Re-opening the Buxton-Matlock line: A comparative CO2 assessment

Commercial in Confidence

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Introduction

A rail route between Matlock and Buxton was first opened in 1863. After carrying tourists and freight on the important Midland line between London and Manchester for over 100 years, the line was closed in 1968 by the then Minister for Transport, Barbara Castle.

Since then, the line has left a gap in the transport routes between the Midlands and the North West, as well as limiting access routes to the Peak District, which despite being the most visited National Park in the world, remains one of the least accessible in terms of public transport.

Since 1987, the heritage group Peak Rail has reopened parts of the line, initially from Darley Dale to Matlock Riverside, then via various extensions to its current route between Rowsley and Matlock in 2011. Peak Rail operates a heritage service of diesel and steam trains.

Numerous proposals for the full reopening of the route have been made, and Derbyshire County Council has promised to retain the trackbed in case of future reinstatement. In 2004 a proposal for the reopening of the line was assessed by consultancy company Scott Wilson. The resulting report [1] concluded that the study "was not able to attribute to the route any financial benefits arising from the additional overall rail network capacity, which the link would create". However, it did highlight the future potential for the route, stating that "all the economic forecasts indicate that a railway operating in the latter years of the study period (2025 onwards) would have a much better financial profile than one opening in 2011 or soon after".

The MEMRAP (Manchester and East Midlands Rail Action Partnership) group was established in 2018 with the aim of building a case for the reopening of the line. The group believes that doing so would result in a reduction in Carbon Dioxide (CO_2) emissions due to modal shift from passenger road to passenger rail journeys, as well as due to a reduction in freight transport distance. MEMRAP believes that the results of the 2004 Scott Wilson report are overly conservative and are no longer economically or environmentally accurate.

The University of Derby Institute for Innovation in Sustainable Engineering has carried out an initial study of potential CO_2 reductions achievable through the reopening of the Buxton to Matlock line, the results of which are given in this report. It should be noted that this is a CO_2 emission study, not an economic study as the aforementioned Scott Wilson report was.

Report format

This report is made up of 3 main sections, preceded by this introduction and a description of the work to be carried out, and followed by conclusions and additional information contained in appendices. Section 1 describes the MEMRAP route in comparison to existing routes, and defines the cases studied in this project. Section 2 includes details of the transport modes compared, including carbon dioxide (CO_2) emissions and passenger capacity. Section 3 contains the results of the comparative CO_2 across the Freight, Commuting, Leisure and Airport cases studied.

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Description of Work

The aim of this work is to study the potential changes in CO_2 emissions which could be expected if the MEMRAP proposal was adopted and the Buxton to Matlock rail line re-opened. In order to present a balanced view of the resulting emission changes, calculations were carried out to ascertain the levels of CO_2 emitted by a journey using the current method, and of the same journey carried out in the proposed MEMRAP case.

Comparative studies were carried out across four cases: Freight, Commuting, Leisure and Airport trips. The current and MEMRAP journeys in each case are given in Table 1, followed by a more detailed explanation of each case.

Case	Current		MEMRAP
Freight			
Hindlow to Handsacre	Hope Valley rail route		MEMRAP Rail route
Commuting			
Derby to Manchester	Car (Small, 2 passengers)		MEMRAP Rail route
Leicester to Manchester			
London to Buxton			
Leisure			
Cromford to Bakewell	Car (SUV, 2 passengers)		MEMRAP Rail route
Nottingham to Bakewell			
Leicester to Buxton			
Airport (Manchester)			
Derby to Airport	Car (Small, 2 passengers)	Existing rail route	MEMRAP Rail route
Leicester to Airport			
Nottingham to Airport			

Table 1: Details of the current and MEMRAP proposed journeys used for comparative CO_2 emission calculations.

Freight

Freight journeys were calculated from the Tarmac Hindlow Quarry, near Buxton, to Handsacre in Staffordshire. The starting point was selected as the Tarmac operations in the Peak District are the source of a significant volume of the freight transported by rail in the region. Products from all Tarmac sites in the area pass through the Hindlow site before continuing on their journey, making this an obvious start point for the comparative study. Handsacre was selected as the end point as it is the starting point for the new HS2 high-speed rail line [2]. This project is likely to require a significant volume of quarried products over its lifetime. The Handsacre site was also selected to provide a fair comparison between the two rail routes, rather than selecting a location at the convergence of the two (for example Ambergate), which would artificially amplify any benefit of the proposed MEMRAP route.

In all cases, a Class 66 engine was assumed, with 18 type HAI aggregate hopper wagons of 24t empty and 90t full mass [3]. In the case of freight journeys, a complete journey was assumed to include travel from Hindlow to Handsacre with all wagons full, and a return journey with all wagons empty.

Commuting

The vehicle for which emissions data was used was the Ford Fiesta 1.1 Zetec Petrol, which has CO_2 emissions of 114gCO_2/km [4]. Occupancy of two people per vehicle was assumed.

In all passenger train cases, a class 43 locomotive was assumed, with emissions data taken from the EU TRACCS database [5]. 8 passenger carriages were assumed, each with capacity for 56 passengers. 75% occupancy was assumed in all cases.

Leisure

The Peak District is one of the most visited national parks in the world, but it has been described as one of the least well-served by public transport. In this case, transport by the MEMRAP route was compared to travel in a small SUV. This vehicle was selected as anecdotal evidence suggests that it is a common vehicle type for leisure travellers to the Peak District, particularly those travelling for outdoor activities such as Mountain Biking, walking or rock climbing. The vehicle for which emissions data was used was the Nissan Qashqai 1.3 DiG-T, which has CO_2 emissions of 122gCO_2/km [6]. Occupancy of two people per vehicle was assumed.

Airport

Trips to Manchester Airport by the MEMRAP route were compared to two current options. Journeys from Derby, Leicester and Nottingham to Manchester airport by road were again based on the Ford Fiesta 1.1 Zetec Petrol, which has CO_2 emissions of 114gCO_2/km, with an occupancy of two people. Though Manchester airport receives more road visitors per trip than many comparable airports, the airport does have a dedicated rail station so rail journeys using the current routes were also compared to the MEMRAP proposal.

Carbon Dioxide emissions

Carbon Dioxide is a greenhouse gas. Greenhouse gases are the insulation around the earth, and allow heat from the sun to be trapped within the earth's atmosphere, thus maintaining temperatures suitable for life on earth. A balance is needed since if too much heat is trapped the earth will warm too much and life on earth will be threatened. Since the industrial revolution, atmospheric CO_2 has risen from around 280 parts per million (ppm) to over 410ppm. This is linked to a rise in global temperatures and appears to be the cause of an increasing number of anomalous climatic events. Changes in atmospheric CO_2 and global temperature are illustrated in Figure 1.

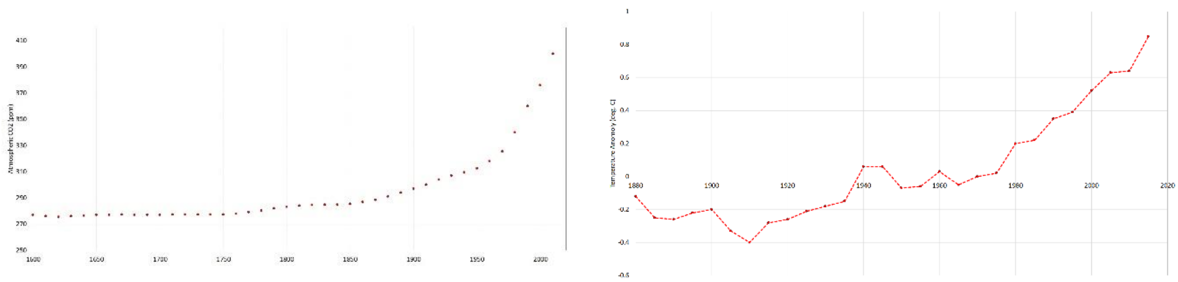

Figure 1: The impact of Carbon Dioxide emissions: Atmospheric CO_2 parts per million (l) and global climate temperature anomoly degrees Celcuis (r)

Carbon Dioxide is emitted by many processes undertaken as part of daily human life, including transport. Transport by road, rail, air and sea are all powered by the combustion of fossil fuels, and thus all emit CO_2.

Other emissions

Carbon dioxide is not the only emission from the burning of fossil fuels for transport. Different forms of fuel (for example diesel, petrol, or kerosene) create differing amounts of a range of emissions. Some of these emissions are important as they are greenhouse gases like CO_2, whereas some are particulate matter and can be harmful to human health. Other commonly-monitored emissions from fossil fuel combustion include Carbon Monoxide (CO), particulate matter of below 10 microns (PM10), Nitrogen Oxide (NOx), and Volatile Organic Compounds (VOCs). However, in terms of atmospheric greenhouse gas, CO_2 is by far the most important, and is thus the focus of this study.

1 The MEMRAP Route

The location of the proposed MEMRAP route is shown in Figure 2 below. As shown in the map, the group proposes the re-opening of the line between Matlock, Darley Dale and Rowsley (part of which is operated as a heritage railway by Peak Rail), Bakewell, Longstone, Millers Dale, and Buxton.

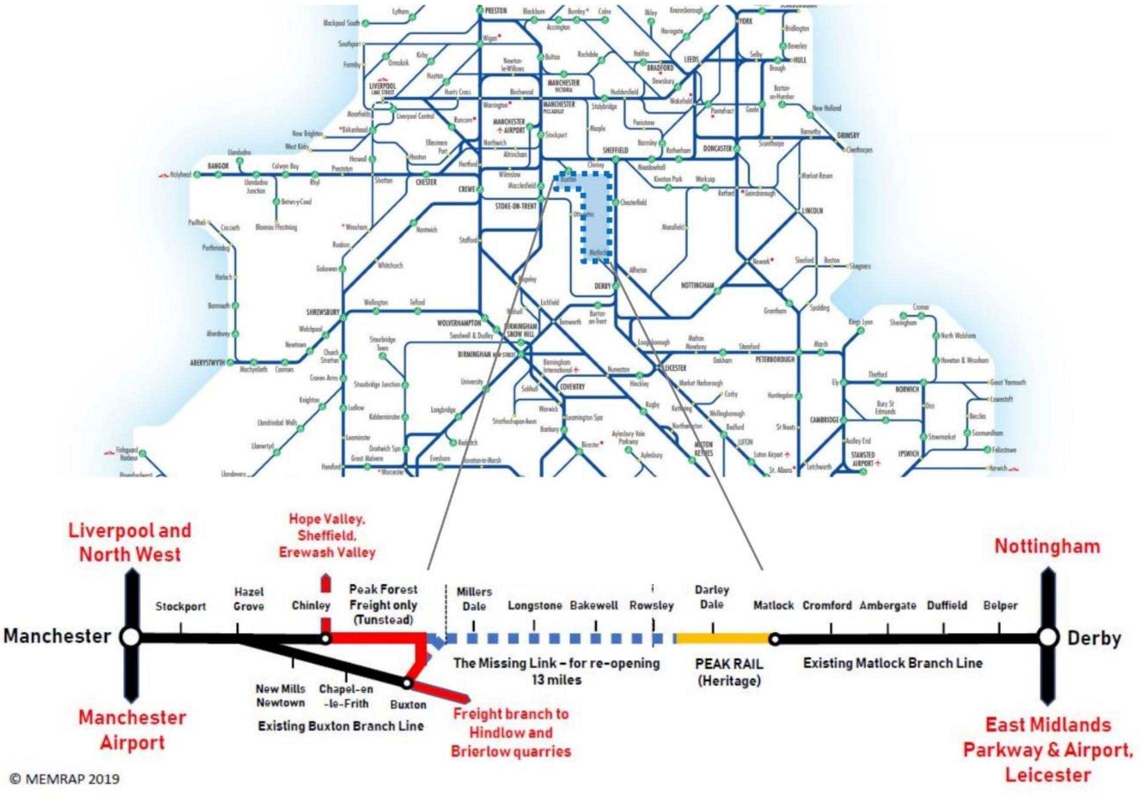

Figure 2: The route of the proposed MEMRAP rail line, shown in context (upper image [7]) and in detail (lower image [8])

2 Transport modes

Freight trains

As mentioned previously, freight journeys were assumed to be made using a Class 66 engine with 18 type HAI aggregate hopper wagons. This arrangement is shown in Figure 3.

Figure 3: Freightliner Class 66 with 18 type HAI aggregate hopper wagons, shortly after leaving Hindlow Quarry [9]

Data on CO_2 emissions for freight was taken from Rail Safety and Standards Board figures [10].

Passenger trains

Data for the Class 43 “Intercity 125” locomotive was used in passenger cases, with emissions data taken from the EU TRACCS database [5]. 8 passenger carriages were assumed, each with capacity for 56 passengers. 75% occupancy was assumed in all cases.

Figure 4: Class 43 passenger locomotive with 8 carriages [11]

Despite having been first manufactured in the 1970s, the class 43 locomotive is still very common on UK railways. Alternative newer locomotives could have been used (for example the Bombardier Class 220 Voyager), but due to their regular use the class 43 is likely to give more representative CO_2 emission figures for the lines studied here. The use of class 43 data is also likely to give a more conservative CO_2 estimate than alternative locomotives.

Road Transport

Three vehicles were used for comparative road transport studies. In all cases, the assumption was made that road vehicles would be new 2019 models. Emissions data for new vehicles are measured using the Worldwide Harmonised Light Vehicle Test Procedure (WLTP). This test gives a single value of CO_2 emissions per kilometre, giving an overall estimate of a vehicle's emission performance across a range of driving conditions. These WLTP values were used in this study.

Ford Fiesta

The Ford Fiesta is the UK's most popular new car. The 1.1 Petrol Zetec model was used in this study, and has a CO_2 emissions value of 114gCO_2/km.

Nissan Qashqai

To give a reasonable comparison on the leisure case, an SUV was used. The Nissan Qashqai 1.3 DiG-T has CO_2 emissions of 122gCO_2/km.

Toyota Prius

For later comparison, some results were also recalculated using a hybrid vehicle. In this case the Toyota Prius Prius 1.8 VVTi Hybrid was used, with CO_2 emissions of 75gCO_2/km [12].

Figure 5: Cars used in comparative studies: Ford Fiesta (l), Nissan Qashqai (centre), Toyota Prius (r).

3 Comparative CO_2 calculations

Calculation method

In order to compare emissions, the following process was undertaken for each journey:

First, the emissions of the current method were calculated. In commuting, leisure and airport cases this was a car journey, so the distance between the start and finish points was calculated using Google Maps [13]. Any temporary route changes were ignored and the route giving the quickest journey time was selected. This distance was multiplied by the combined per kilometre CO_2 emission figures for the appropriate vehicle to give the overall CO_2 emissions per vehicle. Dividing this figure by the occupancy gives the total per person journey CO_2 emissions.

For rail journeys, the process was more complex. Since rail emissions are not available for a standard combined journey in the same way as for cars, taking account of hills required the calculation of the distance, ascent and descent of each rail route. This was undertaken using Ordnance Survey online mapping software [14]. Distance and height gain / loss were measured using this method and distance checked by the Railmiles [15] database for validation. To calculate journey emissions, overall emissions data for freight [5] or passenger [10] trains per flat kilometre were multiplied by journey distance, including a factor for the net height gain calculated by the mass of the train and the resulting additional engine power required to climb. This was based on flat tractive effort data for each train type. For example, it was calculated that a Class 66 freight engine would use an additional 0.83% power per kilometre to climb a 1 degree slope. CO_2 emissions were calculated based on the total power requirement of the train over the journey.

Comparative CO_2 results

Results of the comparative CO_2 studies described in previous sections of this report are presented in this section.

Freight

Route details:

MEMRAP (108km, 1186m ascent):
Hindlow – Buxton – Millers Dale – Bakewell – Rowsley – Matlock – Cromford – Ambergate – Derby – Burton-upon-Trent – Handsacre

Hope Valley (149km, 1272m ascent):
Hindlow – Buxton – Chalel-en-le-Frith – Edale – Dore – Clay Cross – Ambergate – Derby – Burton-upon-Trent – Handsacre

Results:

Case	**State**	**kgCO_2**
MEMRAP		
Outward (Hindlow – Handsacre)	Full (1750t)	9943
Return (Handsacre – Hindlow)	Empty (560t)	3222
TOTAL		*13,165*
Hope Valley		
Outward (Hindlow – Handsacre)	Full (1750t)	13,064
Return (Handsacre – Hindlow)	Empty (560t)	4393
TOTAL		*17,998*

Table 2: CO_2 results for Freight case.

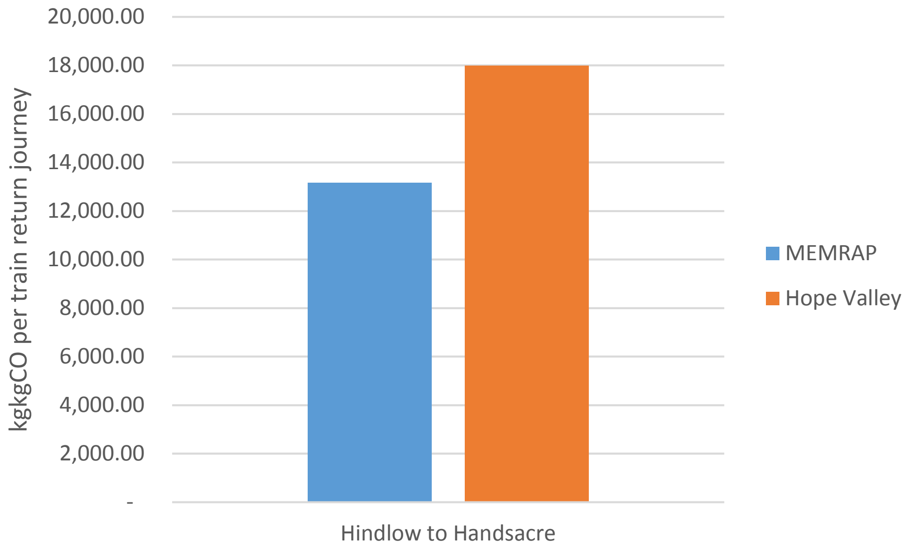

Figure 6: Comparitive CO_2 study results: Freight case

Commuting

Derby to Manchester route details:

MEMRAP (75km, 1310m ascent):

Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton – Manchester Piccadilly

Road (124km):

Derby – Ashbourne – M67 J4 – M67 J2 – Manchester Piccadilly

Leicester to Manchester route details:

MEMRAP (122km, 1540m ascent):

Leicester – Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton – Manchester Piccadilly

Road (185km):

Leicester – M1 J22 – M1 J24 – M6 J15 – M6 J19 – Manchester Piccadilly

London to Buxton route details:

MEMRAP (262km, 2605m ascent):

London St Pancras – Leicester – Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton

Road (271km):

London – M1 J1 – M1 J24 – Sudbury – Buxton

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Results:

Case	Road		Rail
***kg**CO_2*	**Fiesta (2 pass.)**	**Prius (2 pass.)**	**MEMRAP**
Derby to Manchester	7.0	4.6	2.6
Leicester to Manchester	10.6	7.0	4.0
London to Buxton	15.5	10.2	8.4

Table 3: CO_2 results for Commuting case (per passenger per journey).

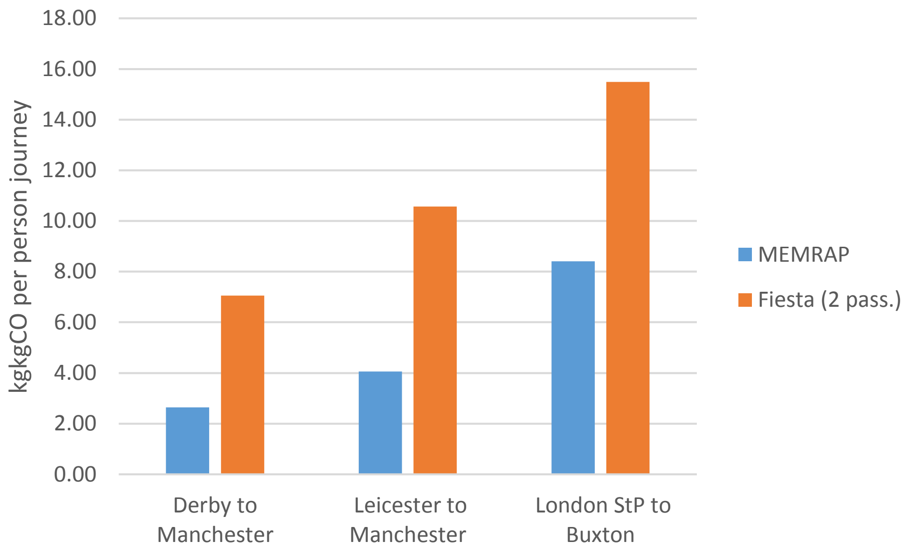

Figure 7: Comparitive CO_2 study results: Commuting case

Leisure

Cromford to Bakewell route details:

MEMRAP (16km, 330m ascent):
Cromford – Matlock Bath – Matlock – Rowsley – Bakewell

Road (20km):
Cromford – Grangemill – B5056/A6 – Bakewell

Nottingham to Bakewell route details:

MEMRAP (66km, 595m ascent):
Nottingham – Beeston – Attenborough – Long Eaton – Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell

Road (95km):
Nottingham – M1 J26 – M1 J28 – Matlock – Bakewell

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Leicester to Buxton route details:

MEMRAP (106km, 1460m ascent):

Leicester – Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton

Road (119km):

Leicester – M1 J22 – M1 J24 – Sudbury – Buxton

Results:

Case	Road		Rail
kgCO_2	**SUV (2 pass.)**	**Fiesta (2 pass.)**	**MEMRAP**
Derby to Manchester	1.2	1.2	0.6
Leicester to Manchester	5.6	5.4	2.1
London to Buxton	7.3	6.8	3.6

Table 4: CO_2 results for Leisure case (per passenger per journey).

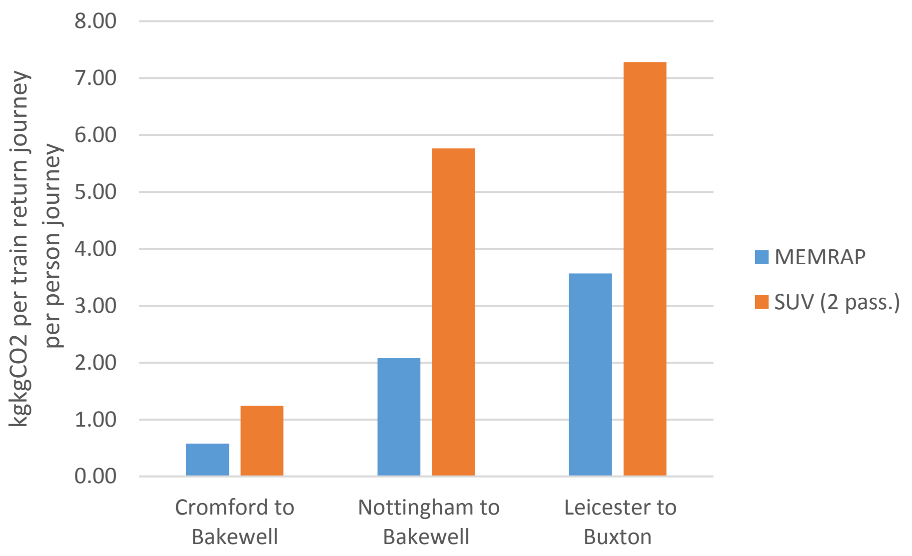

Figure 8: Comparitive CO_2 study results: Leisure case

Airport

Derby to Manchester Airport route details:

MEMRAP (115km, 1730m ascent):

Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton – Manchester Piccadilly – Manchester Airport

Existing Rail (118km, 665m ascent):

Derby – Crewe – Manchester Airport

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Road (119km):
Derby – Sudbury roundabout – M6 J19 – Manchester Airport

Leicester to Manchester Airport route details:
MEMRAP (162km, 1963m ascent):
Leicester – Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton – Manchester Piccadilly – Manchester Airport

Existing rail (188km, 1850m):
Leicester – Sheffield – Manchester Airport

Road (160km):
Leicester – Sudbury roundabout – M6 J19 – Manchester Airport

Nottingham to Manchester Airport route details:
MEMRAP (140km, 1807m ascent):
Nottingham – Beeston – Attenborough – Long Eaton – Derby – Duffield – Belper – Ambergate – Whatsandwell – Cromford – Matlock – Rowsley – Bakewell – Millers Dale – Blackwell – Buxton – Manchester Piccadilly – Manchester Airport

Existing rail (168km, 1585m ascent):
Nottingham – Derby – Sheffield – Manchester Airport

Road (145km):
Nottingham – Sudbury roundabout – M6 J19 – Manchester Airport

Results:

Case	**Road**	**Rail**	
kgCO_2	**Fiesta (2 pass.)**	**Existing**	**MEMRAP**
Derby to Manchester Airport	6.8	3.6	3.9
Leicester to Manchester Airport	9.1	6.0	5.4
Nottingham to Manchester Airport	8.3	5.4	4.7

Table 5: CO_2 results for Airport case (per passenger per journey).

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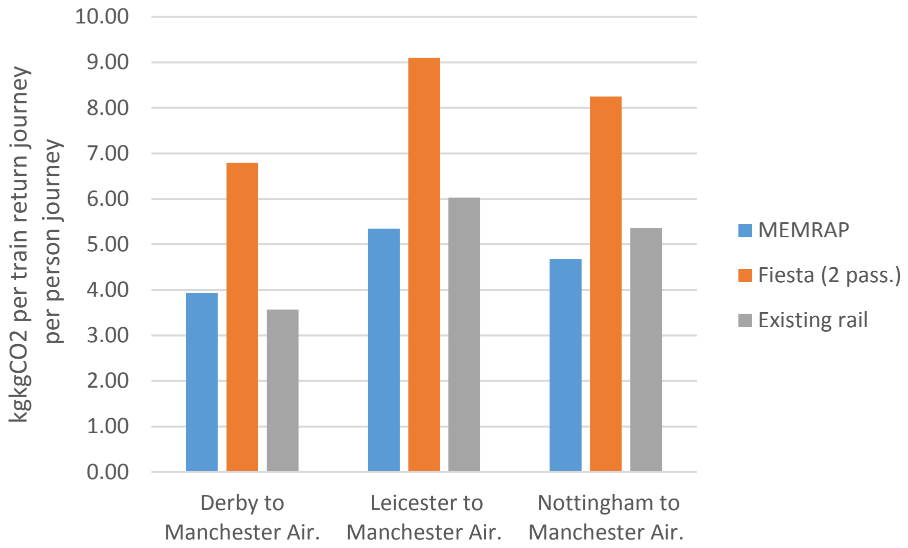

Figure 9: Comparitive CO_2 study results: Commuting case

Conclusions

The MEMRAP group proposes the reopening of the Matlock to Buxton railway. Section 3 of this report summarised the potential of this proposal to reduce CO_2 emissions of transport within, into and out of the Midlands. This has been presented as CO_2 saving results per freight and per passenger journey.

In all but one case, the MEMRAP rail proposal appears to result in CO_2 savings compared to the presented alternatives. The calculations described in this report suggest that:

- Compared to the existing freight route, the MEMRAP proposal results in a CO_2 saving of around 25%.
- Compared to road transport, the MEMRAP proposal results in approximately a 50% CO_2 saving in commuting cases.
- Compared to road transport, the MEMRAP proposal results in at least a 50% CO_2 saving in leisure cases.
- Compared to road transport, the MEMRAP proposal results in at least a 40% saving in airport travel.
- In comparison to existing rail travel to Manchester airport, the MEMRAP proposal results in a CO_2 saving of around 10% for journeys from Leicester or Nottingham, but 10% greater CO_2 emissions than the existing rail route for journeys from Derby (due to the flatter nature of the existing route).

On the whole, these figures appear to suggest that the MEMRAP proposal would offer significant CO_2 savings. Many of the passenger journey savings are reliant on modal shift from road to rail transport, so although significant, they cannot be guaranteed. The potential savings in the freight case are large. Over a single return rail journey of a full freight train from Hindlow to Handsacre, 4000kg of CO_2 could be saved using the MEMRAP route over the existing Hope Valley route.

Recommendations

An obvious next stage of this work is to extrapolate the per-passenger and per-journey data to give annual figures for potential CO_2 savings. This is outside the scope of this report, particularly in the case of passenger journeys where it is very difficult to estimate the number of travellers who might shift modes, but it is clear to see that the results could be significant. For example, if the reopening of the Matlock to Buxton line led 100 Leicester to Manchester commuters to move from road to rail travel, over 150,000kgCO_2 per annum could be saved. Due to its regularity, commuting is likely to offer the greatest CO_2 saving of the three passenger journey types considered here. However, it appears that freight transport is where the largest savings could lie. With a saving of over 4,000kgCO_2 per journey compared to the Hope Valley line, it is notable that the same annual savings achieved through the previous example of modal shift of 100 commuters could be met in just 38 freight journeys.

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