

Conclusions:

- Electrolyser plants are a mature and reliable technology which can easily be scaled up
- CAPEX prices will continue to decrease
- Provides opportunities for grid balancing

Hydrogen supply

Almost all hydrogen currently produced from methane gas (reforming) so has CO_2 emissions. This requires a large chemical plant and distribution infrastructure

Rail decarbonisation report expresses concerns about decisions on a national infrastructure being at least five years off.

Yet Aberdeen bus trial demonstrates transport operators can source their own green hydrogen from electrolysis using surplus overnight wind power. Such plants offer future synergies with hydrogen powered road vehicles.

Aberdeen's buses required 150 kg of hydrogen per day, A fleet of 10 hydrogen trains would require ten times this.

A hydrogen plant to service these trains would thus cost circa £15 million and require a 10 MW supply.

It is likely that the train manufacturer would provide and operate such plants for the operator.

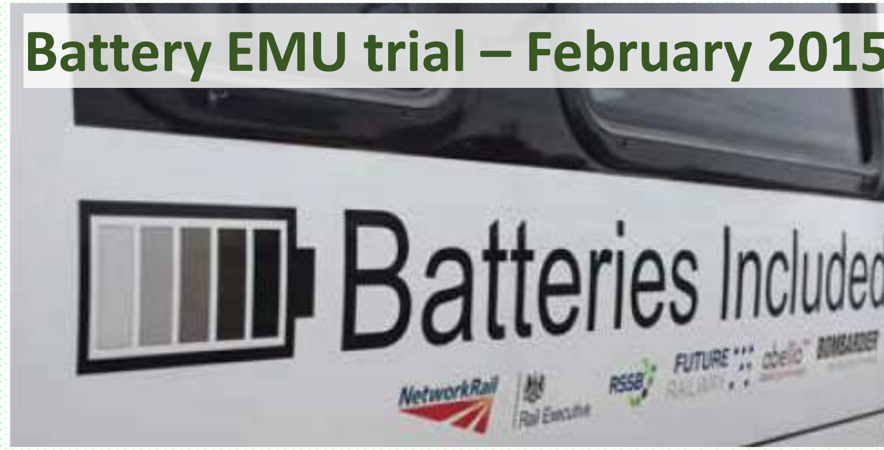
With a range of 1,000 km, hydrogen trains on rural Scottish routes could be fuelled from hydrogen plants in Glasgow and Inverness


Batteries Included

Battery trains

2019 - Hitachi in talks with LNER to replace Azuma diesel power pack with batteries for short distance services off the wires e.g. 17 miles off wire to Lincoln

Battery EMU trial – February 2015



- Trial in East Anglia showed potential for Battery powered EMUs to operate on branch lines off the electrified network
- Unit had an eight tonne traction battery
- Achieved out and back range of 24 miles with DMU-like acceleration off the wire

- Unlikely to offer EMU-like acceleration
- Battery packs have 2.5 % the energy density of diesel (1.0 vs 39 MJ/litre) - UK automotive council expect this to improve but not dramatically, maybe double by 2035
- Batteries are costly and may get more expensive (over a billion cars needing batteries!)
- Producing and recycling batteries uses rare materials and has high environmental costs

Battery powered EMUs could operate branch lines off electrified lines

Getting to net zero – the role of each type of traction

	Transition to NZR	**Net zero railway (NZR)**
Battery	As for NZR, also cover gaps to facilitate a rolling electrification programme	Branch line and battery / electric bi-modes on inter-city spurs Last mile running for freight locos
Hydrogen	As for NZR	Passenger services that do not require high speed, long distance or frequent acceleration.
Diesel bi-mode	No diesel running under the wire. Facilitates a rolling electrification programme	No role
Dual fuel	Lower emissions if engines burn LNG & diesel	No role
Electric trains	As for NZR	Passenger services that require high-speed or frequent acceleration (e.g. commuter services). Only solution for Freight

How much electrification is required?

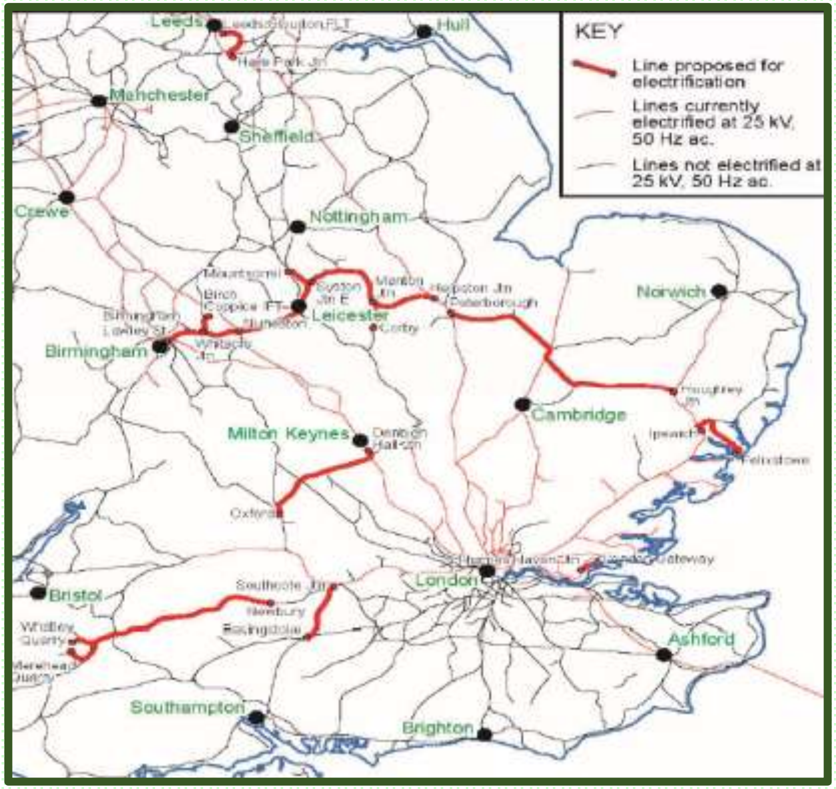
Rail Engineer feature analysed all unelectrified lines to consider what type of traction can operate the service if diesel traction was eliminated and current performance was to be maintained?

Suitability of each type of traction for a net zero railway

Passenger service types		Traction Type
Inter-City core	Routes connecting London to other cities, NE/SW cross country services, Trans Pennine services	Electric
Inter-City secondary	Unelectrified lines on routes to towns and cities with a direct service to London, internal Scottish inter-city	Electric, possible battery on branches
Commuter	High frequency services into London and other cities	Electric
Freight	Significant freight flow on any route deemed to require electric traction. Freight only routes identified	Electric
Cross Country	Long distance services connecting town and cities that are not Inter-City	Electric / hydrogen
Urban	Populated area with no significant commuter flow	Electric / hydrogen
Rural	Mainly sparsely populated area	Electric / hydrogen
Branch lines	Spurs to main lines that do not have through services onto the main line	Electric / batteries

And not forgetting rail freight

- Accounts for 29% of UK rail diesel CO_2 emissions
- Currently electric locomotives constitute 17% of the freight locomotive fleet
- CILT Rail Freight Forum has concluded that 500 km of electrification would enable 66-75% of freight traffic to be electrically hauled



- Other useful freight routes (G&SW, Settle and Carlisle) considered to be definite electrification requirements
- Rail freight and yellow plant on routes not suitable for electrification will require carbon offsets

Rail is only sector with a decarbonisation heavy freight solution

Considering passenger traction on a net zero railway

174 non-electrified service tables in National Rail Timetable analysed

1. Record data:

   Unelectrified mileage; Frequency (tph); Service type; to London (Y/N); Freight route (Y/N); To and From and Route

	A	B	C	D	E	F	G	H	I
1	Table No	Miles	Frequency tph	Service type	To London	Freight route			Route
2	10	16.75	1	Branch			Marks Tay	Sudbury	self contained
3	13	12.25	1	Rural		Priority	Felixstowe	Ipswich	
4	13	45.5	1	Rural			Westefield	Lowestoft	
5	14	39	1	Cross Country		Priority	Stowmarket	Ely	East Anglia-Midlands
6	14	19.5	1	Rural			Kennet	Cambridge Ely	
7	15	18.25	1	Rural			Norwich	Great Yarmouth	
8	15	17.75	1	Rural			Brundhall	Lowestoft	
9	15	8	0.25	Rural			Reedham	Great Yarmouth	
10	16	30.5	1	Rural			Brundhall Garde	Sheringham	

Electrification requirement

1. Definite priority 1
2. Definite priority 2
3. Possible
4. Unlikely
5. Never

2. Analyse data to assess:

   a) Electrification requirement in a net zero carbon railway from traction characteristics

   b) Annual thousand vehicles miles timetable data and assumed number of coaches

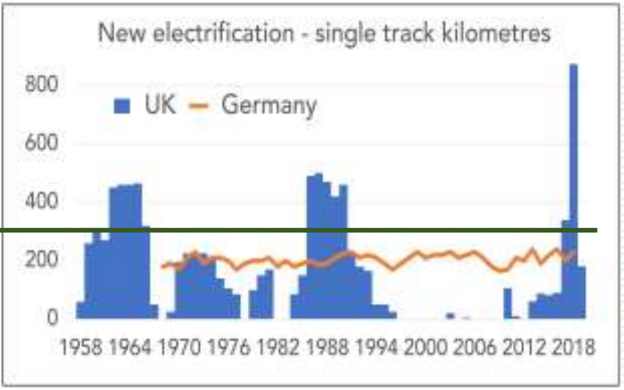
	A	B	C	F	G	H	K	L	N	O	P	Q
1	Table No	Electrification requirement	Miles	Frequency tph	Coaches	vehicle miles thousand	Service type	Route	To London	Freight route	From	To
2	115	1 Definite P1	58.75	3	4	4351	Commuter	Chiltern			Wembley	Kings Sutton
3	114	1 Definite P1	40.5	2	4	1999	Commuter	Chiltern			Marylebone	Aylesbury Parkway
4	116	1 Definite P1	11.75	1	4	290	Commuter	Chiltern			Oxford	Bicester Village
5	184	1 Definite P1	25	1	4	617	Commuter	London to Uckfield	Y		Hurst Green	Uckfield
6	78	1 Definite P1	7.75	2	4	383	Commuter	Manchester			Rose Hill Marp	Guide Bridge
7	78	1 Definite P1	6.25	2	4	309	Commuter	Manchester			Romiley	Ashburys
8	78	1 Definite P1	5.25	1	4	130	Commuter	Manchester			Chinley	Romiley
9	82	1 Definite P1	6.5	2	3	241	Commuter	Manchester			Lostock Jnc	Wigan NW

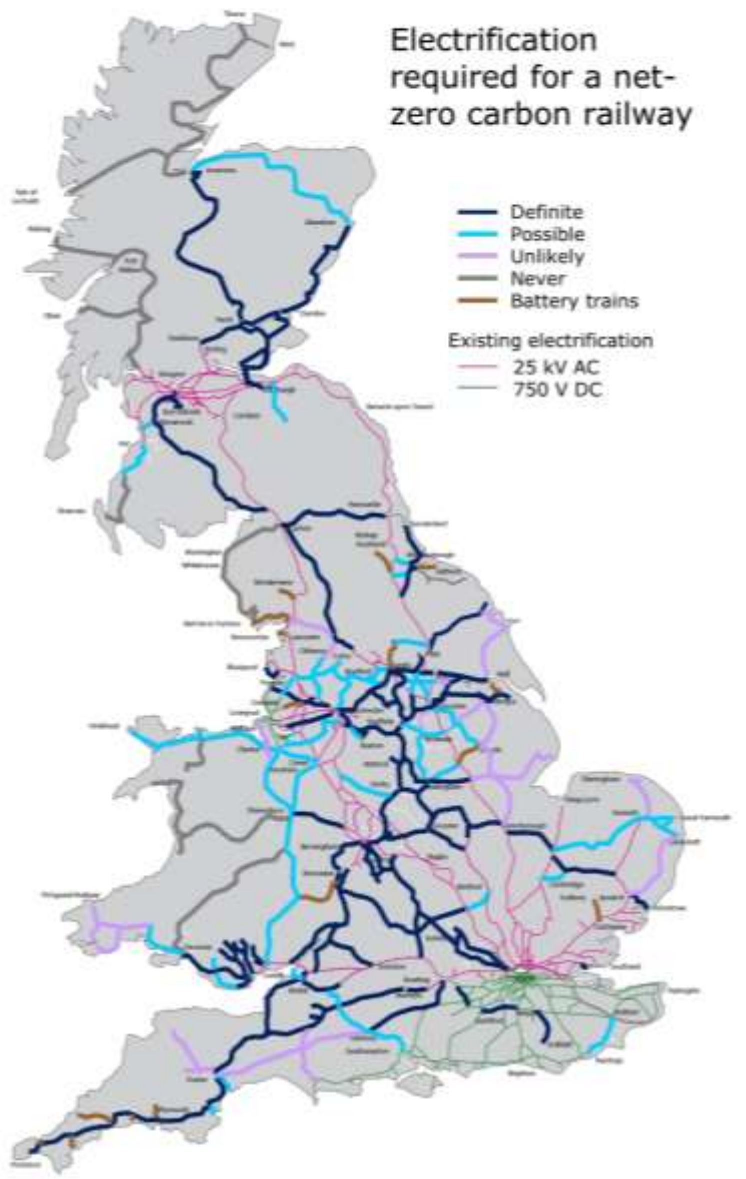
The judicious mix

Table 1 – Electrification requirement (route kilometres)						
Route type	Route km	Definite	Possible	Unlikely	Never	Battery
Branch lines	139	0	5	0	0	134
Commuter	751	751	0	0	0	0
Cross Country	900	426	428	0	0	46
Freight only	140	140	0	0	0	0
Inter City Core	1505	1505	0	0	0	0
Inter City Extension	1318	859	179	143	0	136
Rural	3645	299	1034	884	1401	27
Urban	722	348	317	8	0	49
Total	9120	4327	1963	1036	1401	393
Percentage		47.4%	21.5%	11.4%	15.4%	4.3%
Freight routes included	950	950	0	0	0	0

Definite and possible scenarios indicate that between 4,327 and 5,993 route kilometres is required. Definite scenario is very similar to the 4,250 figure in the decarbonisation report

Electrifying 4,327 route km by 2050 would require a programme of 144 route km, say 300 stk, per year.





The judicious mix

The contribution of each type of traction is related to the traffic it powers. The analysis concluded that the percentage of passenger traffic on unelectrified lines is:

Table 2. Estimated passenger traffic percentage for each electrification scenario

Route type	Total	Definite	Possible	Unlikely	Never	Battery
Branch lines	0.8	0	0	0	0	0.8
Commuter	12.3	12.3	0	0	0	0
Cross Country	8.7	3.7	4.5	0	0	0.5
Inter City Core	39.0	39.0	0	0	0	0.0
Inter City Extension	15.8	11.5	2.8	0.6	0	1.0
Rural	16.0	1.9	7.1	3.6	3.3	0.1
Urban	7.5	3.3	3.9	0	0	0.3
Total	100	71.7	18.2	4.2	3.3	2.6

Percentage contribution of each type of traction – range is between definite and possible scenarios

	Electric		Hydrogen		Battery	
	Max	Min	Max	Min	Max	Min
Passenger	90	72	26	8	3	0
Freight	80	70	0	0	0	0
Overall	87	71	18	5	2	0

Total current passenger and freight emissions of 1361 and 554 Mt C02 used to determine overall contribution

The judicious mix

The contribution of each type of traction is related to the traffic it powers. The

The role of each type of traction depends on emerging cost and performance of Hydrogen and Battery traction as well as cost savings achieved by a long term electrification programme and Treasury decarbonisation incentives.

On currently unelectrified lines, carbon emission reduction contribution for each traction type is estimated to be:

Electrification	73 to 86%	Only high powered zero carbon traction
Hydrogen	5 to 18%	Only alternative to electrification for medium range. Has performance limitations
Battery	0 to 2%	Short distances only. Electrification / Hydrogen could be best solution

Assessing the end game is the easy bit

TDNS will provide a map of traction to be used and a deployment programme. It also has the much harder job of developing a transitional strategy

The strategy is considering:

- Carbon reduction
- Modal shift
- Passenger and Freight user benefits
- Cost efficiency, reduced operating costs
- Air Quality
- Wider economic benefits of investing in green technologies

A rolling decarbonisation programme

TDNS will also provide a whole life regional / network model capturing all capital and operational costs for each traction type. It will be sufficient flexible to accommodation current unknowns (e.g. cost, programme and technology)

This will provide:

- A decarbonisation map
- NR Regions with a strategic document to guide the development of their infrastructure programmes.
- Those buying and manufacturing trains the confidence to invest money in the required technology
- Information about future train operating requirements
- Guidance on retrofit opportunities
- A link to decarbonisation development in other transport sectors

A rolling decarbonisation programme

Spreadsheet from Rail Engineer analysis shared with TDNS team who advised that it was "broadly in line" with emerging TDNS conclusions

50 FEATURE

DAVID SHIRRES

Respond, Rebuild, Revive and Renew

Andrew Haines considers a post-Covid railway

Network Rail chief executive Andrew Haines holds round-table briefings with the editors of the rail industry's press, including Rail Engineer and sister publication RailStaff, every six months or so.

On 8 June, thanks to the Covid-19 lockdown, no table was in evidence and instead everyone logged into Zoom. Andrew Haines spoke for about 15 minutes, then opened the sessions up to questions from those attending. It was a far-reaching session, and gave Andrew the chance to explain how he felt the four phases of Covid-19's had affected and would still have an impact on the rail industry. In doing so, he used the four 'R' words.

Respond

Andrew Haines considers that the railways have responded very well to the Covid-19 crisis and is

Andrew Haines confirmed that Traction Decarbonisation Network Strategy will be presented to DfT in July.
Hope is that this will result in an extensive electrification programme. He senses Ministers are taking it very seriously.

Conclusions

1. It will only be possible to achieve net-zero carbon on the UK rail network by 2050, if there is net-zero carbon electricity.
2. A net-zero rail network requires a large rolling programme of about 200 route kilometres a year up to 2050.
3. It is currently not possible to specify the amount of electrification required due to current unknowns. These will be assessed in the ongoing development of the TDNS. For now there are clear definite electrification requirements.
4. Unless there are financial incentives to invest and use low-carbon technologies, such as rail electrification, the Government's net zero target is unlikely to be achieved.

And the Judicious Mix?

After 21 months, Government now seems about to accept that it is a lot of electrification, some hydrogen and a dash of batteries

Thanks for your attention