Updated impacts of changes in track access charges on the transport by rail of biomass

Report for Office of Rail and Road

May 2023

MDS Transmodal

CONTENTS

1. EXECUTIVE SUMMARY

The Office of Rail and Road (ORR) is currently undertaking the 2023 Periodic Review (PR23). This will ultimately determine what Network Rail must deliver during Control Period 7 (CP7, which covers the period from April 2024 to March 2029), as well as determining the track access charges paid for use of the rail network over this control period.

As part of PR23, ORR has commissioned MDS Transmodal to update the Biomass to Drax Transport Model (BDTM) that was developed in PR18, to estimate the potential impact of changes in track access charges on the transport by rail of biomass. This model represents the competition between ports (and domestic sourcing), for the supply of biomass to Drax based on inland transport costs. As well as switching between ports, it also included the potential impact of increased transport costs in terms of reducing the overall consumption of biomass. Updated estimates of these impacts can be used to inform ORR's proposals for setting the freight specific charge (FSC) for biomass traffic in CP7.

We have updated the results of the BDTM by firstly developing a reference case forecast of biomass traffic in 2028/29, and then testing the impact of different FSCs on the number of tonne kms transported by rail. The 2028/29 reference case included expected changes in drivers' wages and fuel costs, along with the Variable Usage Charge (VUC) increasing to uncapped rates, and the FSC remaining at end-of-CP6 levels (i.e. £1.599 per thousand gross tonne miles (kgtm), in 2022/23 prices). We then modelled the following alternative scenarios:

- Removing the FSC altogether
- Increasing the FSC by 25% to £1.999 per kgtm
- Increasing the FSC by 50% to £2.399 per kgtm
- Increasing the FSC by 100% to £3.198 per kgtm

Subsequently we have run equivalent scenarios but with VUC rates 20% higher, as reported in the appendix. This indicates that while the sensitivity of biomass traffic to a given FSC is to some extent impacted by the level of other rail costs (such as VUC rates), it does not vary very significantly.

To include all biomass traffics on the rail network, as well as biomass to Drax, the results include biomass from the port of Tyne to Lynemouth power station. There are no obvious options to viably use alternative ports, so port competition is not included for Lynemouth.

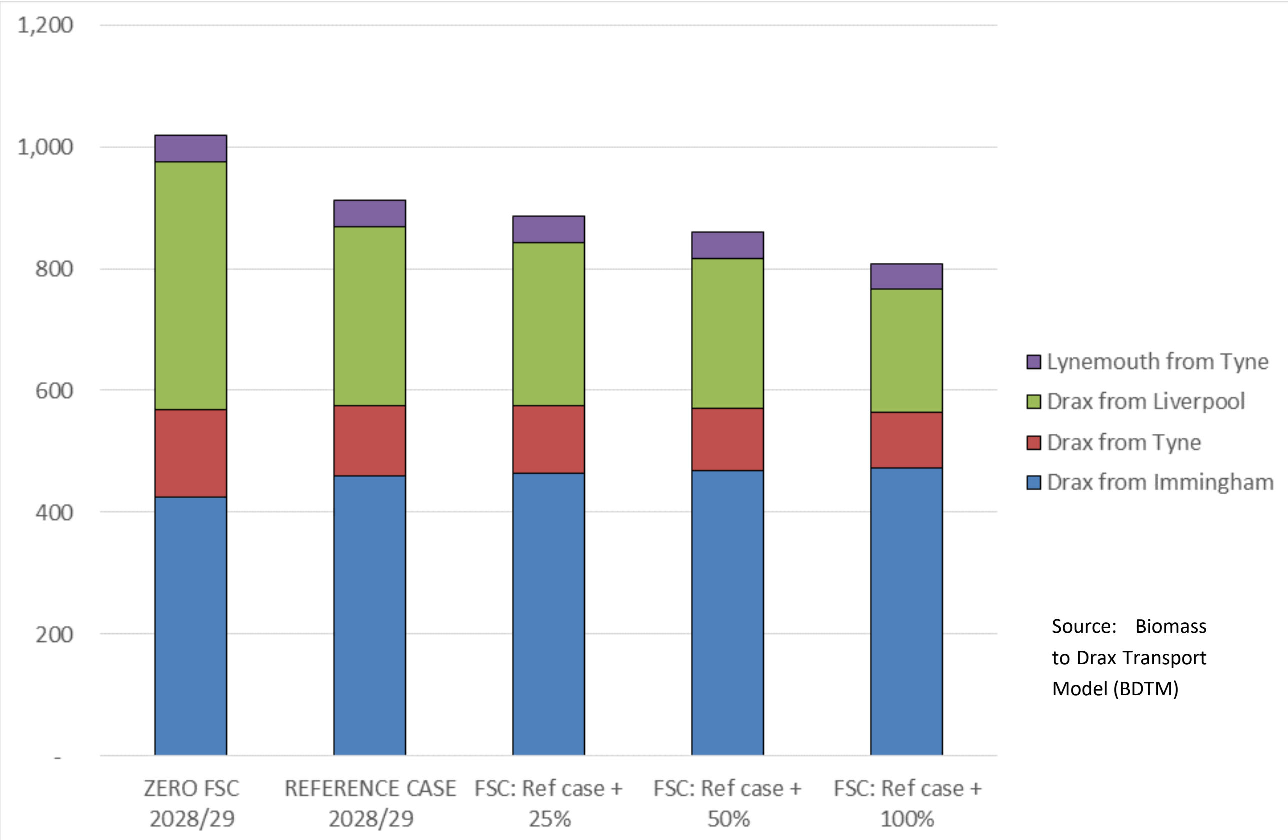
The results also include the estimated impact of changes on the FSC on overall biomass consumption (though this is not as significant as the impact of switching to different transport modes).

Table 1 and Figure 1 below present the impact in terms of rail tonne kms of changing the FSC from this 2028/29 reference case scenario.

Table 1: Biomass traffic (Million rail tonne kms) in 2028/29 for each FSC scenario, incorporating reduced consumption elasticity

Scenario	Drax by rail from…			Lynemouth from Tyne	Total	% Change from Ref case
	Immingham	Tyne	Liverpool			
ZERO FSC	424	144	407	42.5	1,018	11.7%
REFERENCE CASE	459	116	294	42.3	912	-
FSC: Ref case + 25%	465	109	269	42.3	885	-2.9%
FSC: Ref case + 50%	469	102	245	42.2	859	-5.7%
FSC: Ref case + 100%	474	89	202	42.1	808	-11.4%

Figure 1: Biomass traffic (Million rail tonne kms) in 2028/29 for each FSC scenario, incorporating reduced consumption elasticity



These results show that doubling FSC from the 2028/29 reference case would be estimated to reduce biomass traffic by rail (as measured in tonne kms) by 11.4%. Removing the FSC altogether would be estimated to increase biomass traffic by 11.7%. This is a larger modelled response to increased track access charges than in the work undertaken for PR18. This is primarily because for the PR23 work, road already has a significant share of traffic in the reference case, so changes in that share can make a meaningful difference to rail tonne kms. However, in the PR18 work, road was a very small component in the reference case, so struggled to gain a significant share of the market even with large increases in track access charges.

2. INTRODUCTION AND BACKGROUND

As part of the ORR's PR23 review of Network Rail's access charges, the ORR has been updating the market-can-bear analysis that underpins how they set freight infrastructure cost charges (ICCs) for the next control period (CP7). The ORR has confirmed that it will continue to permit an ICC to be levied on ESI biomass traffic for CP7[1]. This is known as the freight specific charge for biomass, or FSC. The next phase of the ORR's work involves reviewing the level of this FSC, to ensure that it continues to be set at an appropriate level, based on an updated view of ability to bear.

The main evidence base underpinning the existing biomass FSC is a study of relative biomass transport costs undertaken by MDS Transmodal as part of the ORR's PR18 review of charges[2]. This study involved developing a logit model representing competition between sources and routes to supply power stations with biomass. This model, known as the Biomass to Drax Transport Model (BDTM), was then used to estimate the impact of an increase in track access charges on Drax's choice of transport mode / method.

This modelling work indicated that the main impact of an increase in charges would be on port choice, with higher rail costs prompting Drax to re-route biomass from distant ports to nearby ports. There would be a small impact of higher charges on the actual quantity / volume of biomass transported.

Lynemouth is a separate, smaller biomass power station to Drax, which sourced all of its biomass via the nearby port of Tyne in the base year.

Based on the outputs of the modelling work, the ORR set an ICC for biomass equivalent to 75% of the end-CP5 average biomass variable usage charges, which the modelling suggested would be consistent with a less than 10% reduction in gross tonne miles for biomass. On a fully phased-in basis, this was equivalent to an FSC of £1.45 per kgtm (in 2017/18 prices, or £1.599 per kgtm in 2022/23 prices)[3].

For PR23, the ORR is seeking to update the results of this model, to reflect the latest available information on the costs of transporting goods by different transport modes, as well as more recent forecasts of freight traffic on the network. As far as possible, the ORR is also seeking to reflect recent changes in competition and substitutability within the UK's energy supply market, which may also have affected ability to bear an FSC on freight biomass traffic. This will inform its proposals for the level of charges paid by freight operators transporting biomass in CP7.

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[1] ORR, PR23 Review of access charges – Conclusions on charging framework, October 2022, https://www.orr.gov.uk/search-consultations/review-network-rails-access-charges. ESI means biomass for the electricity supply industry.
[2] The potential impact of increases in track access charges on the transport by rail of biomass, report by MDS Transmodal for ORR, April 2018, available here.
[3] See Section 2 of ORR's PR18 final determination supplementary document, October 2018, https://www.orr.gov.uk/sites/default/files/om/pr18-final-determination-infrastructure-cost-charges-consultation-conclusions.pdf.

The core task consisted of updating MDS Transmodal's BDTM, as set out in Section 4.3 of the 2018 report, to refresh the forecast impact of imposing an FSC on biomass volumes transported by rail. We have updated the BDTM accordingly to reflect current conditions and those expected in 2028/29, which is the final year of CP7. We have then tested further scenarios with various changes in track access charges, to understand the likely impact on biomass traffic movements.

The rest of this report describes the modelling update exercise, and the results of the modelled scenarios with different levels of track access charges.

- Section 3 summarises the BDTM and the PR18 work.
- Section 4 describes the updates made to the model for PR23.
- Section 5 summarises the model results.

3. SUMMARY OF BIOMASS TO DRAX TRANSPORT MODEL AND PR18 WORK

This section summarises how we developed the BDTM for PR18, and how it can be used to forecast the impact of changes in rail costs on volumes.

3.1. UK biomass market

Given the aim of decarbonisation, biomass has become an important component of the UK's energy mix in recent years. There is one major user of biomass (Drax) and another smaller plant at Lynemouth. There are several other smaller biomass power stations across the country. These smaller sites have been excluded from the study because they are unlikely to have viable significant rail freight opportunities in 2028/29.

The main component of biomass consumed in large UK power stations is wood pellets, and this is primarily sourced from North America and Europe. This is the only biomass product moved by rail. Drax also consumes small volumes of sunflower husk pellets, oat pellets and peanut husks. Other UK biomass power stations consume waste wood, straw, recycled wood and sawmill residues, along with a range of other biomass fuels.

After a period of co-firing coal with biomass, Drax's first biomass burning unit was converted from coal to biomass in 2013. Biomass tonnages by rail increased to around 6-7 million tonnes in 2015 and have been reasonably stable since then. By 2018, Drax had converted 4 of their 6 units to biomass, and in April 2023, they announced that their power generation from coal had come to an end.

✂

3.2. Biomass sources and transport routes

Drax uses several sources of biomass and transport routes to serve its biomass power station. Drax is likely to favour the cheapest source and transport route combination, and to choose to allocate the most traffic to that source and route. However, in order to have better resilience in times of disruption and to avoid being dependent on any one source and route, Drax chooses several source and transport route combinations. These are primarily from North America and Europe to a Northern English port:

- Then **by rail** from Tyne, Immingham or Liverpool to Drax
- Or **by road** from Hull (and from other locations) to Drax.

Any change in the overall cost of sourcing via any of these routes is likely to change the balance between the options. For example, if any one route became more expensive, some biomass would be likely to transfer to the other routes.

This allows us to model how Drax would likely change its source and route options if some options were to have increased costs as a result of increased ICCs , or lower costs. As ICCs are charged on a per tonne km basis, longer rail journeys pay higher ICCs per tonne. Increased ICCs are likely to result in a switch of some biomass from the routes involving long rail journeys (Liverpool and Tyne) to the routes involving short journeys (Immingham and Hull) and by road. Drax would experience a higher overall cost for its delivered biomass, and the amount of rail freight moved (measured in tonne kms) would decrease even if the overall tonnes delivered to Drax remained the same.

3.3. Developing a logit model

A logit model is a statistical model that represents the choice between several options based on cost. As such, it can be used to explain the mix of different transport options used to source biomass, and then explore how this mix changes when the relative costs of those options change.

We have previously developed and now updated such a logit model – the BDTM - for the biomass traffic that travels from the 3 ports of Tyne, Immingham and Liverpool by rail, and biomass by road, to Drax, based upon the flow of traffic moving by rail[4] and road.[5]

The logit model considers the 4 main route options open to Drax:

1. Arriving at Tyne, then by train;
2. Arriving at Immingham, then by train;
3. Arriving at Liverpool, then by train;
4. Arriving **by road** from Hull and other locations.

The model then shares the traffic between these options based on the full cost of delivering biomass via each route (including all purchase and transport costs to Drax). The higher the cost of a particular route, the smaller the proportion of the overall market it is able to capture. Mathematically for biomass route option ‘A’:

$$S_A \propto e^{-\frac{C_A}{\beta}}$$

where:

- S_A = Route A’s share of all the biomass traffic to Drax
- $\propto$ means: “is directly proportional to”
- e is the exponential function
- C_A = Full cost of delivering biomass to Drax via route A (including purchase costs)

[4] Source: Network Rail traffic data processed by MDS Transmodal, confirmed by HMRC trade data and Drax
[5] Source: Drax and HMRC trade data.

- β = Logit distribution parameter. This defines how much the traffic is spread amongst the various sourcing options. If a very high value is chosen, the cost of the route options is not very important and the model will allocate similar volumes of traffic to all 4 options unless there are very large differences in cost. If a very low value for β is chosen, cost is very important and the model will allocate nearly all of the traffic to the cheapest option, even if other options are only slightly more expensive.

We calibrated the model for the base year to ensure the proportions allocated by the model to each option reflect actual volumes of biomass transported by each mode. This calibration involves choosing an appropriate logit distribution parameter (β) and then adding some "intangible" costs to each option to reflect the fact that our model cannot encompass all factors relevant to Drax's decision making process. Those 'intangibles' effectively include the cost of using shipping and the different ports, along with reliability issues and a wish to have a diverse set of sourcing options.

In calibrating the original model in PR18 (for a 2017 base year), we concluded that an appropriate logit distribution parameter β was £0.50 per tonne. For the updated modelling exercise, we have increased this in line with inflation to the new base year (2021 Q4 – 2022 Q3) to give a β value of £0.57 per tonne.

A logit model works best when the options being considered are independent, and the quantities being predicted can be switched between the options when costs are changed, without any favouring of one alternative over another. The real world is not always this simple. For example, it might be easier to switch from Immingham to Liverpool because they are both by rail, rather than from Immingham by rail to Immingham by road. Conversely it may be easier to switch from Immingham by rail to road because the port would be unchanged. We have made the assumption that *in the long term*, biomass can switch between any of the options solely based on the cost changes, treating each option equally, even if in the short term, there may be some "stickiness" holding back some switches between options. This may slightly overstate the actual degree of responsiveness to changes in rail costs, though, for the time period we are considering (as discussed in the next section), we consider this to be a reasonable assumption[6].

On the other hand, the logit model only outputs the changes in the *proportion* of traffic using each source and route as a result of changes in costs. However, following the logic of supply and demand; if the cost of delivered biomass to Drax increases overall, this will make their electricity more expensive to produce and they are likely to be able to sell less of it in the competitive electricity market. The results of the BDTM shown in section 5.1 ignore any reduced consumption as a result of increased costs. However, in section 5.2 we consider this additional aspect of potential reduction in biomass volumes.

[6] Likewise, we have also ignored potential capacity constraints such as port capacity and the ability to secure timetabled paths from the ports to Drax. Where changes in volumes from each port are relatively modest, we consider this is a reasonable simplifying assumption.

3.4. Volatility of energy markets

Recent months have seen large increases and then subsequent declines in the wholesale price of gas – which has encouraged the use of other fuels such as biomass for electricity generation. However, this does not affect competition between the ports, which is the main component of the model. There will also still be a biomass consumption response to a changed overall delivered price, irrespective of the market conditions.

Drax's Renewables Obligation Certificates (ROC) subsidies will end in March 2027 which could potentially damage the viability of Drax and biomass in general. Drax is currently investing in Bioenergy with Carbon Capture and Storage (BECCS) technology and has entered into formal discussions with UK Government on large-scale Power BECCS. If this comes to fruition and proves highly effective, they may well increase their biomass consumption above current levels. However if the technology is not developed as hoped, biomass consumption could well be below current levels.

Again, so long as there are some significant volumes of biomass to Drax, there will be competition between the ports, and a biomass consumption response to a changed overall delivered price, such that the modelled percent changes in biomass tonnes and tonne kilometres by rail are still relevant.

The nature of the model is such that it implicitly assumes that the port competition, rail freight and electricity markets will fully respond to their changed charges when they are introduced. Inevitably some elements of the market take time to adjust to their new circumstances.

4. UPDATING THE BIOMASS TO DRAX TRANSPORT MODEL FOR PR23

This section explains the updates that have been made to the model for PR23, and the assumptions used. The subsections cover the time periods, biomass volumes, transport costs and the scenarios tested.

4.1. Time Periods

4.1.1. Base year

To ensure we are reflecting recent developments in the market, it is beneficial to use as recent a base year as possible. The model has therefore been updated to a new base year with biomass tonnage data for the 12 months to the end of September 2022: i.e. 2021 quarter 4 to 2022 quarter 3, with transport costs reflecting the same period.

4.1.2. Future Reference Case year

The PR23 charges review determines Network Rail's charging framework for CP7, which runs from 2024/25 to 2028/29. As such, the ORR is primarily interested in how demand for rail freight would change in response to changes in track access charges over this period. To be consistent with previous analysis, the main focus is on volumes in the final year of CP7 (2028/29). We have made the assumption that by this time, most existing contracts between Drax and the ports will have ended, such that they would be free to negotiate new contracts with the ports with the knowledge of upcoming changes in FSC. However, we recognise that some contracts may actually expire a year or two beyond this date, such that there may not be full flexibility in port choice in 2028/29. The model's costs changes for future years are in real terms.

4.2. Biomass Volumes

Table 2 shows the data we have obtained on biomass volumes to Drax from various sources, for the base year (2021 Q4 to 2022 Q3).

Table 2: Million Tonnes of biomass moved as provided by various data sources

	Period	Rail				Road
		Immingham	Liverpool	Tyne	Hull	
Rail data (to Drax)	2021 Q4 – 2022 Q3	✄	✄	✄	✄	
…Of which	2022 Q1-3 only	✄	✄	✄	✄	
Trade data (road/rail split not provided)	2022 Q1-3 only	2.73	1.44	1.06	0.22	
Information from Drax	2021 Q4 – 2022 Q3	✄	✄	✄	✄	✄

Notes:

- Rail data is sourced from MDS Transmodal's processing of Network Rail's billing data.
- UK Trade data[7] only started being reported by port at the beginning of 2022 (previously the port was not recorded for EU trade).
- The 2022 rail data we have obtained from Network Rail closely matches the trade data well for Immingham and Liverpool – where the biomass virtually all goes to Drax. ✄
- The information from Drax very closely corroborates the rail data from Network Rail ✄.

In light of the above, we have used the rail data obtained from Network Rail as the source for rail traffic for our base year. For road-sourced biomass, we are largely reliant on information obtained from Drax. We have therefore used this data. ✄. Overall, the biomass traffic to Drax by port has remained reasonably consistent with that in 2017, when the BDTM was created. However the main change is that a greater proportion of biomass from the port of Hull is transported to Drax by road.

In estimating volumes for the reference year (2028/29), we must make an assumption about how volumes will change from our base year. Biomass traffic by rail to Drax has been reasonably stable over recent years (albeit with short-term fluctuations, as shown in Figure 2 below), and our recent central case 2028/29 forecasts for Network Rail[8] suggested that such traffic would remain largely unchanged from its 2021 base year. We have retained this assumption of stability for this modelling exercise, and have assumed that the tonnage in our base year remains constant up to 2028/29. This assumption reflects Drax's current investment plans, which involve investment in Bioenergy with carbon capture and storage (BECCS), to operate 2 burners continuously and 2 non-BECCS burners at 'peak' times, which would lead to consumption levels which are similar to current levels. High gas

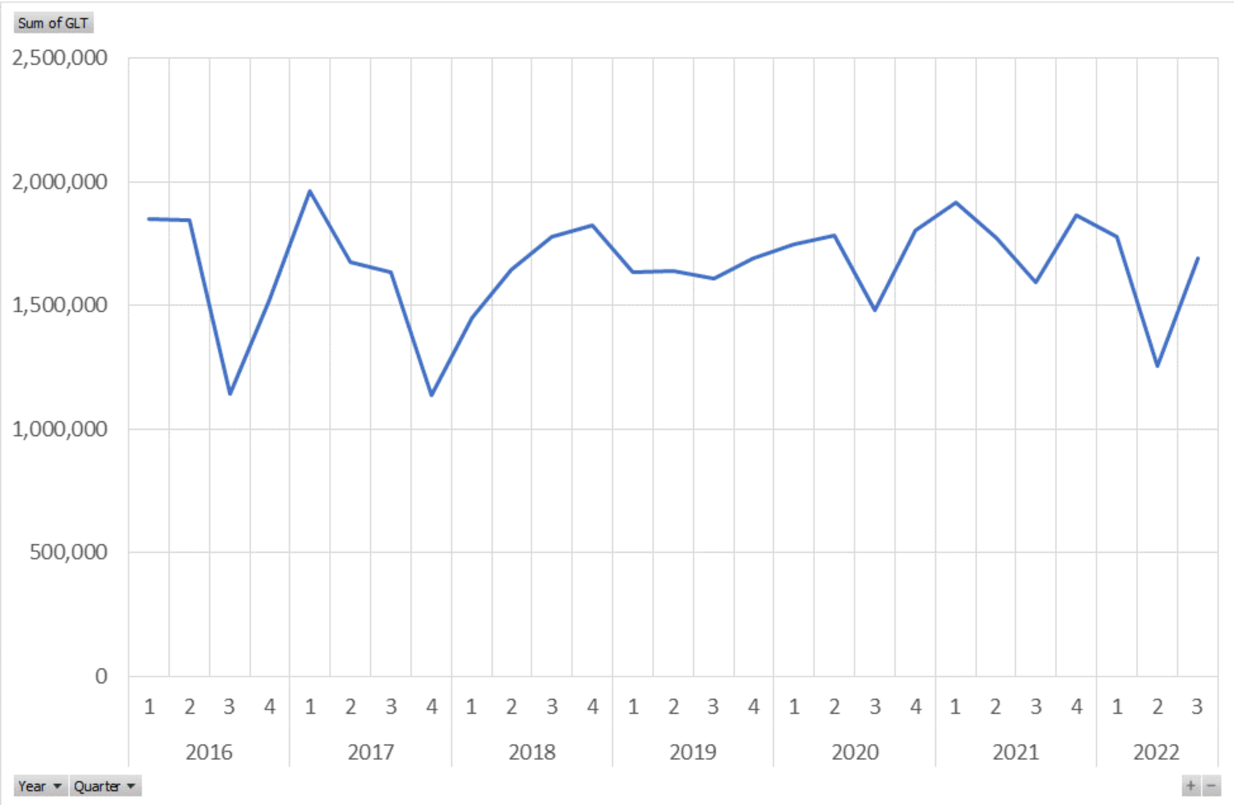
[7] https://www.uktradeinfo.com/trade-data/

[8] These forecasts involved forecasting rail freight demand and then suppressing that demand in line with expected network capacity available to freight. The results will inform Network Rail's business plans and be the basis for their rail freight growth targets for CP7. The report is expected to be published imminently on Network Rail's website.

prices may encourage the burning of more biomass, but if BECCS proves difficult or expensive, this may reduce the attractiveness of using biomass.

We have discussed this assumption with Drax and they have agreed that this is a reasonable assumption to make, albeit all parties acknowledge there is a large degree of uncertainty, with the Contracts for Difference (CfD) government subsidies coming to an end in 2027, and the timing and level of support for BECCs as yet unclear.

Figure 2: Tonnes of biomass by rail to Drax in recent years, by quarter



Source: MDS Transmodal processing of Network Rail billing data.

Lynemouth is the only other rail-served biomass power station in addition to Drax. All of Lynemouth's biomass by rail is sourced through the nearby port of Tyne, so there is minimal opportunity for easily switching between sources if its rail costs were to increase.

We are not aware of proposals for any new biomass power stations sourced by rail, and do not believe that the economics would be favourable to encourage the private sector to develop such new sites given the risk that Renewables Obligation Certificates (ROC) subsidies may cease in the coming years.

All biomass carried on the rail network is for the electricity supply industry (ESI).

4.3. Transport Costs

As explained in Section 3, the BDTM depends on the relative costs of transport via the different ports (or domestically by road), so it is important for us to update the rail and road cost models accordingly to calibrate the base year.

The cost models are built up of the various cost components that make up the overall running costs of HGVs and trains, and are often compared to actual market rates for validation. Values for some cost components are readily available from public domain sources, while others are based on our experience and market knowledge. The rail cost model includes Variable Usage Charges (VUC) and FSC rates for the appropriate period, which are chargeable to wagons (loaded and empty), and locomotives.

To inform our cost model, we have looked at a recent period of Network Rail billing data (October 2022) to find the typical:

- Wagon choice by port
- Number of wagons per train – this is typically ✂.
- Tonnes of biomass per wagon – this is typically ✂.
- Average distance travelled from each port to Drax (loaded direction):
    - Immingham 104 km
    - Liverpool: 217 km
    - Tyne: 186 km
- Average journey times to Drax (loaded direction):
    - Immingham: ✂
    - Liverpool: ✂
    - Tyne: ✂
- Number of roundtrip journeys each wagon makes per day
    - Immingham: ✂
    - Liverpool: ✂
    - Tyne: ✂

The majority of wagons used are IIA-D wagons.

Using this information, we estimate that the current transport cost per cargo tonne of biomass delivered by rail (2022/23 price base) is:

- ✂ from Immingham
- ✂ from Liverpool
- ✂ from Tyne

This includes all the costs of running the train, but excludes terminal costs at both ends of the journey. This matches reasonably well with information provided by Drax, with our results being slightly lower for Immingham, and slightly higher for Liverpool, and very close for Tyne.

Most of the biomass by road to Drax comes from Hull port. We calculate that the current transport cost per tonne of biomass delivered from Hull by road is ✂. This includes the costs of running the HGV, but excludes terminal costs at both ends of the journey. Drax report a slightly lower figure.

HGVs carrying biomass to Drax also come from ✂. Using distances and journey times for each origin, we calculate the current weighted average transport cost per tonne of biomass delivered by road to be £8.35.

It is helpful for the BDTM to have a reasonably accurate representation of the overall costs by road and rail. However, the most important factor is the level of track access charges paid, and how that could change in different scenarios. We have been able to accurately determine that in the base year from the Network Rail data, based on the routes taken, the wagons used and the tonnage in each wagon, for each delivered biomass consignment. This was based on the billing data we receive from Network Rail for input into our GB Freight Model.

In modelling terms, if we were to have slightly different costs (other than the FSC component) in the base year, this would just mean that the calibration factors attached to each port would have to change in order to again arrive at the observed source shares in the base year (see section 3.3). Therefore the assumptions on base year costs are not that crucial to the final results, so long as the FSC is correctly represented.

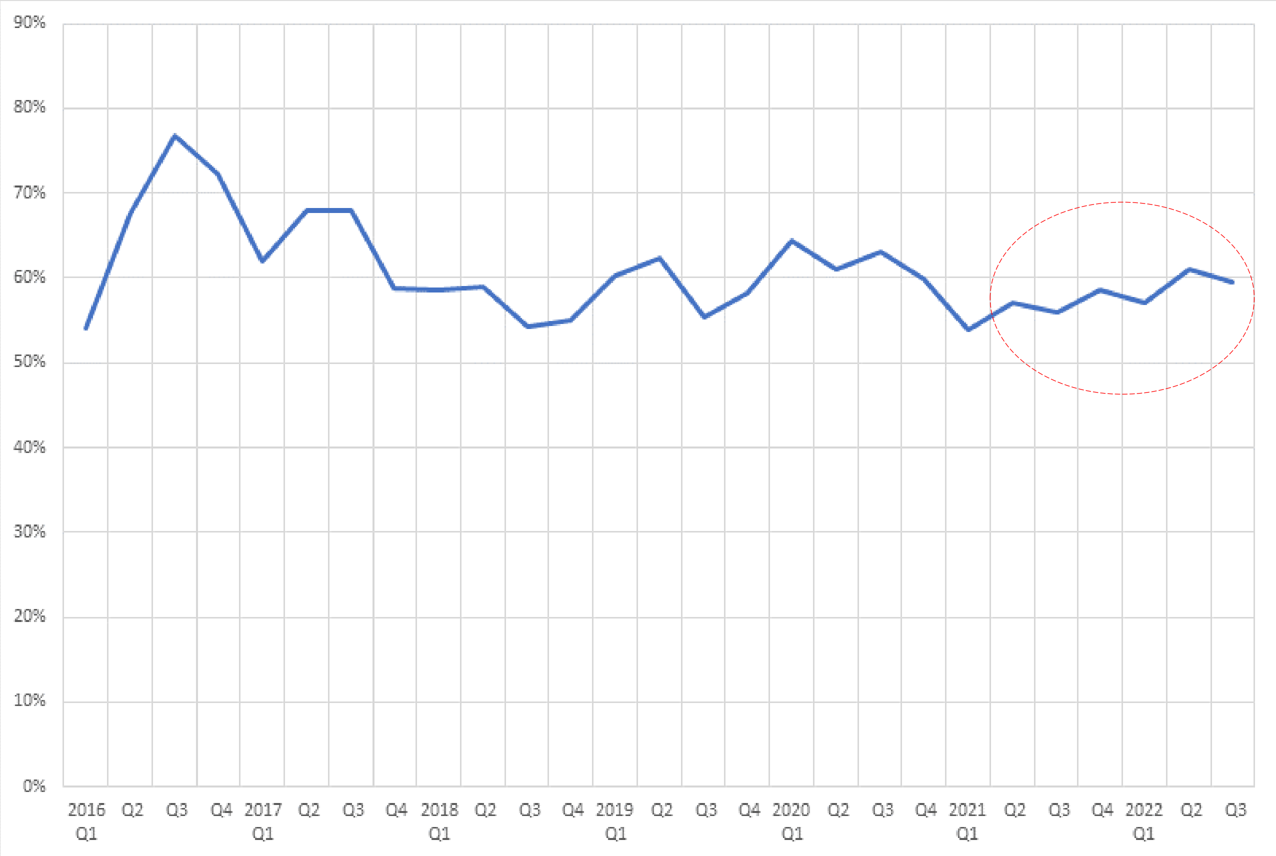
In contrast to the original modelling work, which was used to set a FSC on biomass traffic for the first time, we note that the FSC is currently being levied on freight operators. This potentially provides an opportunity to validate the BDTM's response to changes in FSCs, by comparing with actual data showing how the nearby ports' (Immingham and Hull) share of biomass volumes has increased at the expense of the long-distance ports (Liverpool and Tyne) since the FSC was introduced. However:

- the FSC is being phased-in over the course of CP6 and so operators only began paying this charge in April 2021 (at a relatively low level). This also coincided with increases in the VUC.
- it can take some time for markets to fully respond.
- there are other things going on in the market that can affect port shares that can drown out any small impact from changes in track access charges.

For all these reasons, it is difficult in practice to robustly discern any impact of the introduction of the biomass FSC using historic data.

Nevertheless, we have considered the available data. Figure 3 below shows how the nearby ports' (Immingham and Hull) share of total biomass traffic arriving by rail to Drax (i.e. also including the more distant ports of Liverpool and Tyne) has changed over recent years.

Figure 3: Nearby ports' share of total biomass traffic arriving by rail to Drax in recent years



Source: MDS Transmodal processing of Network Rail billing data.

There is potentially some indication that the short-range ports have slightly increased their share since 2021 quarter 2, when the FSC was introduced (although it is not a consistent increase over those quarters). This would be broadly consistent with the expected impact of an FSC, and with the BDTM's outputs. However, there was larger variation in the graph in earlier quarters, with much more significant changes to the graph in 2016. This suggests that the small changes in access charges seen since April 2021 are likely to be overwhelmed by other events in the market, such that it is difficult to robustly discern any relationship between increased charges and nearby ports' share.

4.4. Scenarios

As explained in Section 3.3, we have calibrated the model for the base year such that it is outputting traffics consistent with the observed rail volumes by each port, and sourced by road.

To represent the 2028/29 reference case, some inputs to the cost models have been changed from their base year (2021-Q4-to-2022-Q3) levels. These changes take on board anticipated changes in drivers' wages and fuel costs based on the latest available data from DfT's Transport Analysis Guidance (TAG v1.20.2, January 2023). They also reflect planned changes in VUC and FSC rates as determined by ORR's decisions on the CP6 and CP7 charging frameworks:

Table 3: 2028/29 assumptions relative to base year (2021-Q4-to-2022-Q3)

2028/29 assumptions relative to base year	Value
Drivers' wages	+8.13%. Source: TAG table A1.3.2
Fuel resource cost	-12.6%. Source: TAG table A.1.3.7
HGV fuel duty	+9.70%. Source: TAG table A.1.3.7
Rail fuel duty	+0.69%. Source: TAG table A.1.3.7
VUC loco (class 66)	+31%. These VUC rates are consistent with ORR's existing capping and phasing-in policy for VUC rates, whereby these rates reach their fully cost-reflective levels by 2028/29
VUC Loaded wagon	+43%
VUC Empty wagon	+2%
FSC (wagon and loco)	+150% to £1.599/kgtm (2022/23 price base). This is the 2023/24 rate, which is assumed to remain constant for the 2028/29 reference case. Note that the base year is represented by an average of 2021-22 and 2022-23 values.
Tonnage of biomass consumed at Drax sourced by rail	Same as the model's base year (as explained earlier in this section)

Having calibrated the reference case based on the assumptions above, we then tested four alternative scenarios involving different assumptions for the level of the biomass FSC, as follows:

- Removing the FSC altogether.
- Increasing the FSC by 25% to £1.999 per kgtm
- Increasing the FSC by 50% to £2.399 per kgtm
- Increasing the FSC by 100% to £3.198 per kgtm

In the base year, tonnages and throughputs were as shown in Table 4, together with our estimates for road and rail costs. The logit model was calibrated to reproduce these base year tonnages. We then forecast volumes for the 2028/29 reference case using the logit model, for the scenario described above.

Table 4: Port traffic, market shares and inland transport costs: Biomass to Drax (base year & reference case forecast)

	Immingham rail	Tyne rail	Liverpool rail	Road	Total
BASE YEAR (2021 Q4 - 2022 Q3)					
'000s cargo tonnes	✂	✂	✂	✂[9]	✂
Share	✂	✂	✂	✂	✂
Estimated cost. £/tonne	✂	✂	✂	✂	
of which FSC	✂	✂	✂	-	
Rail million cargo tonne kms	✂	✂	✂	-	✂
REFERENCE CASE 2028/29					
'000s cargo tonnes	✂	✂	✂	✂	✂
Share	62.0%	8.8%	19.0%	10.1%	100.0%
Estimated cost. £/tonne	£2.66	£4.53	£6.16	£8.52	
of which FSC	£0.21	£0.38	£0.44	-	
Rail million cargo tonne kms	459	116	294	-	869

Source: Biomass to Drax Transport Model (BDTM).

Note: In this report, tonne kms always refers to cargo (net) tonne kilometres i.e. not including the weight of the wagons themselves.

It can be seen that Liverpool and Tyne (long distance journeys, therefore with a higher overall FSC per tonne transported) decrease their shares relative to the base year. This is largely because FSC and VUC are both assumed to increase significantly from the base year to the 2028/29 reference case.

The next section presents the expected impact of changing the FSC on Drax's transport mode choices.

[9] ✂.

5. MODEL RESULTS

5.1. Results without reduced consumption

This section presents the results of the updated BDTM exercise, as described in Section 4.

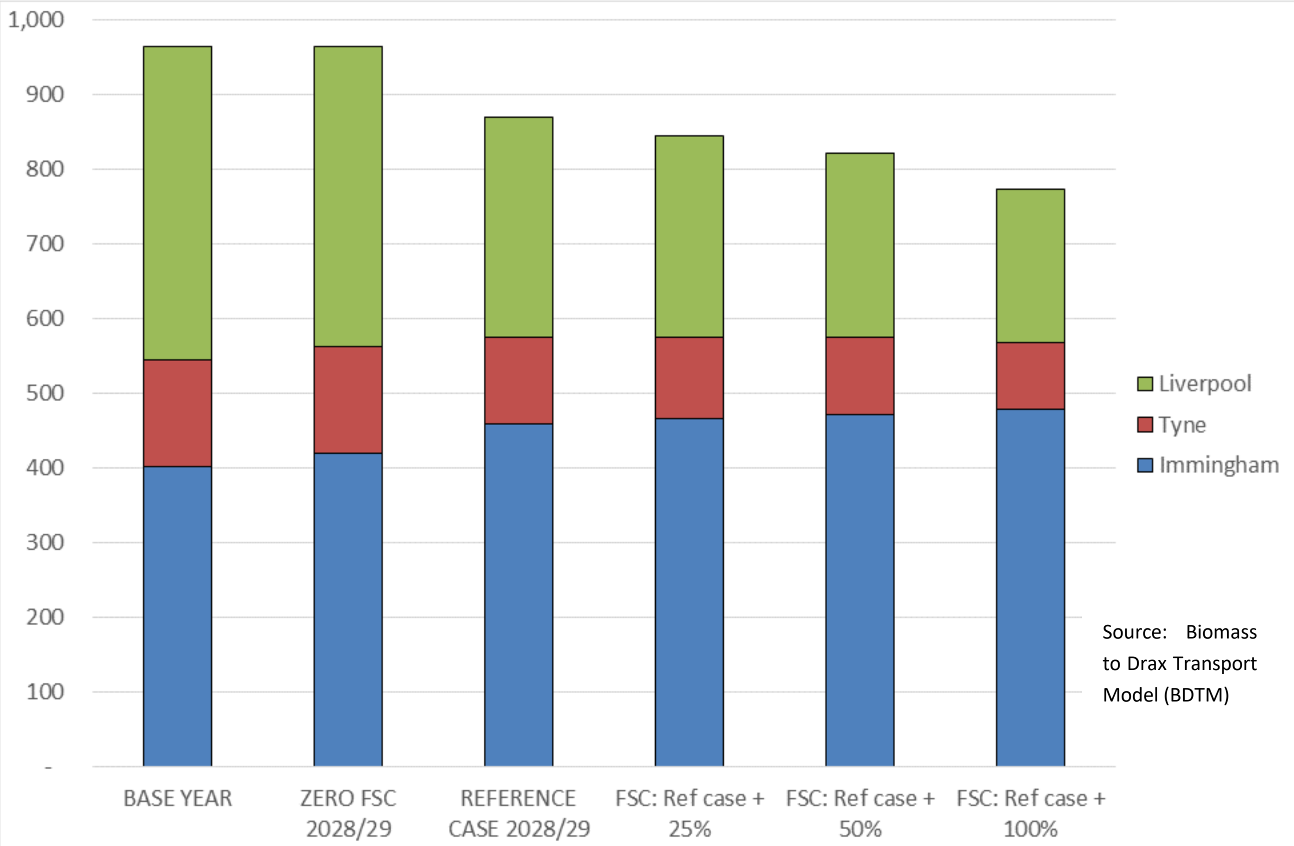
The key modelled output of interest is rail *tonne kilometres* – rather than the rail *tonnes,* as this captures the impact of different FSCs on overall use of the rail network (which is the primary focus of interest for this study. For each scenario, Table 5 and Figure 4 present the total number of estimated rail tonne kms compared to the reference year, and how this is disaggregated by different port sources. This captures the impact both of switching to / away from road-sourced biomass, as well as the impact of re-optimising the mix of rail-sourced biomass from the different ports, in response to the changes in transport costs. This is intended to represent the decision-making process of Drax in selecting port and mode, in responses to changes in the FSC.

Table 5: Biomass traffic to Drax in 2028/29 with changed FSC by source and scenario

	Immingham rail	Tyne rail	Liverpool rail	Road	Total
ZERO FSC					
Share	56.8%	10.8%	26.1%	6.4%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	420	142	403	-	965
REFERENCE CASE					
Share	62.0%	8.8%	19.0%	10.1%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	459	116	294	-	869
FSC: Ref case + 25%					
Share	63.0%	8.3%	17.5%	11.3%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	466	110	270	-	845
FSC: Ref case + 50%					
Share	63.7%	7.8%	16.0%	12.5%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	472	103	247	-	821
FSC: Ref case + 100%					
Share	64.6%	6.8%	13.2%	15.3%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	478	90	204	-	773

Source: Biomass to Drax Transport Model (BDTM).

Figure 4: Biomass to Drax. Million annual cargo tonne kms by rail by port by scenario



Source: Biomass to Drax Transport Model (BDTM)

It can be seen that increasing the FSC has the effect of reducing the total rail tonne kms by switching cargo from long distance ports to short distance ports and road. Specifically, the BDTM suggests that a doubling of FSC from the 2028/29 reference case would lead to an **11.1% reduction in rail freight traffic (tonne kms)**. Removing the FSC would instead lead to an **11.0% increase in tonne kms**. These scenarios (along with the 25% and 50% FSC increase scenarios) suggest a near linear relationship whereby every 10% increase in FSC from the reference case results in roughly a 1.1% reduction in rail freight traffic (tonne kms).

Table 6 summarises tonne kms from Table 5 and also shows the 'composite delivered cost' for each scenario. The 'composite delivered cost' is a standard output from a logit model that represents the overall cost that Drax faces to receive biomass from its variety of sources (incorporating purchase and transport costs). It can be thought of as an average cost which also incorporates the benefits of having several choices, and is therefore cheaper than the cheapest individual option. It includes the average purchase cost to a UK port of £160 per tonne (sourced from UK trade statistics; HMRC), plus the cost of transporting biomass from port to the power plant. The main use of the composite cost is to be able to compare the overall delivered cost of biomass to Drax for different scenarios to estimate the impact on overall consumption - see section 5.2.

Table 6: Biomass traffic to Drax, composite cost faced by Drax by scenario

Scenario	Rail million cargo tonne kms, 2028/29	Composite delivered cost, 2028/29 (£/tonne)
ZERO FSC	965	162.13
REFERENCE CASE	869	162.39
FSC: Ref case + 25%	845	162.45
FSC: Ref case + 50%	821	162.51
FSC: Ref case + 100%	773	162.63

Source: Biomass to Drax Transport Model (BDTM);

As shown in Table 6, a higher FSC results in a higher composite cost of biomass received at Drax. Specifically, the model suggests that a doubling of FSC from the 2028/29 reference case would lead to a 23.5 pence per tonne increase in composite delivered cost. This compares with a 24.9 pence per tonne change if the route shares were unchanged; i.e. the increased cost is slightly mitigated by changing the route shares. Similarly, removing FSC would instead lead to a 26.3 pence per tonne decrease. These scenarios (along with the 25% and 50% FSC increase scenarios) again suggest a near linear relationship whereby every 10% increase in FSC from the reference case results in approximately a 2.5 pence increase in composite delivered cost.

5.1.1. Lynemouth power station

In the base year there were ✂ million tonnes of biomass by rail from the Port of Tyne to Lynemouth. As with Drax, we assume that this tonnage continues unchanged for the 2028/29 reference case. As Lynemouth only makes up 4% of the biomass rail tonne kms in the base year, if Lynemouth tonnage were to significantly change, it is unlikely to make a large impact on the conclusions of this study.

This is a short rail journey where the FSC in the 2028/29 reference case is only £0.10 per cargo tonne. Large increases in FSC would have little impact on the choice of source or port because the proportion of overall costs made up by FSC is so small that even large percentage increases have little effect on overall delivered cost, and there are no other nearer suitable ports that the traffic could be easily transferred to.

5.2. Reduced consumption as a result of increased costs

The results presented above assume that increases in the FSC only have an impact on the choice of biomass sources and transport routes, and have no impact on the *overall* consumption of biomass. However following the logic of supply and demand; if the cost of delivered biomass to the power stations increases, this will make their electricity more expensive to produce and they are likely to be able to sell less of it in the competitive electricity market.

In previous work in 2012 on the coal market for the ORR[10], we estimated the elasticity of coal demand with respect to overall delivered cost for each power station. From this coal elasticity we derived an approximate consumption elasticity for biomass for our original BDTM for the PR18 work, accounting for its lower calorific value per tonne. Accounting for inflation to 2022/23 price base, this becomes:

Adding £1.23 per delivered tonne reduces biomass burn by 5%.

The nature of the electricity market has changed since 2012 and 2018, and there has been particularly significantly volatility in wholesale markets in the last year (as discussed in Section 3.4). It is therefore likely that this elasticity is different now, and will change between now and 2028/2029. Nevertheless, we can use this elasticity assumption as an illustrative indication of the impact of a different FSC on overall biomass consumption, as a way of capturing this element of the relationship between track access charges and rail freight volumes for biomass.

In the modelled scenario where the FSC increased by 100% from the 2028/29 reference case, we have a £ / delivered tonne increase of £0.24 per tonne for Drax (composite cost of £162.39 increasing to £162.63), and £0.10 per tonne for Lynemouth. Using the elasticity estimate above, this would result in a 1.0% decrease in biomass consumption at Drax and a 0.4% decrease in biomass consumption at Lynemouth. Overall this is a 0.9% decrease in biomass consumption across the two power stations – which serves to reduce the overall rail tonne kms slightly further than the results presented above.

Table 7 and Figure 5 below show the resultant total rail tonne kms under each scenario, incorporating this additional impact on overall biomass consumption.

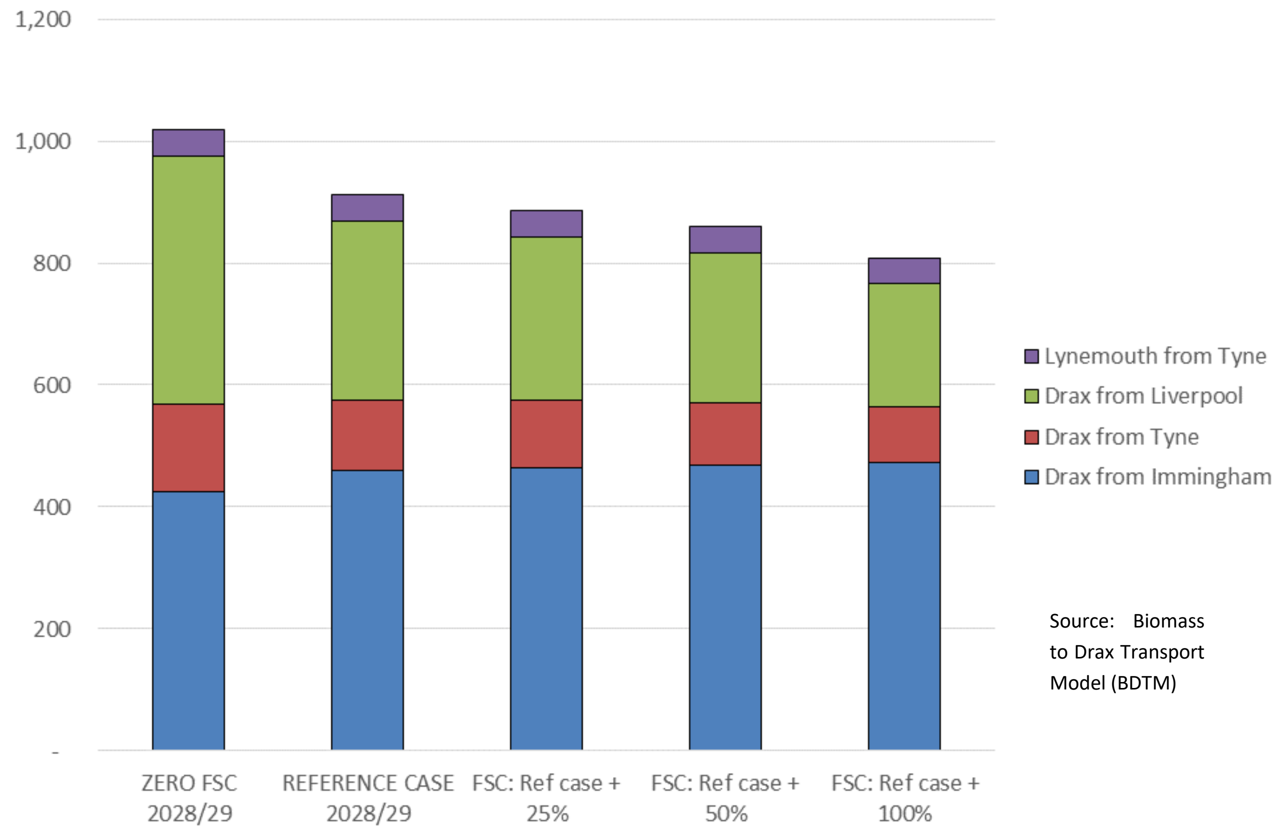
Table 7: Biomass traffic (Million rail tonne kms) in 2028/29 for each FSC scenario, incorporating reduced consumption elasticity

Scenario	Drax by rail from…			Lynemouth from Tyne	Total	% Change from Ref case
	Immingham	Tyne	Liverpool			
ZERO FSC	424	144	407	42.5	1,018	11.7%
REFERENCE CASE	459	116	294	42.3	912	-
FSC: Ref case + 25%	465	109	269	42.3	885	-2.9%
FSC: Ref case + 50%	469	102	245	42.2	859	-5.7%
FSC: Ref case + 100%	474	89	202	42.1	808	-11.4%

Source: Biomass to Drax Transport Model (BDTM)

[10] "Impact of changes in track access charges on freight traffic. Stage 2 Report", July 2012: http://orr.gov.uk/__data/assets/pdf_file/0016/1780/mdst-freight-tac-changes-jul2012.pdf

Figure 5: Biomass traffic (Million rail tonne kms) in 2028/29 for each FSC scenario, incorporating reduced consumption elasticity



Source: Biomass to Drax Transport Model (BDTM)

These results show that doubling the FSC from the 2028/29 reference case would reduce biomass traffic by rail (as measured in tonne kms) by **11.4%**. This is slightly higher than the equivalent result without any adjustment for reduced overall consumption (11.1%).

As noted above, the true biomass **consumption** elasticity may be higher or lower than the elasticity used to derive these results. We have therefore run some sensitivity tests to show the model's output would change if:

- the biomass **consumption** elasticity was halved
- the biomass **consumption** elasticity was doubled

The results are shown in the table below.

Table 8: Varying the biomass consumption elasticity. Results for the default elasticity, and sensitivity tests for the elasticity halving and doubling.

	Default elasticity		Elasticity HALVED		Elasticity DOUBLED	
Scenario	Million Rail Tkm	% Change from Ref case	Million Rail Tkm	% Change from Ref case	Million Rail Tkm	% Change from Ref case
ZERO FSC	1,018	11.7%	1,013	11.1%	1,029	12.8%
REFERENCE CASE	912	0.0%	912	0.0%	912	0.0%
FSC: Ref case + 25%	885	-2.9%	887	-2.8%	883	-3.1%
FSC: Ref case + 50%	859	-5.7%	861	-5.5%	855	-6.2%
FSC: Ref case + 100%	808	-11.4%	811	-11.0%	800	-12.2%

Default elasticity: Adding £1.23 per delivered tonne reduces biomass burn by 5%.
Source: Biomass to Drax Transport Model (BDTM)

Although there is significant uncertainty about the true consumption elasticity for biomass, both now and in future, it can be seen from Table 8 that in terms of rail tonne kms, the impact of changing this biomass **consumption** elasticity even by significant amounts is relatively small.

5.3. Comparison to equivalent work for PR18

For this work, the biomass transport market to Drax is little changed from that in PR18, with similar annual tonnes and similar port shares. The main difference is that biomass sourced from Hull has switched from rail to road. This means that the overall share of biomass traffic forecast to be transported by road is significantly higher in this reference case year (a 10.1% share in 2028/29) than in the previous reference year for the PR18 work (a 0.2% share in 2023/24).

For the PR18 work, the increases in track access charges modelled were based on different VUC rates, whereas this work has focused on changes to the FSC paid by freight operators. In absolute terms, a 100% increase in VUC rates for Liverpool represented an increase of 64 pence per tonne (73 pence in 2022/23) prices. In this work, a 100% increase in FSC for Liverpool represents an increase of 44 pence per tonne. This means that the scenarios being considered in this work involve lower changes in track access charges – in absolute terms – than in PR18. However, the impact on rail tonne kms in response to a 100% increase in VUC / FSC rates is very similar in both PR18 (down 11.2%) and PR23 (down 11.4%), despite these representing different absolute increases in track access charges as explained above.

The reason why biomass volumes transported by rail are more sensitive to a given change in track access charges in this updated work is due to a greater willingness to shift mode to road, as represented by the BDTM logit model. Because road is a well-established option in the PR23 work, with 10.1% market share in the 2028/29 reference scenario, the model indicates that Drax is more easily able to transfer significant extra tonnages to road when cost of transporting biomass by rail increases, with market share increasing to 15.3% in the "FSC: Ref case + 100%" scenario. However, in the PR18 work, road was starting from a very low base (0.2% market share in the future reference case), so even with a significant increase in rail costs, the extent to which road transport could increase its share of the market was limited: increasing to 0.5% in the "VUC Ref case + 100%" scenario.

This means that any absolute increase in track access charges results in a slightly larger modelled response (in terms of reduced rail tonne kms) in this PR23 work than it did in the PR18 work.

Drax's choice to transport biomass from Hull by road may be in part due to technical reasons and its difficulty in accommodating deliveries by train to supply some of its units, rather than purely being based on relative transport cost. In such circumstances, changes in cost for different options may not impact so directly on its road traffic in the short term, but could still impact on Drax's choices and incentives. For example, if there was an increase in rail costs, the incentive to resolve any technical challenges requiring the extensive use of road would be reduced.

APPENDIX: ADJUSTED VUC ASSUMPTIONS FOR BIOMASS

The results presented in this study incorporate the assumption that VUC rates would increase in line with ORR's existing capping and phasing-in policy, such that this charge reaches its fully cost-reflective level (as calculated in PR18) by 2028/29[11].

In order to understand the sensitivity of these results to changes in the VUC, the ORR requested that the BDTM be re-run, but testing an illustrative assumption that VUC rates would be 20% higher.

This appendix reports on the revised results when this increased VUC rate is used, and compares the revised results to the main results.

1. Revised results without reduced biomass consumption

This section presents the revised results of the modelling exercise i.e. how freight volumes change under the scenarios along with the implied elasticity with respect to changes in FSC. These revised results can be compared to the tables in the main report.

Revised Table 5, Revised Figure 4 and Revised Table 6 show the revised results **without** incorporating reduced consumption as a result of increased biomass delivered costs.

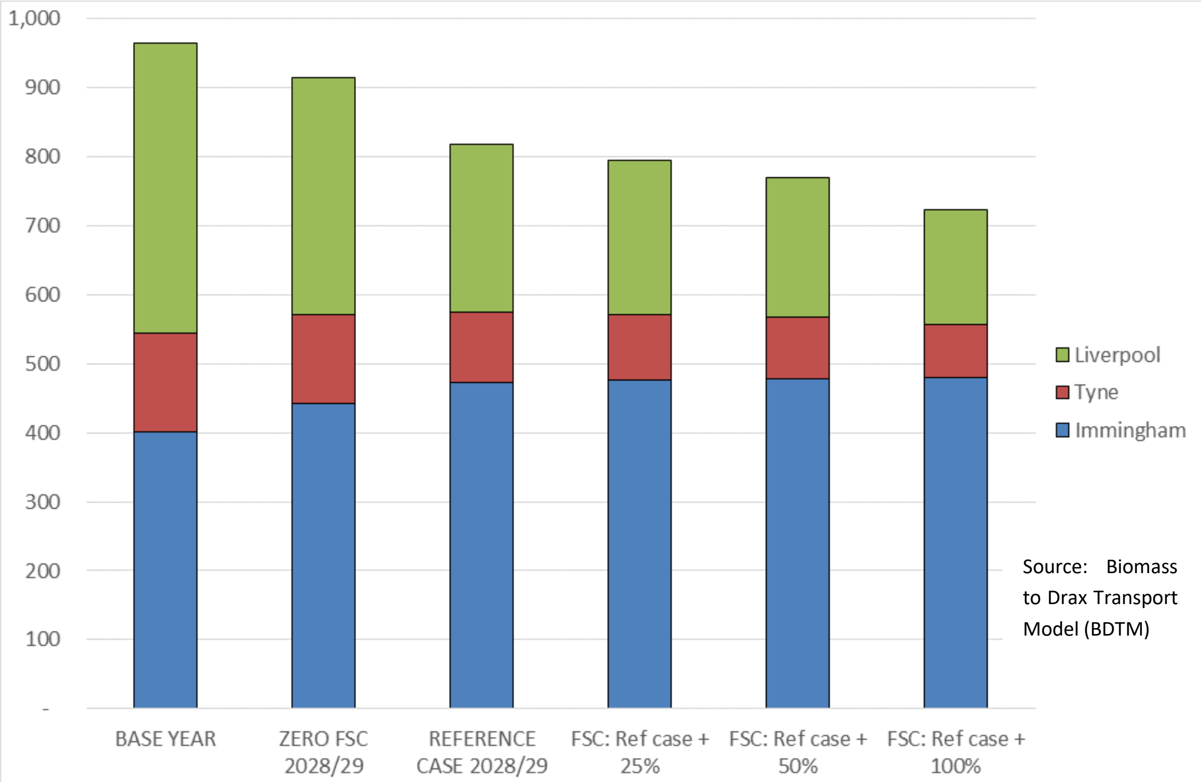
[11] See Section 4.4 of this report.

Revised Table 5: Biomass traffic to Drax in 2028/29 with changed FSC by source and scenario

	Immingham rail	Tyne rail	Liverpool rail	Road	Total
ZERO FSC					
Share	59.8%	9.7%	22.2%	8.2%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	443	129	343	-	915
REFERENCE CASE					
Share	63.8%	7.7%	15.8%	12.7%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	472	102	244	-	819
FSC: Ref case + 25%					
Share	64.3%	7.2%	14.4%	14.0%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	476	96	223	-	794
FSC: Ref case + 50%					
Share	64.7%	6.8%	13.1%	15.5%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	479	90	202	-	770
FSC: Ref case + 100%					
Share	64.8%	5.9%	10.7%	18.7%	100%
'000s cargo tonnes	✄	✄	✄	✄	✄
Rail million cargo tonne kms	479	77	166	-	722

Source: Biomass to Drax Transport Model (BDTM).

Revised Figure 4: Biomass to Drax. Million annual cargo tonne kms by rail by port by scenario



The BDTM suggests that a doubling of FSC from the 2028/29 reference case would lead to an **11.8% reduction in rail freight traffic (tonne kms)**. Removing the FSC would instead lead to an **11.8% increase in tonne kms**. These scenarios (along with the 25% and 50% FSC increase scenarios) suggest a near linear relationship whereby every 10% increase in FSC from the reference case results in roughly a 1.2% reduction in rail freight traffic (tonne kms). This is similar to the results in the main report (using the baseline assumption for VUC rates in 2028/29), under which a 10% increase in the FSC results in a roughly 1.1% reduction in rail freight traffic.

Revised Table 6 summarises the tonne kms from Revised Table 5 and also shows the 'composite delivered cost' for each scenario.

Revised Table 6: Biomass traffic to Drax and composite cost faced by Drax by scenario

Scenario	Rail million cargo tonne kms, 2028/29	Composite delivered cost, 2028/29 (£/tonne)
ZERO FSC	915	162.27
REFERENCE CASE	819	162.52
FSC: Ref case + 25%	794	162.58
FSC: Ref case + 50%	770	162.63
FSC: Ref case + 100%	722	162.74

Source: Biomass to Drax Transport Model (BDTM);

As shown in Revised Table 6, the model suggests that a doubling of FSC from the 2028/29 reference case would lead to a 22.1 pence per tonne increase in composite delivered cost. This compares with a 23.5 pence per tonne change if the route shares were unchanged; i.e. the increased cost is slightly mitigated by changing the route shares. Similarly, removing FSC would instead lead to a 24.9 pence per tonne decrease. These scenarios (along with the 25% and 50% FSC increase scenarios) again suggest a near linear relationship whereby every 10% increase in FSC from the reference case results in approximately a 2.3 pence increase in composite delivered cost.

2. Revised results WITH reduced consumption as a result of increased costs

A 20% higher VUC rate in 2028/29 would increase biomass delivered cost in all the 2028/29 scenarios, compared with the estimates in the main report. This would therefore have the effect of reducing demand in the 2028/29 reference case scenarios as well as other FSC scenarios for Drax. It would also slightly reduce traffic at Lynemouth too.

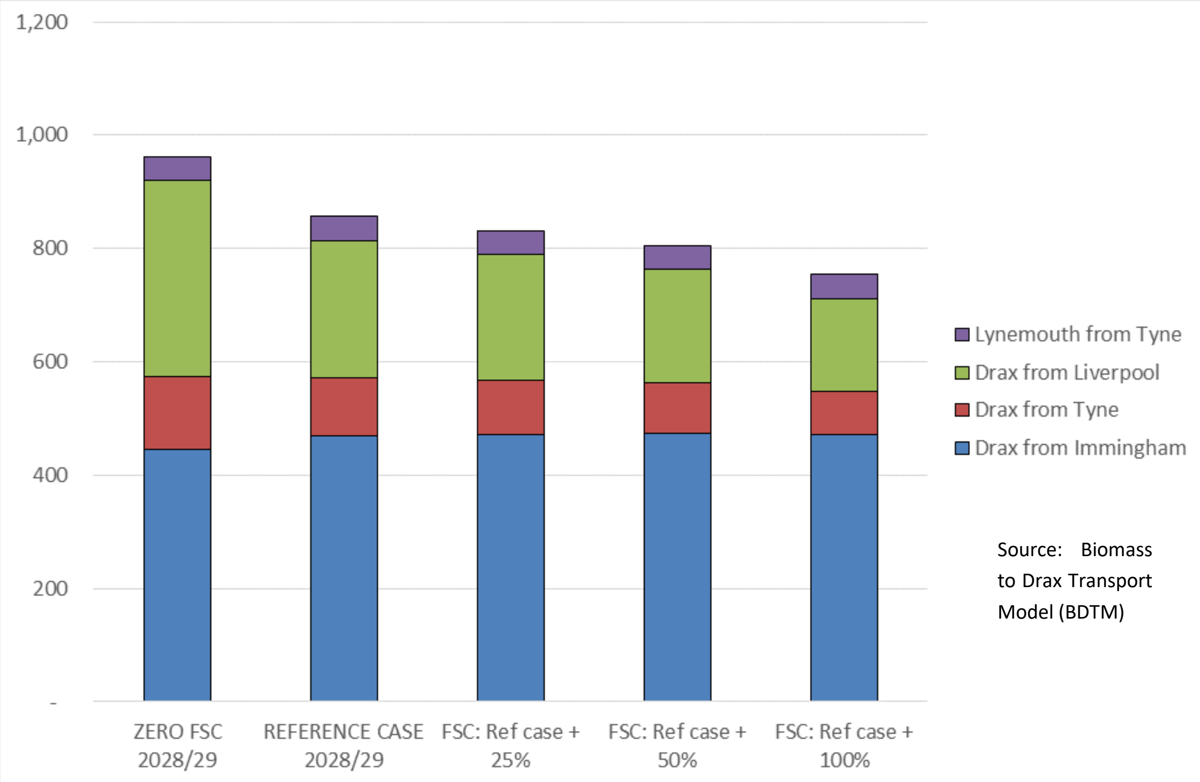
Revised Table 7 and Revised Figure 5 reflect the revised results incorporating the reduced consumption elasticity (as discussed in Section 5.2 of the main report).

Revised Table 7: Biomass traffic (Million rail tonne kms) in 2028/29 for each FSC scenario, incorporating reduced consumption elasticity

Scenario	Drax by rail from…			Lynemouth from Tyne	Total	% Change from Ref case
	Immingham	Tyne	Liverpool			
ZERO FSC	445	129	345	42.4	962	12.3%
REFERENCE CASE	470	102	243	42.2	857	-
FSC: Ref case + 25%	472	95	221	42.2	831	-3.0%
FSC: Ref case + 50%	474	89	200	42.1	805	-6.0%
FSC: Ref case + 100%	472	76	163	42.0	754	-12.0%

Source: Biomass to Drax Transport Model (BDTM)

Revised Figure 5: Biomass traffic (Million rail tonne kms) in 2028/29 for each FSC scenario, incorporating reduced consumption elasticity



These results show that doubling the FSC from the 2028/29 reference case would reduce biomass traffic by rail (as measured in tonne kms) by **12.0%**. This is slightly higher than the equivalent result without any adjustment for reduced overall consumption (11.8%).

Revised Table 8 shows the revised results if alternative values for the biomass consumption elasticity are used.

Revised Table 8: Varying the biomass consumption elasticity. Results for the default elasticity, and sensitivity tests for the consumption elasticity halving and doubling.

	Default elasticity		Elasticity HALVED		Elasticity DOUBLED	
Scenario	Million Rail Tkm	% Change from Ref case	Million Rail Tkm	% Change from Ref case	Million Rail Tkm	% Change from Ref case
ZERO FSC	962	12.3%	960	11.7%	966	13.4%
REFERENCE CASE	857	0.0%	859	0.0%	852	0.0%
FSC: Ref case + 25%	831	-3.0%	834	-2.9%	825	-3.2%
FSC: Ref case + 50%	805	-6.0%	809	-5.8%	797	-6.5%
FSC: Ref case + 100%	754	-12.0%	759	-11.6%	744	-12.7%

Default elasticity: Adding £1.23 per delivered tonne reduces biomass burn by 5%.
Source: Biomass to Drax Transport Model (BDTM)

3. Comparison to main results (without VUC + 20%)

Incorporating a 20% increase in VUC over and above the expected VUC increases assumed in the main report, increases the cost per km of rail freight. This increases the delivered cost per tonne more for long distance rail journeys than it does for short distance rail journeys. This favours Immingham and penalises Tyne and Liverpool. As all rail journeys are more expensive, there is also a switch of some cargo to road. This reduces the rail tonne kms in the reference case.

As the overall average (composite) cost of delivering to the power stations increases, there is an effect of reducing overall tonnage demand too.

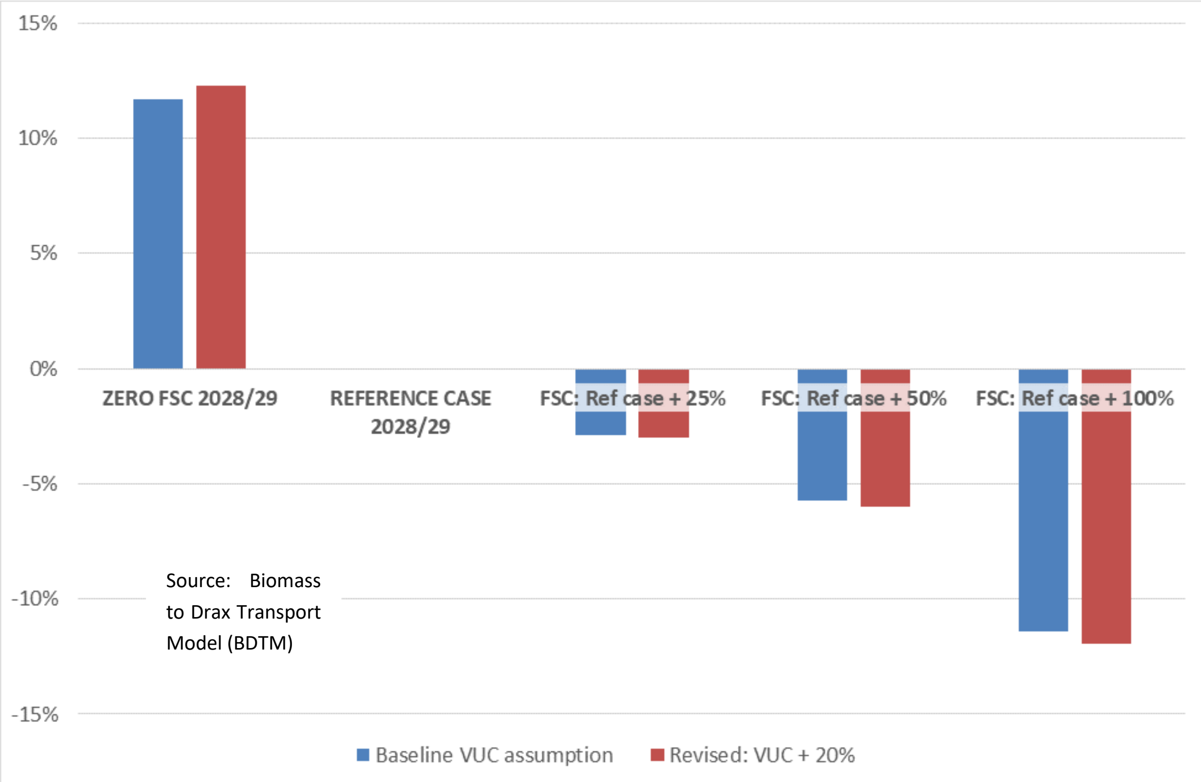
However the main area of interest is not in how a higher assumed VUC rate affects the traffic in each modelled scenario, but whether it significantly affects the **difference** between the scenarios and the derived elasticities.

Table 8: Comparing the revised (VUC + 20%) traffic and elasticities with the March 2023 results

	Baseline VUC assumption		Revised: VUC + 20%		Change	
Scenario	Million Rail Tkm	% Change from Ref case	Million Rail Tkm	% Change from Ref case	Million Rail Tkm	% Change from Ref case
ZERO FSC	1,018	11.7%	962	12.3%	-56	0.6%
REFERENCE CASE	912	0.0%	857	0.0%	-55	0.0%
FSC: Ref case + 25%	885	-2.9%	831	-3.0%	-55	-0.1%
FSC: Ref case + 50%	859	-5.7%	805	-6.0%	-54	-0.3%
FSC: Ref case + 100%	808	-11.4%	754	-12.0%	-54	-0.6%

Source: Biomass to Drax Transport Model (BDTM)

Figure 6: Million Rail Tonne kms. % Change from Reference case



It can be seen that increasing the VUC by 20% in all 2028/29 scenarios (relative to the baseline VUC assumption) has the effect of slightly increasing the rail tonne kms elasticities with respect to increasing FSC. This is largely due to the fact that road is slightly more attractive relative to rail in the revised scenarios. In the reference cases, road has:

- 10.1% tonnes market share in the main results
- 12.7% tonnes market share in the revised results (VUC + 20%)

This slightly larger market share in the revised reference case gives road more scope to grow its share. For example, for the scenario in which the biomass FSC is doubled, the road tonnes market share increases by:

- 5.2% to 15.3% in the main results
- 6.0% to 18.7% in the revised results (VUC + 20%)

This greater loss of traffic to road in the revised results contributes to a slightly larger elasticity in the revised results.

However the extent of the difference in elasticities is relatively small; with doubling FSC resulting in:

- an 11.4% loss of rail Tkms in the main results (incorporating the reduced consumption elasticity); and
- a 12.0% loss of rail Tkms in the revised results

This indicates that while the sensitivity of biomass traffic to a given FSC is to some extent impacted by the level of other rail costs (such as VUC rates), it does not vary very significantly.