ECONOMIC STUDY INTO THE ELECTRIFICATION OF RAIL SERVICES TO PLYMOUTH AND CORNWALL

FINAL REPORT – WITH A REVISED SET OF SCENARIOS

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Cover photo acknowledgement: An HST southbound on the South Devon Main Line at Teignmouth. Photo: Nilfanion, 2010

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Executive Summary

WSP was appointed by Plymouth City Council in November 2012 to assess the benefits of the electrification of the railway serving the city, and to provide a plan by which the necessary investment could be delivered. The scope of the study was extended in February 2013, at the request of Cornwall Council, to assess in more detail the implications on services running into Cornwall. This included an assessment of the costs and benefits associated with the extension of electrification all the way to Penzance.

Since this time, we have been commissioned again to undertake the same analysis but using a different set of train service scenarios. As part of this update, we have taken the opportunity to update the capital costs of electrification. The results demonstrate that there is a good case for delivering journey time reductions from London to Exeter, Plymouth and beyond to Penzance. This is in part achieved by operating additional trains, to provide fast, frequent and regular trains to all the intermediate calls en route. This two-tier service involves an additional cost of operation but delivers quite significant additional revenue and economic benefits. Such a service enhancement is possible with electric or diesel trains. The principal advantage of electrification is reduced operating costs: in simple terms, electric trains are cheaper and more reliable to operate than diesel trains. The savings in operating costs help to pay the extra cost of the intensified service. Moreover, electric trains are more environmentally friendly than diesel trains, despite advances in technology, and the costs of electric trains are likely to be lower than diesel trains as manufacturers adapt their rolling stock designs to meet the more stringent environmental criteria.

Recently, Cornwall Council, Devon County Council, Plymouth City Council, Somerset County Council and Torbay Council have united around a central message of promoting investment in the railway to the South West. They have produced a manifesto for improvement of the network entitled: *The South West Spine – the Case for Greater Investment across the South West Peninsula Railway Network.* These authorities will use this document as the springboard for making a case for significant improvements to the rail network. It is important that all stakeholders who stand to benefit from electrification, and these include all those transport authorities to the west of Newbury, make a strong and consistent case to the Department for Transport and to Network Rail about electrification. In particular it is necessary for the authorities to present a strong united front for:

- Network Rail's updated Electrification Route Utilisation Strategy (RUS);
- Submissions about investment plans for Control Period 6 (initial consultation, Network Rail's initial strategic business plan, the finalisation of the DfT's plans through this period), from 2014 onwards;
- Discussions with bidders on service planning and rolling stock, for the Great Western franchise, and in due course, the Cross Country franchise, from 2015 onwards; and
- Discussions about localism – a process of partial or full devolution of the specification of services in a particular geographical area (from now onwards)

A consistent, strong message from all authorities, recognising that the economic and financial benefits to the communities on the network is substantially greater than the sum of the parts, will be of great benefit in making the case for investment. A particular opportunity occurs in Control Period 6, for which planning is in its early stages. This runs from 2019 to 2024, and decisions will be taken about enhancement schemes that will feature, by 2017/8 at the latest. Furthermore, it is in this same time period that the High Speed Trains will either need life extension or replacement: it is imperative that authorities engage early and positively with the DfT, Network Rail and operators/franchise bidders to ensure the right outcome on rolling stock for all concerned.

This report provides a weight of evidence, compiled according to industry standards, to support the investment that these authorities are seeking to bring about for this part of the rail network which has, in contrast with many other parts of Great Britain's railway, witnessed very little investment in recent years.

1 Project Background

1.1.1 Following the production of the *Economic study into the electrification of rail services to Plymouth and Cornwall* in 2013 the local authorities of the South West Peninsula wish to commission further scenario analysis, to be produced in a separate report on behalf of the Peninsula Rail Task Force (PRTF). The methodology used is identical.

1.1.2 To enable all five Local Authorities in the South West Peninsula who make up the PRTF to levy their support to a future proposed business case and lobbying for electrification in the region a new report is required. This is based on previous work undertaken by WSP, but updated train service scenarios have been tested in line with stakeholder desires. Furthermore, this latest piece of work uses updated capital costs of electrification, based on the electrification – already underway - of the Great Western Main Line from Paddington, to Oxford, Newbury, Bristol and South Wales.

2 Methodology

2.1.1 In this work, we have followed a rigorous and recognised methodology in which we have calculated the operating costs and revenue for a variety of options for the future train service, and have assessed what the implications of electrification would be for each one. We have defined a series of options designed specifically to assess the benefits of electrification from Bristol and Newbury through to Penzance.

Capital costs

2.1.2 The capital costs of electrification are significant but are a fixed cost: once the catenary has been installed, it may be used in whatever way future specifiers and operators choose. It is the task of this study to determine plausible ways in which the service will evolve in the future, with and without electrification. These assumptions should be robust, but nevertheless there are many other options, above all in stopping patterns, which could be considered. For each scenario which involves electrification, we have assumed that the scope of electrification, and its cost, is identical.

2.1.3 We have taken a cost of £1.2bn for the electrification of the lines from Newbury to Paignton / Penzance and from Cogload Junction (near Taunton) to Bristol. This cost is approximately double the unit costs quoted in Network Rail's Electrification RUS, and is the cost per track km (£1.2m) of the electrification scheme currently underway from Airport Junction to Newbury, Oxford, Bristol and South Wales. We believe that it represents the 'worst case' scenario for costs: improvements in efficiency and lessons learnt from the extensive electrification programme may mean that the eventual costs would be less. We have not undertaken any form of engineering assessment of the line or the complexities involved in electrification and the costs, which have been disaggregated by route section, are in unit cost terms only.

2.1.4 The following table illustrates the costs per route section:

Route section	Track km (approx)	Estimated capital cost £m
Bristol – Plymouth/Paignton	460	544
Newbury – Cogload Junction	285	342
Plymouth – Penzance	256	307

2.1.5 The costs of electrification are dependent above all on the complexity of the network proposed, the need for gauge clearance work (bridges, tunnels) to be undertaken, and the cost of feeder stations from the National Grid. The network under consideration for electrification does not include a significant number of complex trackwork locations. In particular, Bristol Temple Meads station will already have been electrified under the main Great Western electrification scheme. This means that the cost would be less than implied in these analyses. We are, however, aware of the Bath Road bridge, just south of Bristol Temple Meads, which is likely to prove particularly costly to modify to permit the erection of catenary below. The viaducts and tunnels that are a feature of the line west of Exeter may also prove more complex and expensive to electrify than other locations. The level of uncertainty in the capital cost is reflected in the level of optimism bias applied in the appraisal of the scheme in chapter 4.

2.1.6 Rolling stock procurement is dealt with under operating costs as it is normal for trains to be leased rather than purchased outright by a train operator.

Operational costing analysis

2.1.7 The principal steps in the assessment of the benefits of electrification are the following:

- Definition of a number of train service scenarios, in which different options of stopping patterns, journey times and rolling stock types are tested;
- Calculation of the operating costs involved for each train service scenario. The categories of the costing analysis include rolling stock lease charges, rolling stock maintenance, fuel (diesel or electric) and the variable track access charge (which notionally represents the cost of maintenance necessary to rectify the damage to the track caused by the passage of the train);
- Whilst money is not paid from one organisation to another for the emission of carbon dioxide, we have included within the analysis of operating costs a monetised value of carbon dioxide. These costs are treated in exactly the same way as the actual monetary costs associated with the categories outlined in the point above; and
- Calculation of the demand and revenue generated for each operating scenario.

2.1.8 This analysis generates the first set of results, for a single year. It would not be expected that the capital costs of electrification could possibly be justified as a result of the savings/revenue benefits over one year. It is therefore necessary to appraise the benefits over a longer period of time, which normally for a significant investment such as electrification would be 60 years. This appraisal period is consistent with rail industry practice and represents notionally the life of the asset.

2.1.9 We assume in our analysis that the train service stays constant over this 60-year period, in order to ensure consistency between the different elements of analysis conducted. However, there are some aspects of the net costs that will evolve, namely demand levels, revenue growth and the relative costs of diesel and electricity. Demand and revenue tend to follow economic growth (with notable local and regional variations), but a significantly enhanced train service is able to generate additional demand, for instance with rail gaining a greater mode share. Assumptions taken about other modes (such as the fuel price for cars, or road congestion) may also have a positive effect on rail demand. In our 60-year appraisal, we therefore make a series of assumptions about how the costs and revenues will evolve (chapter 4).

Revenue analysis

2.1.10 Moira is a standard industry tool designed to calculate changes in demand, revenue and transport user benefits as a result of changes in the service pattern. It is a tool used by all train operators, the DfT and Network Rail in an assessment of proposals for service changes. It does not have a crowding algorithm – in other words, it takes no account of the fact that certain services will become overcrowded – but for a strategic study such as this, that does not undermine the results at all. It is perfect for assessing the overall revenue and transport user benefits for significant changes to the service, which is one reason why we have deliberately proposed a number of contrasting scenarios.

2.1.11 Each train service scenario is coded into Moira and the demand, revenue and transport user effects are generated. Those results are then analysed to ensure accuracy and if necessary, any inputs are amended. We have used a base year of 2011 for revenue, but in the 60-year appraisal make a series of assumptions as to how revenue will evolve in line with exogenous forecasts. This is consistent with the appraisal of other electrification schemes around the country.

The train service scenarios

2.1.12 This section presents the definition of a set of train service scenarios. Many different permutations are possible, including almost endless variations in possible stopping patterns. The importance here is to present a set of plausible and realistic service patterns which can be recognised by the industry and on which a case for electrification can be made. Once the decision to invest the significant capital sums needed for electrification has been made, then detailed service planning, involving local and regional authorities, the operators, Network Rail and the Department for Transport, can be undertaken, in line with the demand position at the time, rolling stock availability and other factors.

Definition of the train service scenarios

2.1.13 We have analysed the costs and revenue of five train service scenarios, and two sub-options. Our analysis is confined to the Bristol – Penzance/Paignton and London – Penzance/Paignton routes – but recognising that Cross Country services generally come from well beyond Birmingham. We assume therefore that Control Period 5 delivers electrification from London to Newbury and Bristol, and that the central assumption for Control Period 6 is the electrification of Birmingham – Bristol. Our analysis seeks to identify a case for electrification south of Bristol and west of Newbury.

2.1.14 The five core train service scenarios are defined in the table below. The advantage of the definition of these scenarios in this way is that 1 and 3 are contiguous, as are 2 and 4. This permits comparison of results on a very similar basis.

2.1.15 In the analysis we have had to identify a range of realistic rolling stock types in order to include the relevant costs. We have deliberately adopted a train other than the IEP for the longer-distance electric services (both Great Western and cross country). We have chosen a class 395 as a representative of a modern class of electric multiple units, with high acceleration and deceleration. Such a train would be configured to be suitable for the long-distance workings to Devon and Cornwall[1]. These currently run on High Speed 1 between London and North/East Kent. Costs for the IEP are confidential, although reports suggest that their cost is much higher than other potential rolling stock options. For the diesel options, we have also assumed that class 165s/166s currently operating on the slower services out of Paddington towards Reading, Oxford and Newbury, are cascaded to the West Country to replace the Sprinter trains which run these services. These trains have 3 carriages instead of 2 and become available following electrification of the Thames Valley routes. With electrification of the routes towards Plymouth, we have assumed that a similar capacity electric train would be provided.

2.1.16 The specification of the five scenarios is as follows:

1. Base case

The base case is the current timetable and therefore removes the previously-assumed modification for the 0706 ex-Paddington to run to Penzance and depart at 0650. It assumes HSTs operating the current service.

[1] The class 395 is currently configured for operation on High Speed 1, with on-board technical equipment suitable for that route. It would be assumed for the purpose of this study that appropriate technical equipment for operation on a modernised existing route, would be installed, together with a range of other modifications. Our analysis relies on the operation of a train with the operational characteristics, and operating costs of a class 395.

Voyagers will operate Cross Country trains to the same frequency and journey time as currently.

Class 165/166s running in 3 car formation to operate all other services to the same frequency and journey time as today.

2. Enhanced diesel scenario

London services (assumed class 222 Meridian characteristics):

- Hourly service from London to Penzance (calling at Reading, Taunton, Exeter, Newton Abbot, Totnes, Plymouth, Liskeard, Bodmin Parkway, St Austell, Truro, Redruth, St Erth).
- Hourly semi fast from London (calling at Reading, half for Pewsey, Westbury, half for Castle Cary, Taunton, Tiverton Parkway, Exeter, Newton Abbot) four of which would run to Torquay and Paignton with the remainder running to Totnes and Plymouth.
- Additional variation to be included extending the Penzance stopping service to terminate at Exeter St Davids. To include stops at Ivybridge, Teignmouth and Dawlish.
- Journey times reduced by approximately 10 minutes (end to end) in comparison with today.

Current Cross Country frequency, capacity and journey times remain as they are.

Class 165/166s, running in 3 car formation, to operate all other services in the Peninsula.

- Additional hourly semi fast from Plymouth to Penzance (calling at Saltash, St Germans, Liskeard, Bodmin, Parkway, Lostwithiel, Par, St Austell, Truro, Redruth, Camborne, Hayle, St Erth). Two morning and two evening trains in each direction will additionally stop at Devonport, Dockyard, Keyham, St Budeaux Ferry Road and Menheniot. Where a Cross Country service is making the hourly journey between Plymouth and Penzance an additional Penzance semi fast will not be required.
- Additional variation (scenario 2a) will extend the stopping service to Exeter St Davids rather than Plymouth.
- Service from Exmouth to Paignton to be half hourly throughout.

This scenario would deliver the following:

- Taunton 1 x hourly fast and 1 x hourly semi fast to London
- Exeter 1 x hourly fast and 1 x hourly semi fast to London
- Paignton 4 semi fast trains per day
- Plymouth 1 x hourly fast and 1 x hourly semi fast to London (excluding the 4 services operating to/from Paignton)
- Penzance 1 x hourly fast to London, 1 x hourly stopping service to Plymouth, and connections from Plymouth for semi fast to London.

3. Base case electrification scenario

Electric version of scenario 1.

This scenario assumes that Newbury – Penzance, Cogload Junction to Birmingham, Newton Abbot to Paignton, and Exeter to Exmouth are electrified, in addition to current committed schemes. All services running on these lines only, will be electric, whereas any service serving additional lines and locations will be diesel.

Journey time savings of approximately 10 minutes (end to end) when compared with today for London services.

4. Enhanced electrification scenario

Electric version of scenario 2. This scenario seeks to identify a more intensive level of service in which operating cost savings, or revenue growth, can go further towards contributing to the capital cost of electrification.

This scenario would deliver the following: • Taunton 1 x hourly fast and 1 x hourly semi fast to London • Exeter 1 x hourly fast and 1 x hourly semi fast to London • Paignton 4 x semi fast trains per day • Plymouth 1 x hourly fast and 1 x hourly semi fast to London except the 4 operating to/from Paignton • Penzance 1 x hourly fast to London, 1 x hourly stopping service to Plymouth, and connections from Plymouth for semi fast to London.
5. Electric Long Distance Market Study scenario Network Rail's recently consulted Long Distance Market Study proposed up to three trains per hour between London and Exeter. This scenario takes scenario 4 as its base but with the following changes: • The semi fast from London to Paignton / Plymouth will be amended so six of the services run to Paignton whilst the Plymouth services terminate at Exeter. • An additional hourly limited stop (Reading, Taunton, Exeter, Newton Abbot and Plymouth which then forms the onward extension to Penzance) • A variation of the above limited stop service to include Taunton (Reading, Exeter, Newton Abbot and Plymouth which then forms the onward extension to Penzance) – scenario 5a. This would deliver the following: • Taunton 1 x hourly fast stopping (Reading and Paddington) and 1 x hourly semi fast, half calling at Castle Cary and Westbury, and half at Pewsey, Newbury, Reading and Paddington. The variation would deliver two limited stop trains from Taunton calling at Reading only. • Exeter 1 x hourly limited stop (Reading, possibly Taunton & Paddington only),1 x hourly fast to London calling at Taunton, Reading and Paddington only and 1x hourly semi-fast calling at Tiverton Parkway, Taunton, half at Castle Cary, Westbury, half at Pewsey, Newbury and Reading. • Paignton 6 semi fast trains per day as an extension of the Exeter to London semi-fast. • Plymouth 1 x hourly limited stop calling at Newton Abbot, Exeter, Taunton (in 5a variant only), Reading and Paddington only and 1 x hourly fast calling at Totnes, Newton Abbot, Exeter, Taunton, Reading and Paddington • Penzance 1 x hourly fast to London calling at St Erth, Redruth, Truro, St Austell, Bodmin Parkway, Liskeard, Plymouth, Newton Abbot, Exeter, Reading and Paddington; 1 x hourly stopping service to Plymouth, and connections from Plymouth for semi fast to London.

Commentary on the operational implications of the proposals

2.1.17 A detailed timetable planning exercise is outside the scope of this study. Considerable judgement has however been taken in order to determine the proposed train service scenarios, to ensure that they provide a realistic basis on which to judge the costs and benefits of electrification. The detail of the train services that have been tested is outlined above.

2.1.18 There are without doubt a plethora of alternative permutations of the train service, calling patterns and rolling stock choices. The objective of the work is to determine a business case for the capital cost of electrification of the route, not to determine the intricacies of the train service or calling pattern. The report provides strong evidence for the Far South West authorities in making the case for electrification. Any decision to electrify the routes would be followed by a large-scale review of train services and calling patterns, along the lines of the work currently underway for the Great

Western Main Line to Bristol and Swansea. Similarly, the electrification of much of the north-west network and the trans-Pennine routes is now being refined by a thorough timetable planning exercise for all the routes in question.

2.1.19 Potential journey time savings which have been assumed in this report are also relatively modest and do not rely on any infrastructure enhancements (trackwork, signalling…) other than that which is committed. The journey times associated with the operation of the class 222 Meridian trains and the class 395 Javelin trains have been calculated through an examination of the timetable and identifying sections of the route – such as between Taunton and Plymouth – where the differential between HSTs and the class 220s/221s of Cross Country can be readily identified. Infrastructure modifications, above all to raise the linespeed, would allow additional benefits to be realised to those outlined here, but they would probably be of benefit both to electric and diesel trains. In our analysis we have assumed that a class 395 and a class 222 train would operate in an identical manner (maximum speed, acceleration and deceleration). This is realistic and appropriate for this level of analysis.

3 Results

Operational costing

3.1.1 In this section we present the operational costs for a single year of operation. For each of the scenarios above, we have calculated the operating costs involved on a mileage basis. We have not undertaken detailed rolling stock planning, but have done sufficient work to be able to calculate the amount of rolling stock needed to inform the lease costs. The assessment of operating costs include:

- Electricity or diesel consumption per mile – taking the most up-to-date UK rail industry costs from the Office of Rail Regulation;
- Variable track access charges – again taking the most up-to-date UK rail industry costs from the Office of Rail regulation [these track access charges notionally represent the track wear];
- Rolling stock lease costs (noting that some modern rolling stock lease costs include a maintenance element as well); and
- Rolling stock maintenance costs, where not included within the lease costs – and this will need to include the cost of elderly rolling stock which is likely to require more maintenance.

3.1.2 For those classes of rolling stock where we do not have the relevant information, we have identified the class of current rolling stock whose characteristics are the most similar. The costing also reflects a suitable train length for passenger volumes in the West of England for stock types that have reasonable potential to operate in varying lengths. This will affect both the fleet requirement and incremental running costs.

3.1.3 In addition, we hold information within our operating cost model on the environmental footprint of different types of rolling stock, on a mileage basis, and this is included in our conclusions. We have estimated the carbon savings of different rolling stock types using published data on diesel fuel consumption of different diesel stock types and electric stock, taking into account typical transmission loss from overhead power lines.

3.1.4 We have included a cost for staff, that being for a driver and a guard. An allowance has been made for an additional guard in those scenarios where two units run in multiple on some trains; in those services operated by class 395s or class 222s, for instance, it is not possible for the guard to walk from one unit to the other. Our analysis, however, takes no account of the catering staff that an operator may choose to employ: this is an issue quite separate from electrification, and would be a commercial decision taken by the operator.

Scenario 1 – Diesel base case option

3.1.5 Scenario 1 is the base case service, with only a small number of committed changes to today's level of service. It gives total annual operating costs of £106.7m, of which a large component is rolling stock maintenance. The reason for the large sum we have included in this category is that we have included the refurbishment costs of the High Speed Trains. We have assumed a figure of £8m per set spread over a period of 20 years. The graph below shows the disaggregation of costs:

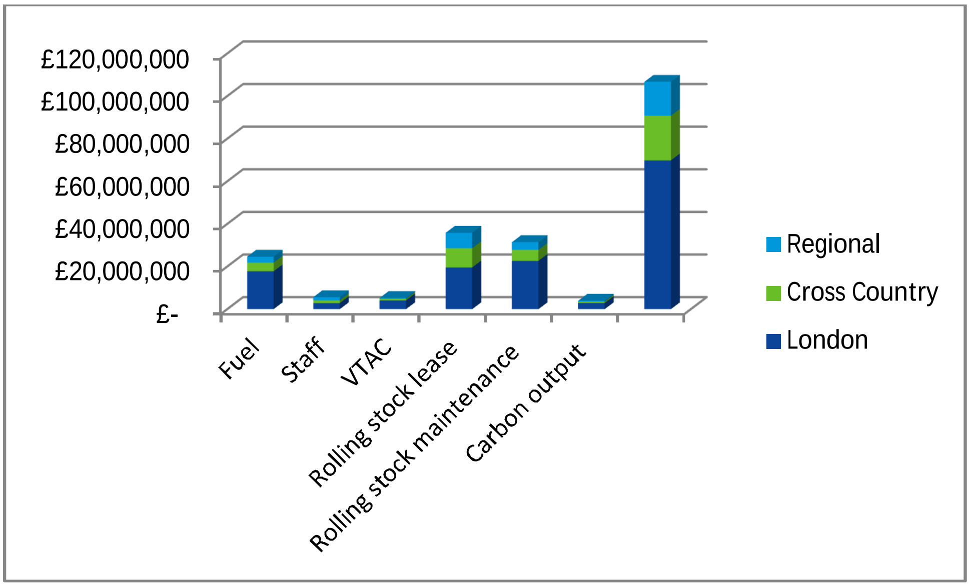

Figure 2: Operating costs associated with scenario 1

Scenario 2 – Expanded diesel operation

3.1.6 Scenario 2 is the enhanced diesel option, and because there are many more train miles operated, it is to be expected that certain aspects of the costs of operation will be higher (fuel, staff, lease charges). The total annual costs amount to £110m. A significant element of the cost is rolling stock lease costs and the extra mileage associated with the introduction of the two-tier service. This sum is determined by the class 222 Meridians being more expensive than HSTs, but their additional expense is mitigated by the fact that we have assumed that a mixture of 5 and 10 car trains operate (as well as no heavy overhaul being assumed for the class 222s). We have assumed 5 car trains operate at less busy times, 10 cars in busier periods[2]. Our analysis has however shown that a total of 145 such vehicles would need to be provided, whereas only 143 are in existence. For the purposes of this analysis, we have not analysed this discrepancy: it could easily be addressed through reformations with the Voyager fleet; likewise our analysis has not analysed likely future crowding levels, which may well mean that more vehicles would be needed. The graph below shows the disaggregation of costs:

[2] East Midlands Trains currently has a fleet of 4-, 5- and 7-car class 222 Meridians. The 4- and 5- car trains operate in multiple at certain times of day. We have assumed simply that 5-car trains would be transferred to these services, with double formations on the busier trains. This would entail a reformation of the sets, a relatively simple task. Nevertheless, a variety of options for train length are possible with this fleet.

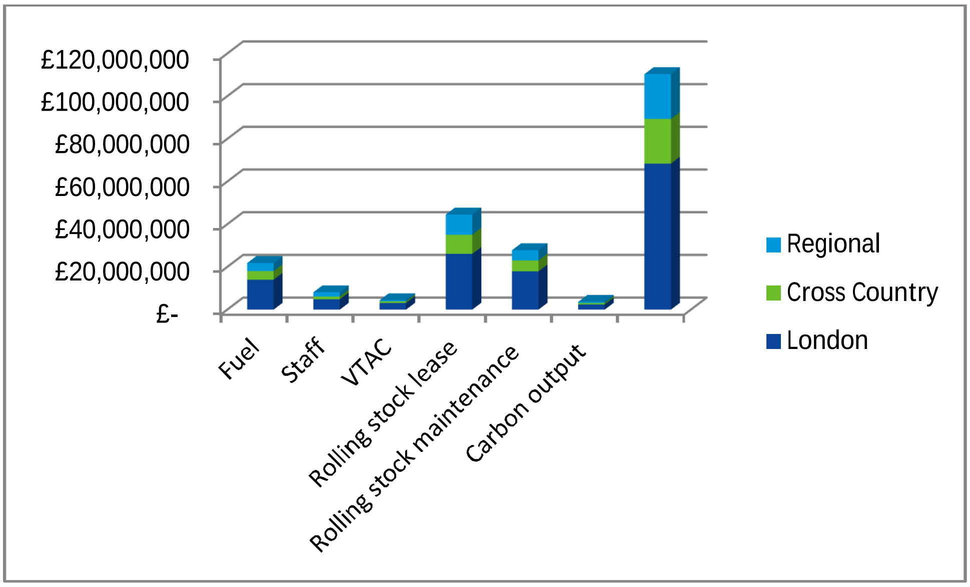

Figure 3: Operating costs associated with scenario 2

3.1.7 Scenario 2a has a variant with a higher operating cost of £113m, because regional services between Plymouth and Penzance would be extended to operate to and from Exeter. The results are below.

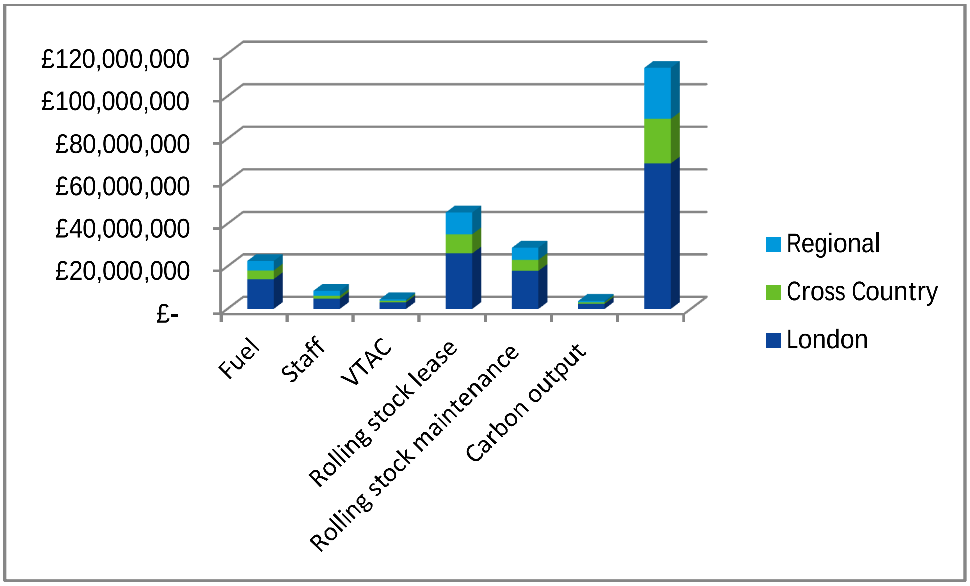

Figure 3a: Operating costs associated with scenario 2a

Scenario 3 – Base case electrified scenario

3.1.8 Scenario 3 represents the most likely scenario of operation were the line to be electrified and for the benefits of new electric rolling stock to be exploited, whilst retaining the structure of the current timetable. There are therefore journey time reductions on most services, when compared to scenario 1, but not a significant overhaul of the timetable. This scenario is the cheapest to operate of the four, with an estimated annual figure of £77m. We have taken the same set of assumptions as for scenario 2, in which shorter trains operate at the less busy times, long trains at the busier times. The graph below shows the disaggregation of costs:

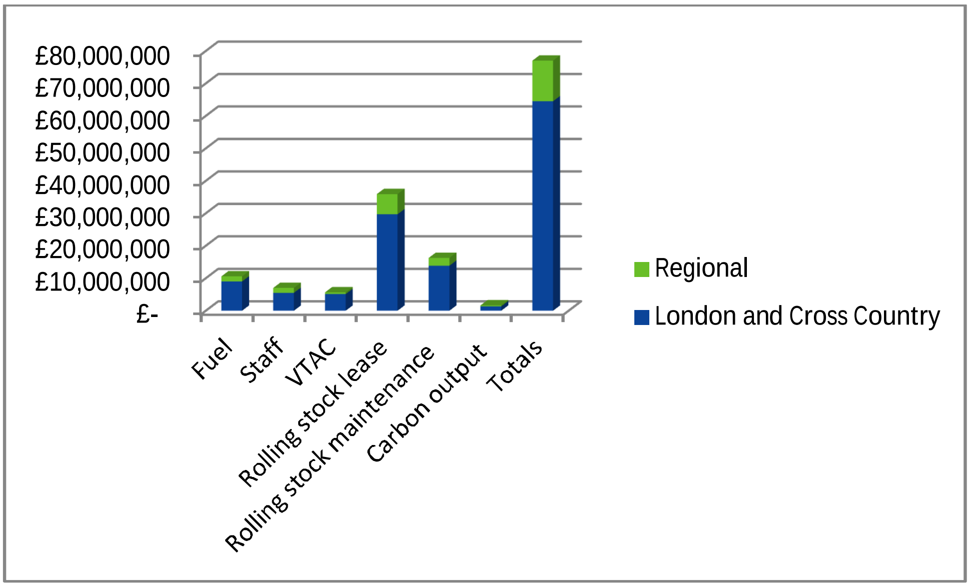

Figure 4: Operating costs associated with scenario 3

Scenario 4 – Enhanced electrified scenario

3.1.9 This expansionist electrified scenario represents an expanded scenario 2. This means that instead of taking the reduced costs of electric operation to contribute to the capital costs, they would be used to support a very significant expansion in service. The total cost of the operation is £87.5m. We have not assumed any journey time reductions when compared to scenario 2 as modern electric and diesel trains have very similar operating characteristics up to 125 mph. The graph below shows the disaggregation of costs:

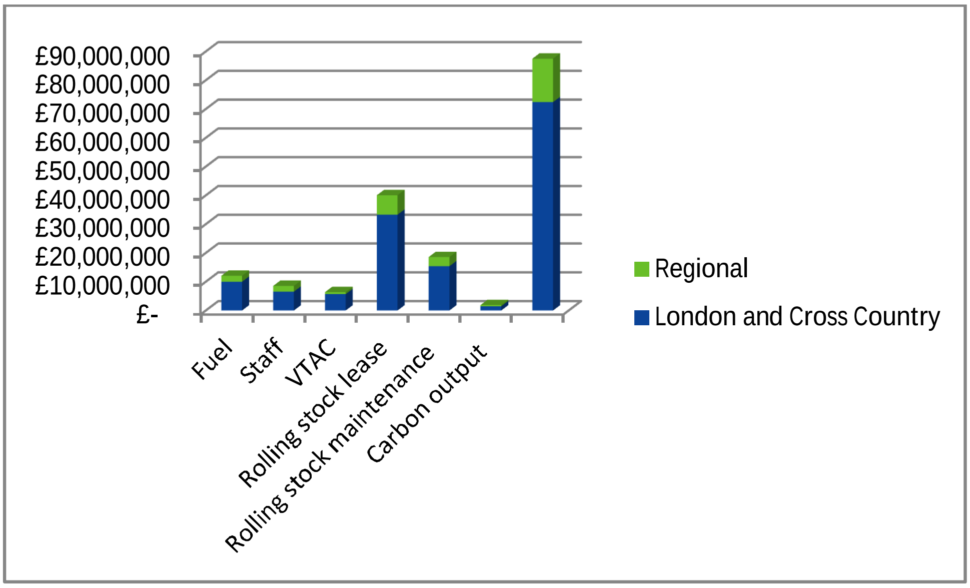

Figure 5: Operating costs associated with scenario 4

Scenario 5 – Electric Long Distance Market Study scenario

3.1.10 This final scenario represents an expansionist approach. The total cost of the operation is £107m. The graph below shows the disaggregation of costs:

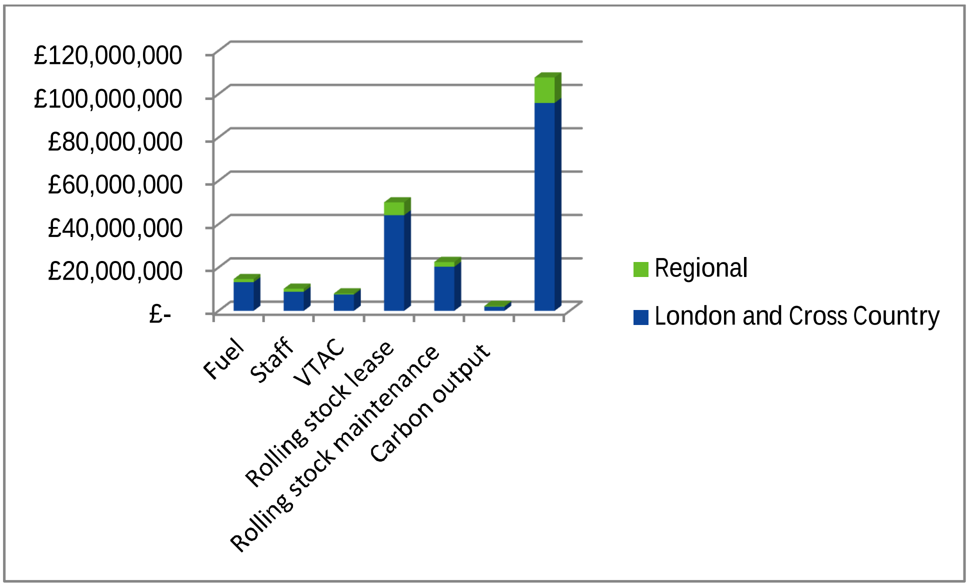

Figure 6: Operating costs associated with scenario 5

3.1.11 Scenario 5a, a variant of scenario 5, excluding the calls at Taunton, does not involve a different operating cost within the context of our analysis of train miles, although the revenue is a little lower.

Revenue

3.1.12 The tables below indicate the additional demand and revenue (with the biggest changes in flows identified) associated with each of the scenarios. In each case, the figures indicated are compared to scenario 1 and are presented for a base year of 2011. Scenario 3 is much less than the others as the improvement is driven solely by journey time reductions, and no frequency increases.

3.1.13 In addition Moira is able to calculate the economic impact of service changes, that being defined as savings in travel time for passengers using appropriate values of time. These figures are generated from the generalised journey times including frequency and actual journey time) and are presented in the ‘User time savings’ column.

	Net revenue increase (per annum)	Net additional journeys per annum	Principal revenue changes	User time savings per annum	Principal reason
2	£15.5m	714,000	Exeter, Plymouth, Taunton, Truro, Newton Abbot, Penzance, Newbury, Tiverton Parkway, Bodmin Parkway, Westbury Faster journey times to Exeter, Plymouth and beyond.	£33m	Faster journey times to Exeter, Plymouth and beyond. More frequent service at many locations.
2a	£15.6m	751,000	As above	£34.5m	Additional train between Exeter and Plymouth as extension of Penzance train
3	£4.1m	183,000	All locations show a benefit	£7.5m	Journey time reductions to all locations without an increase in frequency (hence why revenue increase is lower than the other scenarios).
4	£15.5m	714,000	Exeter, Plymouth, Taunton, Truro, Newton Abbot, Penzance, Newbury, Tiverton Parkway, Bodmin Parkway, Westbury Faster journey times to Exeter, Plymouth and beyond.	£33m	Faster journey times to Exeter, Plymouth and beyond. More frequent service at many locations.
5	£18.8m	849,000	As scenario 5, and with Truro and Penzance (all positive)	£44m	Faster journey times to Exeter, Plymouth and beyond. No call at Taunton Hourly services from London to Cornwall running to significantly reduced journey times
5a	£20m	900,000	Exeter, Plymouth, Newton Abbot, Castle Cary, Newbury, Totnes (all positive)	£46m	Faster journey times to Exeter, Plymouth and beyond. Extra call at Taunton. More frequent service at many locations.

Table 1: Revenue analysis

Costs and revenues

3.1.14 The following table presents a summary of the operational costing and revenue analysis undertaken. The metrics that we have calculated for the cost per train mile and vehicle mile are instructive: it demonstrates the considerable reduction of as much as 35% in unit costs per train mile as a result of electrification.

	Scenario 1	Scenario 2	Scenario 2a	Scenario 3	Scenario 4	Scenario 5	Scenario 5a
Annual operating cost inc carbon	£106,722,217	£110,343,236	£113,397,049	£77,012,515	£87,491,392	£107,631,036	£107,631,036
Difference compared with scenario 1	-	£3,621,019	£6,674,832	-£29,709,702	-£19,230,825	£908,819	£908,819
Revenue increase compared to scenario 1	-	£15,487,000	£15,631,000	£4,100,000	£15,500,000	£18,800,000	£20,021,000
User time benefit	-	£33,000,000	£34,488,000	£7,500,000	£33,000,000	£43,930,000	£46,133,000
Cost per train mile	£14.23	£11.98	£11.65	£10.27	£9.50	£10.11	£10.11
Cost per vehicle mile	£2.04	£2.38	£2.36	£1.90	£1.89	£1.91	£1.91
Capital cost of catenary exc optimism bias	-	-		£1.2bn	£1.2bn	£1.2bn	£1.2bn

Table 2: Cost and revenue summary

4 Appraisal

Approach

4.1.1 This section presents the results of financial and economic appraisals for the options considered. The analysis considers costs, revenues and benefits on a discounted basis so that their sums can be taken together across the life of the project. This is termed Present Value, as the value of impacts in future years are discounted to reflect the investment sum that would be required at current prices.

4.1.2 The Benefit:Cost ratio is calculated as a measure of value-for-money where investment is needed from the public purse. This is calculated by comparing transport benefits and revenue gain with net whole-life costs, both running costs and capital spend, across the life of the project. Some schemes however have a positive financial case. This means that there is not only an economic case for undertaking the scheme, but a financial case: it makes money over the life of the appraisal.

4.1.3 The assumptions underpinning the analyses are consistent with DfT's WebTAG guidance wherever possible. This means:

- A 60-year appraisal of the costs, revenues and benefits;
- A discount rate of 3.50% for the first 30 years, 3% for the second 30 years; and
- The base year for the appraisal is 2010.

4.1.4 For our central case, this means that:

- Operational costs increase in line with inflation + 1% each year (both diesel and electric options);
- Fare rises remain as inflation + 1% per annum (which drives revenue growth);
- Demand growth is 2% for the first 30 years and 1% for the second 30 years;
- User benefits increase by 1.5% per year, driven principally by increases in the value of time which is defined by DfT appraisal guidance; and

- The relationship of competition between rail and road stays constant: measures which may make road travel more expensive (fuel, taxes…) are not introduced.

Wider Economic Benefits

4.1.5 The conventional measures of transport user benefits capture the majority of expected economic impacts from rail investment. Rail travellers in the course of business can be more productive if they spend less time travelling, and particularly if they have more flexibility in taking day-trips to meetings by rail. The quality of the journey, in terms of ride comfort and seating space also contribute to productivity whilst travelling. Benefits to business travellers therefore translate to enhanced GDP impacts. Improved services for commuters and for leisure purposes have their own utility benefits but these do not feed directly through to GDP effects. Research in recent years has considered whether there are additional 'wider economic impacts' that go beyond the historic measures of time savings and externality benefits. The DfT recognises that these time savings alone do not capture the full economic benefits of investment in transport, and that these should be included in economic appraisal so that investment opportunities which could increase productivity are not missed. However, DfT guidance recognises that a proportionate approach should be taken, since the detailed estimation of wider economic impacts, especially agglomeration benefits, is not easily undertaken.

4.1.6 Whilst the list of possible wider benefits of transport is a long one, the DfT recognises three types of wider benefit in economic appraisal:

- ***Agglomeration benefits*** - the term agglomeration refers to the concentration of economic activity over an area. Transport can act to increase the accessibility of an area to a greater number of firms and workers, thereby impacting on the level of agglomeration. Empirical evidence demonstrates that the level of agglomeration affects the productivity of firms and workers in an area, even after controlling for characteristics specific to firms and workers in that area.
- ***Imperfect competition benefits*** - increased output in imperfectly competitive markets. Better transport provision may result in less congestion and hence enable a firm to carry out more deliveries in a day (i.e. increase output). A transport intervention that leads to an expansion of output will deliver a welfare gain as consumers of the goods and services will value any increases in production by more than the cost of the additional units of production.
- ***Labour supply benefits*** - movements to more productive jobs. Transport costs are likely to affect the overall costs and benefits to an individual from working. In deciding whether or not to work, an individual will weigh travel costs against the wage rate of the job travelled to. A change in transport costs is therefore likely to affect the incentives of individuals to work and hence the overall level of labour supplied in the economy.

Analysis and results

4.1.7 Demand and benefit modelling has demonstrated how more passengers would be attracted to use the improved services and has quantified the positive revenue and passenger benefit impacts. These all result from enhanced accessibility via reduced journey times and more frequent services. 2012 represents the base forecasting year and 2026 the future forecast year. The rail user transport benefits for each investment scenario are shown in the table below:

Scenario	Rail User Benefits (£m pa) 2012	Rail User Benefits (£m pa) 2026
2	33	53.6
2a	34.5	58.0
3	7.5	12.3
4	33	53.6
5	43.9	71.4
5a	46.1	75.0

Table 3: Rail user benefits for 2012 and 2026

4.1.8 Growth between 2012 and 2026 reflects both projected growth in rail demand and growth in the value of time, as set out in WebTAG. Detailed modelling work of wider economic impacts was undertaken by Steer Davies Gleave in earlier work for Plymouth City Council[3]. This demonstrated a relationship between user benefits and wider economic impacts which saw the latter worth 13.5% of the former, on average[4].

4.1.9 The SDG work also incorporated an estimate of non-user benefits representing decongestion effects as some new rail passengers switched from road travel. This work does not forecast these explicitly, but the healthy level of new rail revenue, reported above (up to £15m pa in 2012) suggests that this may be a significant factor. Normally, rail passenger benefits dominate total user benefits: as a conservative assumption here we have taken non-user benefits to be a 20% mark-up on rail benefits. If the costs of car use (carbon, fuel) were to change at a different rate then the results would be different.

4.1.10 Applying these assumptions suggests wider impacts and total benefits as follows:

Scenario	Rail User Benefits (£m pa) 2012	Non User Benefits (£m pa) 2012	TOTAL TRANSPORT BENEFITS (£m pa) 2012	Wider Economic Benefits (£m pa) 2012	TOTAL BENEFITS (£m pa) 2012
2	33	6.6	39.6	5.3	44.9
2a	34.5	6.9	41.4	5.6	47.0
3	7.5	1.5	9.1	1.2	10.3
4	33	6.6	39.6	5.3	44.9
5	43.9	8.8	52.7	7.1	59.8
5a	46.1	9.2	55.4	7.5	62.9

Table 4: Benefits, 2012

4.1.11 Given background growth and other factors between 2012 and 2026, this translates into the following set of figures for 2026:

3 *Economic study into rail services for Plymouth Final Report,* Steer Davies Gleave. October 2011.

4 Ibid.Table 7.1.

Scenario	Rail User Benefits (£m pa) 2026	Non User Benefits (£m pa) 2026	TOTAL TRANSPORT BENEFITS (£m pa) 2026	Wider Economic Benefits (£m pa) 2026	TOTAL BENEFITS (£m pa) 2026
2	53.6	10.7	64.4	8.7	73.1
2a	58.0	11.6	69.6	9.4	79.0
3	12.3	2.5	14.7	2	16.7
4	53.6	10.7	64.4	8.7	73.1
5	71.4	14.3	85.7	11.6	97.3
5a	75.0	15.0	90.0	12.1	102.1

Table 5: Benefits, 2026

4.1.12 In appraisal terms, and in strict observance of WebTAG, these wider economic benefits have not been taken into account in the formal appraisal. The appraisal summarised below compares costs, revenues and transport user and non-user benefits on a common (Present Value) basis over a 60 year appraisal period.

	Scenario 2 £m PV	Scenario 2a £m PV	Scenario 3 £m PV	Scenario 4 £m PV	Scenario 5 £m PV	Scenario 5a £m PV
Opex Cost Savings	-96	-177	789	511	-24	-24
Revenue Gains	667	673	177	667	809	862
Capex Costs	0	0	-1,583	-1,583	-1,583	-1,583
Financial Appraisal NPV	570	495	-617	-405	-798	-745
Transport user and non-user benefits	2,030	2,122	464	2,030	2,702	2,838
Economic appraisal NPV	2,600	2,617	-152	1,286	1,455	1,620
Benefit/cost ratio	28.03	15.76	0.81	2.52	2.19	2.30

Table 6: Appraisal table (60 year)

4.1.13 In line with WebTAG, an allowance for Optimism Bias of +66% has been included in the capital costs for the electrified scenarios 3, 4 and 5. The higher electrification costs together with the OB allowance means that the enhanced diesel options (scenario 2 and variant 2a) perform best in Economic NPV and in value-for-money (vfm) terms through the Benefit/Cost Ratio. This is because they secure the majority of the revenue and passenger benefits through a relatively modest increase in operating resources. They also represent the only option that is financially positive.

4.1.14 For the electric scenarios, the operating cost savings of electric operation are still substantial, but only recover a proportion of the capital costs in PV terms across the 60 years. Scenario 3 recovers about a half and scenario 4 about a third. Scenario 5 has the best revenue and passenger benefit, but higher costs mean it is suboptimal to scenario 4 in value-for-money terms. Both scenarios 4 and 5 still represent high value-for-money against recent guidance[5]. Variant scenario 5a delivers the highest level of absolute economic benefit amongst the electrification options.

4.1.15 Due to the uncertainty around capital costs of electrification at this early stage in the process, additional analyses have been undertaken to identify a target capital cost that would allow the appraisal to be financially neutral (ie. capital costs are covered by operating cost savings and revenue gain, across the life of the project). For the electrification scenarios, the results are:

- Scenario 3 £1,216m
- Scenario 4 £1,482m
- Scenario 5 £988m

4.1.16 These costs compare with a full scheme cost of £1,992m incorporating the +66% optimism bias. Further GRIP stage development work will provide more certainty to this analysis and reduce the optimism bias allowance.

4.1.17 An assessment of wider economic benefits is becoming increasingly important in making a case for a particular investment, especially when there are targeted funds and an overall constrained budget. This is because they help to quantify the impact on the real economy. However, the difference in relative WEBs by scenario would not alter the conclusions on the relative merit of the investment scenarios tested.

5 Conclusions

5.1.1 Based on today's service pattern, electrification delivers up to £34m (table 2) of financial benefit per annum, through operational savings (excluding capital expenditure). And over the 60-year appraisal period, at least £1bn will be saved in operating expenditure. The investment will continue to reduce the cost of rail to the taxpayer year on year. The analysis also demonstrates that there is a good case for an enhanced service. In financial terms, this would be best delivered with diesel trains; but, in the context of rolling stock availability, network consistency and the environmental objectives to which the railway is committed, the longer-term solution should be the extension of electrification from Newbury and Bristol towards Exeter, Plymouth and Cornwall.

5.1.2 Electrification permits, at a smaller running cost than is possible with diesel trains, the operation of an enhanced train service, which can bring valuable accessibility and economic benefits to towns and cities on the route. One reason for the savings identified has been the greater flexibility that can be offered through tailoring the train length to expected demand, and this is aided by electrification. There is considerable return to the south west economy as a whole from the substantial investment in the rail network (approx. £100m/year). This is in addition to financial (revenue) benefits of service enhancement, which have been calculated, in some of the service patterns analysed, to be as much as £20m per annum.

5.1.3 Investment in rail infrastructure and rail services will permit a virtuous circle of economic growth to be created: further investment in businesses, a growth in employment and other economic development, generated by reduced journey times and greater train frequencies to other parts of the country. In addition, electrification allows economic benefits to be delivered to the Far South West more cheaply

5 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/267296/vfm-advice-local-decision-makers.pdf p10.

and in an environmentally-friendly way. In today's world, where carbon reduction is an important part of government policy, and in which techniques are being refined to monetise its effect for appraisal purposes, it is important that account is taken of the carbon benefits of electrification.

5.1.4 The capital cost of electrification is very significant however, and will depend on the government's ability to afford it in the context of other financial priorities. Whilst operators will perceive the operating cost and revenue benefits, they would not be able to be realised over the course of a franchise of 7 to 15 years' duration. Any decision to electrify would be taken by the DfT in conjunction with Network Rail, and taking fully into account the franchise and rolling stock implications.

5.1.5 Electrification will allow the Far South West to take advantage of modern electric trains to replace the diesel High Speed Trains. A modern fleet of electric trains, with a high standard of passenger amenities on board, including enhanced luggage space given the flows on the West of England services, wi-fi, and other facilities designed to maximise the value of time to business and leisure travellers, is likely to allow the realisation of further economic and wider economic benefits.

5.1.6 It may be most appropriate to undertake the electrification in phases – and that fits in naturally with the delivery of the substantial investment programme. Early benefits could be realised to Exeter, extending subsequently to Plymouth, Paignton and ultimately Penzance. This may help to make the overall case for electrification stronger. Indeed, the benefits from an increased frequency deploying diesel trains, handing over to electric trains after the investment, may permit a higher level of benefits to be realised, taking the catalytic effect of a higher frequency into account.

5.1.7 The replacement of the High Speed Trains needs to be addressed on this route; plans are in place for their replacement on the rest of the Great Western network, and on the East Coast Main Line. A comprehensive programme of route electrification, infrastructure investment to ensure that the maximum potential of new high-powered trains can be used, and the procurement of a new fleet of electric high-speed trains, will permit improvements in the service to all places from Reading westwards, and especially to those towns and cities which are further away and generate significant demand. Furthermore, electric haulage will bring environmental benefits which are increasingly important with the current focus on reducing carbon emissions across all transport modes.

5.1.8 It is important that all stakeholders who stand to benefit from electrification, and these include all those transport authorities to the west of Newbury, make a strong and consistent case to the Department for Transport and to Network Rail about electrification. In particular it is necessary for the authorities to present a strong united front for:

- Network Rail's updated Electrification RUS;
- Network Rail's Western Route Study recommending a higher frequency of trains;
- Submissions about investment plans for Control Period 6 (initial consultation, Network Rail's initial strategic business plan, the DfT's plans for Control Period 6), from 2013 onwards;
- Discussions with bidders on service planning and rolling stock, for the Great Western franchise, and in due course, the Cross Country franchise, from 2014 onwards; and
- Discussions about localism – a process of partial or full devolution of the specification of services in a particular geographical area (from now onwards).

5.1.9 A consistent, strong message from all authorities, recognising that the economic and financial benefits to the communities on the network is substantially greater than the sum of the parts, will be of great benefit in making the case for investment.

5.1.10 A particular opportunity occurs in Control Period 6, for which planning is in its early stages. This runs from 2019 to 2024, and decisions will be taken about enhancements schemes that will feature by 2017/8 at the latest. Furthermore, it is in this same time period that the High Speed Trains will either need life extension or replacement: it is imperative that authorities engage early and positively with the DfT, Network Rail and operators/franchise bidders to ensure the right outcome for all concerned.

5.1.11 Once the case for the investment in electrification is made and accepted, the details of the train services can be refined to ensure that all locals needs can be met – albeit potentially with a phased introduction - and we recommend that this refinement is based on scenario 5/5a as this demonstrates the highest level of benefits from the electric scenarios. This will need to take into account the probability of a phased approach to delivery, demand patterns at the time, and a rolling stock cascade programme.

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