Case Study 2 How Russian coal is delivered to a power station in the Aire Valley

A COAL END-TO-END FREIGHT JOURNEY

A Coal End-to-End Freight Journey considers the movement of imported coal through the Port of Immingham and its journey by rail to a power station in the Aire Valley – a route of 76 miles. It focuses on the efficiencies, reliability, causes of delay and the issues that the industry faces.

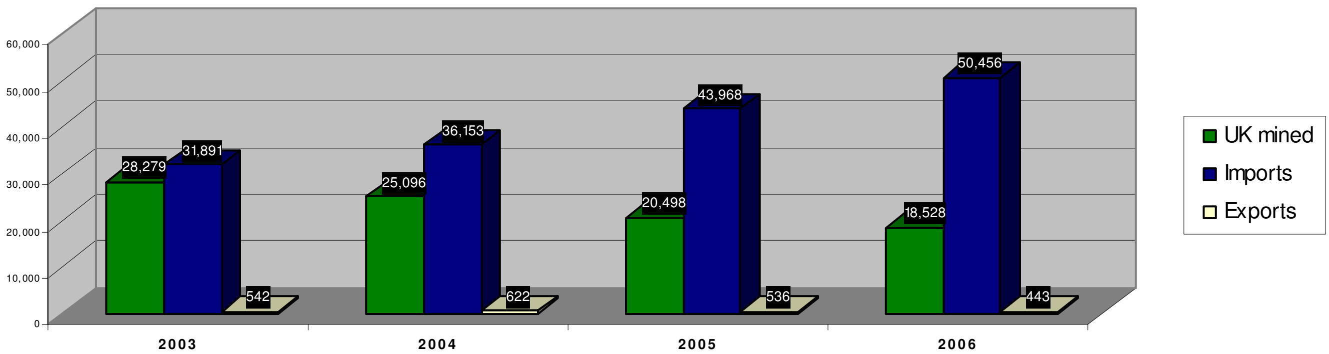
The case study is based on a single live journey undertaken in early 2008. The journey was chosen at random and is not intended to carry the weight of statistical evidence; rather, its purpose is to illustrate some of the common issues faced by freight operators and to assist readers in understanding where opportunities for efficiency improvements may exist.

Courtesy of EWS Energy

Key facts about the coal industry in the UK

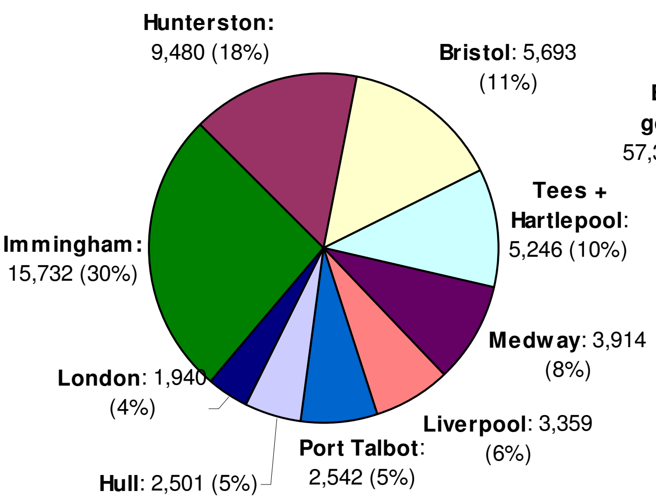
- A significant majority of coal is now imported (Figure 1).
- Coal represents 10% of all UK major port traffic (MDST, UK Port demand forecasts to 2030, 2006).
- The largest coal port is Immingham (Figure 2) in Lincolnshire.
- The majority of coal is used for electricity generation (Figure 3); therefore the largest movement of coal in the UK is from maritime ports to coal-fired power stations. In 2007, the Port of Immingham supplied power stations a combined 12.1 million tonnes of coal (the remaining 3 million tonnes of coal passing through Immingham are largely for steelworks).
- The three power stations in the Aire Valley have the largest electricity capacity in the UK with a 7,785 mw capacity per day.
- The location of power stations is historic: for example, the Aire and Trent Valley stations were built near coal mines, rather than being positioned at maritime ports to receive coal imports.
- Rail is the dominant mode for transporting coal. In 2006, rail transported 82% of UK's coal and it travelled 8.77 billion net tonne kms in the UK in 2006-07 (an average haul of 201 kms). This is the largest commodity moved by rail in the UK.

Figure 1: Coal's Import/Production Split (Per Thousand Tonnes)



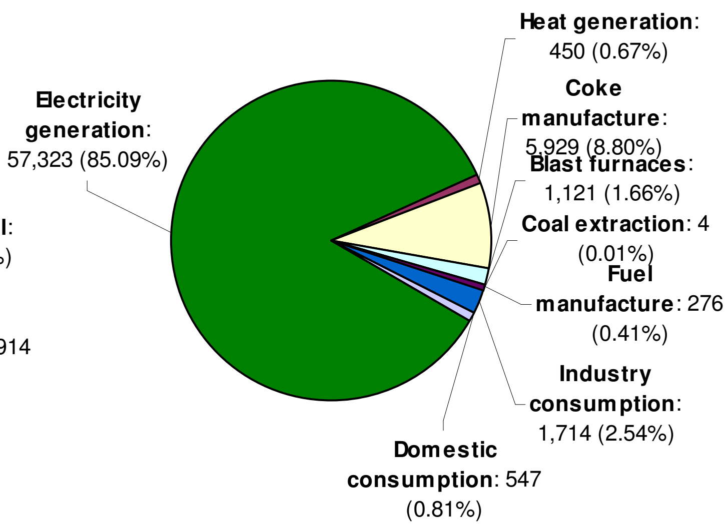
Source: Coal production and stocks 1970-2006, BERR (2006)

Figure 2: Coal's Major Port Traffic
(Per Thousand Tonnes)



Source: Maritime Statistics, DfT (2006)

Figure 3: Coal's Uses
(Per Thousand Tonnes)



Source: Commodity Balances 2006: Coal, BERR (2006)

UK energy forecasts

Figure 4: Forecast of electricity demand to 2020 (Terawatt hours)

Year	Electricity Demand	Electricity from coal-fired power stations	% coal-fired electricity
2000	346.3	111.9	32.3
2005	361.0	116.0	32.1
2010	352.0	90.0	25.5
2015	359.0	81.0	22.5
2020	381.0	62.0	16.3

Source: Updated Emissions Paper, DTI, 2004

Figure 4 presents energy forecasts to 2020. It forecasts electricity demand rising by some 5.5% between 2005 and 2020 but coal-fired electricity generation declining from 116 terawatt hours in 2005 to 62 terawatt hours in 2020. This decline would take coal's share of electricity generation from 32% in 2005 to just over 16% in 2020. However, coal-fired plants believe that the decline in coal-fired generation capacity is unlikely to be as rapid as originally forecast as a consequence of 12 of the UK's 18 coal-fired power stations expected to be fitting flu gas desulphurisation equipment in response to the EU Large Combustion Plants Directive (LCPD) (MDST, UK Port demand forecasts to 2030, 2006).

Daily coal requirements for each coal-fired power station vary and are dependent on customer demand. The coal transported to the power stations feed directly into their furnaces and they rely on a reliable and secure supply chain of both indigenous and imported coal to ensure that the power station meets the day's requirements. When a planned supply of coal is cancelled, the power station must draw on its stockpiles, which have a separate supply chain and are for reserve purposes only.

Courtesy of Chris Wilson

The UK coal market

The coal market is driven by power station demand and an active commodities market.

Today's power stations have an average stockpile of just 30 days. They are for contingencies only and power stations rely on a robust and diverse supply chain to feed their day-to-day needs, typically holding a portfolio of contracts with multiple ports, rail operators and coal suppliers.

It is a fluid environment: forward plans are made but much of the picture can change due to weather patterns, plant outages, movements in the price of coal and coal's chief competitor: natural gas.

Weather patterns

The size of the annual coal market is most dependent on the weather, which drives the absolute level of demand and impacts upon the price of natural gas. Cold weather will increase demand from 250,000 tonnes to 700,000 tonnes at winter's peak. Spring and autumn are the difficult seasons to predict and therefore to estimate coal transport demand.

A 2007 MDS Transmodal study forecasts a decrease in coal tonne kms for the UK energy market; from 7.8 billion kms in 2005 to 5.6 billion kms in 2015, however it notes that future demand for coal will be heavily influenced by any carbon trading arrangements in place and the market price of carbon credits at that time. Wholesale gas prices will also be key.

Rail freight operators face uncertainty going forward due to:

- The future locations of power stations are uncertain and this has impacts on transport planning because, for example, powers stations closer to ports would reduce the demand for rail.
- The unit price for origin and destination is fixed, but the volumes, paths and times change week-to-week. This means that rail freight operators don't have certainty in the deployment of their resources and must forecast power station requirements.
- The key message we hear from the coal freight industry is that freight investment and a finalised Government energy policy are interrelated.

The price of coal

The price of coal can depend on many things. It is a global market and outside the control of the UK government. For example, the world price for coal increased from US$75 last year to US$135. This was due, in part, to China's much increased demand for coal, oil and iron ore.

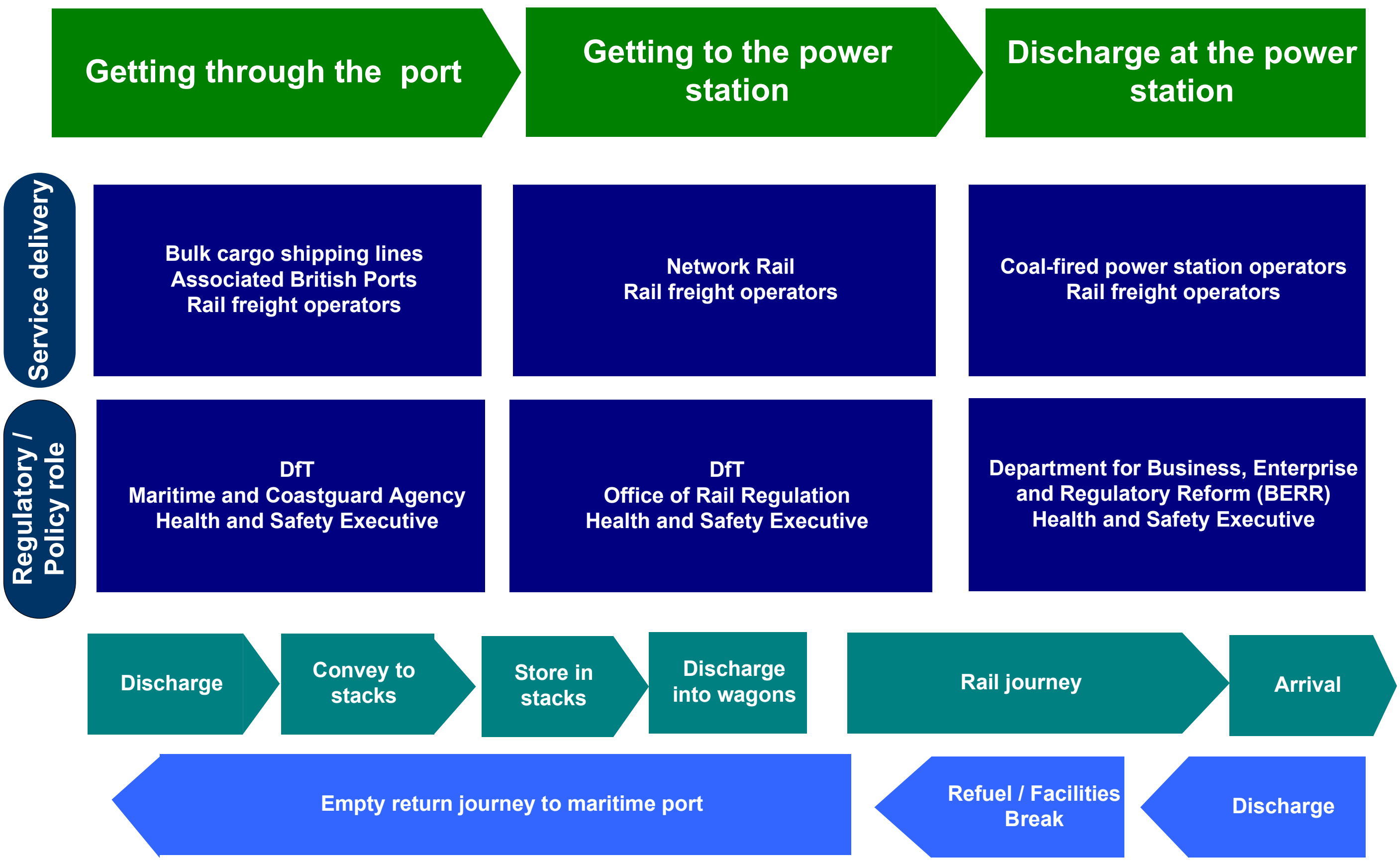
How does an increase in iron ore impact upon the price of coal? One reason is that coal is transported in the same type of bulk ships as iron ore; therefore increased iron ore demand means that there will be less bulk ships for coal and potentially less coal on the market. The restriction, or forecasted restriction, of supply has thereby increased the world price for coal.

The scenario

A power station in the Aire valley in North Yorkshire purchases 60,000 tonnes of coal from a Russian coal mine in the Urals. The coal has been railed from the Urals to Murmansk and is shipped by bulk carrier across the Barents Sea to the Humber International Terminal at the Port of Immingham on the north east coast of England. Two rail freight operators are contracted by the power station to transport the coal from Immingham to the power station, moving 40 loads of 1,470 tonnes (21 wagons with a 70 tonne coal capacity per wagon) over 12 days.

This case study takes each stage of the journey in turn. Figure 5 provides a simplified overview of the end-to-end journey of the first delivery of coal from its arrival at the port through to its discharge at the power station. It considers each segment of the journey: what happens, who has service delivery responsibilities and who has regulatory and policy roles.

Figure 5: The end-to-end journey of coal from port to power station



Source: Department for Transport (2008)

Getting through the port → Getting to the power station → Discharge at the power station

The journey from Russia

The coal is sourced from an open-cast mine in the Urals and railed to Murmansk (a distance of 1,200 kms) where it remains at the coal terminal for 7 days before it is sold by a coal merchant to the Aire valley power station. The power station then arranges shipment to Immingham and rail to the power station.

Discharging the coal at Immingham

1. After travelling 1,511 nautical miles, the bulk carrier docks at the Humber International Terminal on the River Humber at 10am. The terminal handles 13 million tonnes of coal each year and it supplies coal by rail to six coal-fired electricity stations in the Aire and Trent valley.

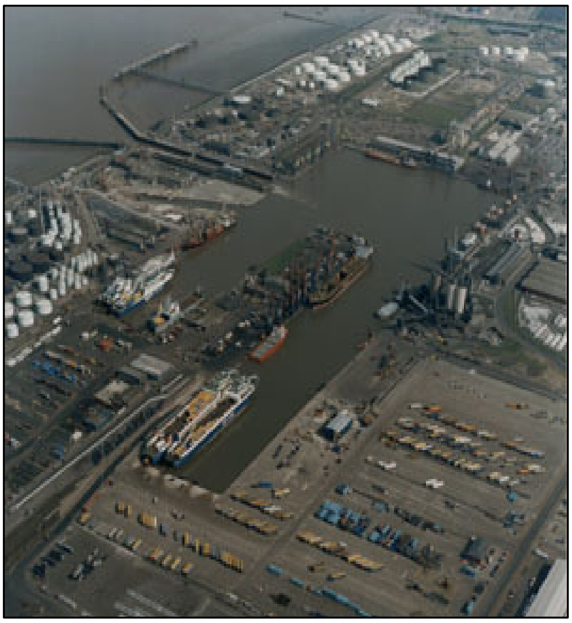
Ship arrivals are generally on time with the port operating a "time of arrival" system that allocates windows for docking. Delays usually only occur when there is a simultaneous arrival of vessels (due, for example, to inclement weather); in such circumstances the bulk ship will wait off the Humber for a berth to become vacant.

Docking may take up to six hours depending on River Humber tides. Once discharged, the bulk ship takes another six hours to leave the port, again depending on tides. Bulk ships importing coal into the UK always depart empty. The coal is then stored in coal stacks for up to one month.

Bulk ships vary from carrying 20,000 to 120,000 tonnes per journey. Until recently, Russian ports had limited capacity for the larger bulk ships and Russian-origin ships tended to be 20,000 tonne ships.

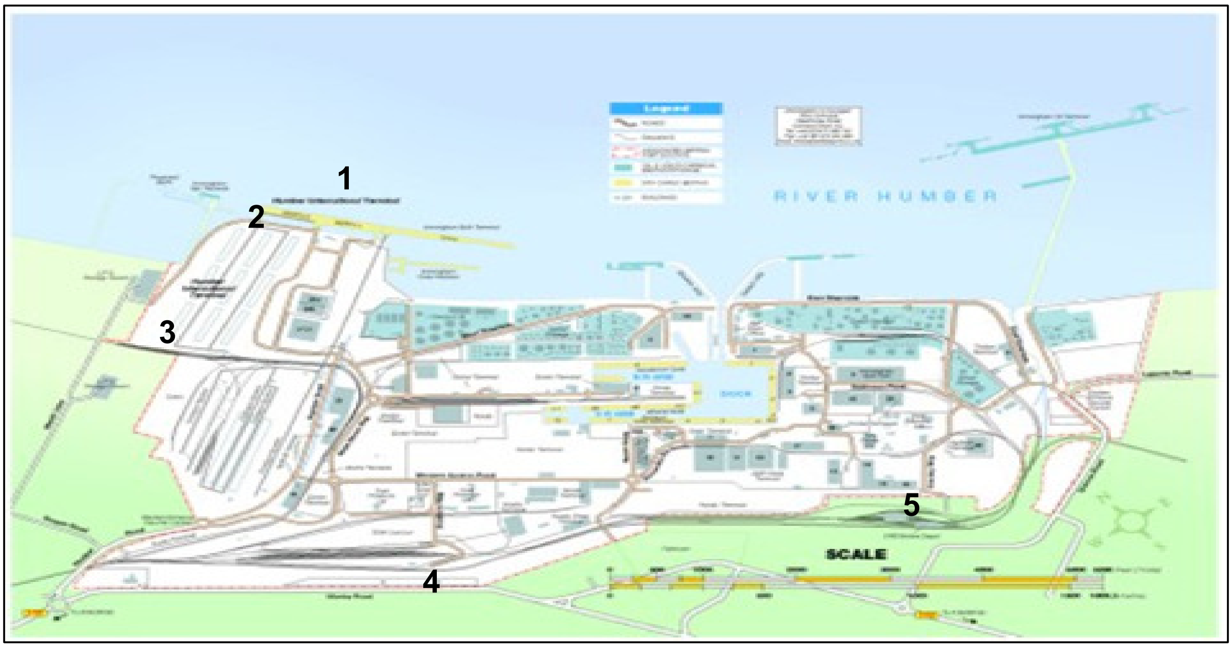
With growing capacity at Russian ports and larger bulk ships, the choice of ports in the UK may increasingly favour deep-sea ports, which could cause congestion at Hunterston and Immingham at the expense of smaller ports. This illustrates the impact that sourcing coal from different countries can have on the UK's ports and transport network.

The Port of Immingham



Source: Associated British Ports

Figure 6: Map of the Humber International Terminal



Source: Associated British Ports

2. Discharge of the coal commences immediately after the bulk ship has docked. The portside crane lifts the coal out of the ship's hold and deposits it into a hopper on the quayside. The coal travels down a conveyor belt or lorry tipper for transportation to the coal yard. Unloading from the ship takes 48 hours and is completed at 11am on the third day since the ship's arrival.

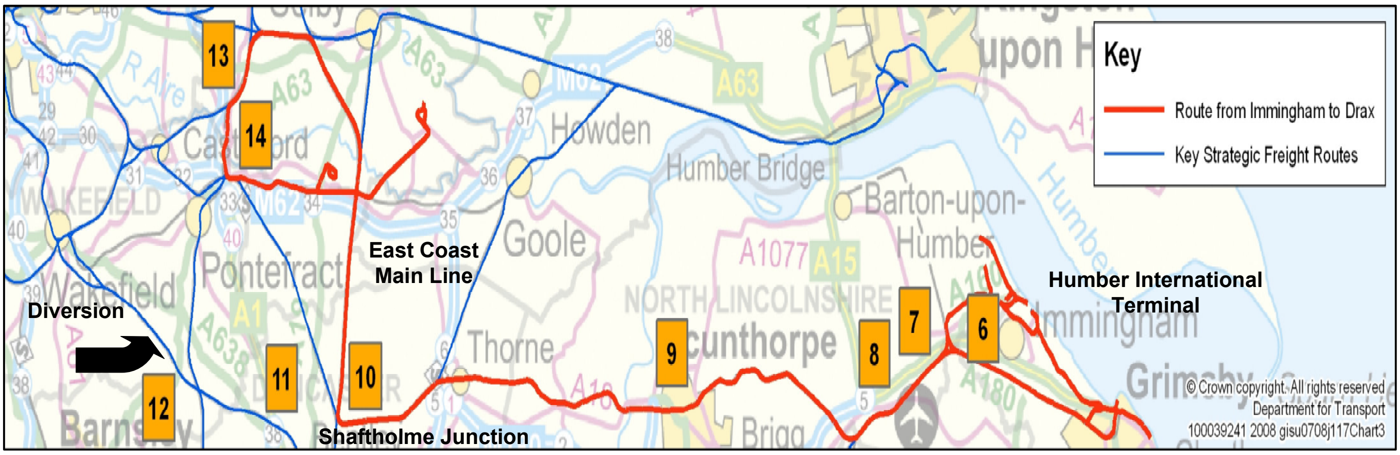
3. The coal is grouped in stacks according to the client and the grade of the coal.

4. At Midday, before the ship has completed discharging, 1,470 tonnes of coal are transported from the stack onto 21 wagons for the first delivery to the power station. Immingham has an automated terminal whereby a rotating bucket wheel (or stacker reclaimer) shifts coal from the stack onto a reclaim conveyor, into a surge bin and down a funnel into the slow-moving wagons that are passing underneath at 0.5 mph. By this method, 1,470 tonnes can be loaded onto wagons in 17 minutes compared to a manual, front-end loading system that takes two hours. Rail operators prefer to keep train assets shuttling between the same points on a closed loop to ensure efficiencies and isolate any problems that may occur on that part of the network.

5. Generally, a train is not loaded with coal until it has a scheduled path on the network. This ensures, in principle, that a train will have immediate departure from the port complex once loading is complete. On this occasion loading is complete at 1.18pm and the train arrives at the exit signal.

The port reports infrequent difficulties with automated equipment and has service and response contracts with suppliers. It also utilises Network Rail's Saturday afternoon to Sunday afternoon maintenance period to conduct its own servicing.

Figure 7: Map of the case study journey



The journey to the power station

6. Today the train is running on an amended schedule due to the closure of part of the East Coast Main Line (overhead lines have been damaged by gale force winds) and is diverted away from the normal route. The running time on the amended schedule is 5 hours 37 minutes against a standard time of 3 hours 30 minutes. The train departs the terminal two minutes early at 1.23pm. The maximum speed for a fully-loaded coal train is 60 mph.

7. Leaving the port, the train increases speed from 12 mph to 18 mph before encountering a Temporary Speed Limit (TSL) of 10 mph due to track replacement work parallel to the line. The TSL ends and the train accelerates to 32 mph, stopping at a red signal for a single-carriage passenger train to pass through the junction; the train has stopped for no more than 20 seconds before given a green signal and departing again; only to stop at a red signal 60 seconds for a second passenger train to pass. The line from Grimsby to Scunthorpe is heavily used by both freight and passenger services.

8. The train is now caught behind a slow-moving iron ore train (which has a maximum speed of 35 mph) and travels at speeds of between 20 and 30 mph between Barnetby and Scunthorpe, where the iron ore train diverts to the Corus steel works.

Tonnage and frequency of service

In the period 1 January 2007 to 16 February 2008, planned total trains and tonnage (combined two main rail freight operators) between Immingham and the following power stations were:

	Trains	Tonnage
Drax	1,775	2,512,020
Eggborough	1,893	2,755,130
Ferrybridge	1,617	2,171,470
EDF Energy	2,019	3,233,090
Ratcliffe	284	417,480
Rugeley	834	1,050,840
TOTAL TRAINS		**8,422**
TOTAL TONNAGE		**12,140,030**

9. After Scunthorpe two more TSLs are encountered due to the conditions of the line and nearby canal infrastructure. The train travels between 40 and 10 mph on this section of the journey.

10. The train proceeds towards Stainforth where it joins the freight-only line towards Wakefield and crosses the East Coast Main Line near Askern at 20 mph.

11. The standard path requires coal trains to turn north at Askern onto the East Coast Main Line towards Hambleton where they then travel north west and loop around to gain entry to the power stations from the correct direction. Because of the gale damage today the train is diverted further west via Wakefield and Castleford. This is the last train directed through the diversion on this day.

12. The train travels on the Doncaster – Leeds Line at 20 mph, stopping or slowing three times to allow passenger trains to pass, before heading north towards Castleford.

13. The train arrives at Milford Yard, near Sherburn-in-Elmet, where it reverses in order to regain the normal route and head back towards the power station. This is a “run round” operation whereby the locomotive is decoupled, moved forward 20 meters and reversed on a parallel line and re-attached to the wagons at the opposite end. This operation takes 20 minutes.

14. At Ferrybridge, the train is stopped for a passing coal train before arriving at Knottingley station where the driver finishes his turn of duty and is relieved by another driver who will take the train into the power station for the discharge operation.

The train arrives at the power station at 6.09pm – 53 minutes early on the amended schedule. The distance travelled was 91 miles at an average speed of 19.6 mph.

Courtesy of Chris Wilson

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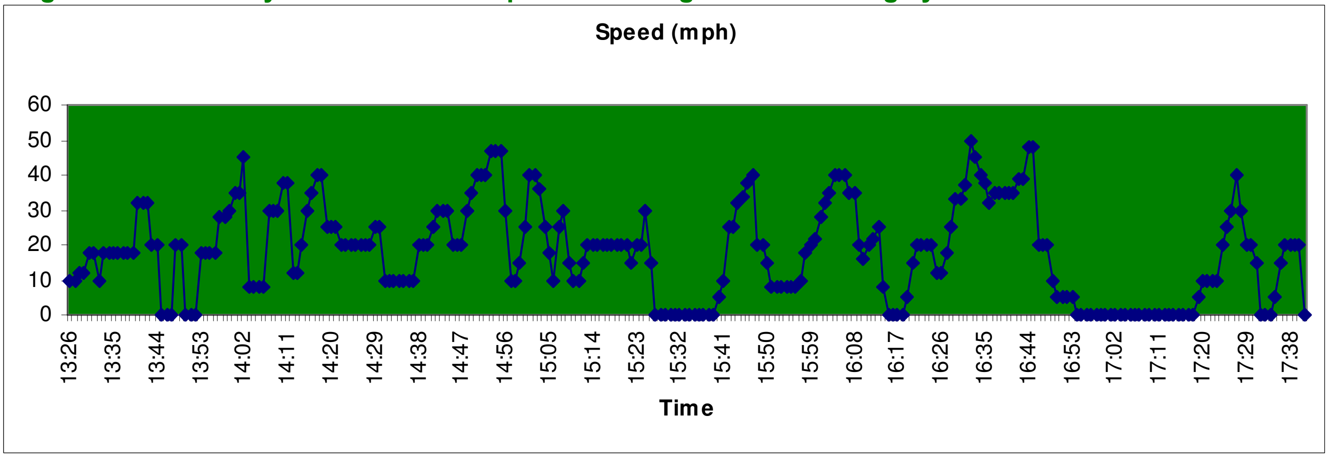
Journey times and reliability

Figure 8: Case study: train times and speeds: Immingham to Knottingley



Source: Department for Transport (2008)

Figure 8 summarises the train's speeds between Immingham and Knottingley that was the subject of the case study. The graph illustrates that at no point did the coal train reach its maximum potential speed of 60 mph, and visualises the productivity and efficiency impact of Temporary Speed Limits and waiting for passenger trains on the train's performance.

Figure 9 demonstrates the broader picture and details the combined journey time data of the two main rail freight operators of coal trains between the Humber International Terminal (HIT) at Immingham and power stations in the Aire and Trent valleys. The data captures one week's performance in April 2008 of trains from HIT to the Drax and Eggborough power stations, both located in the Aire Valley. It indicates that train and network operators build in significant buffers into planned times to reduce the impact of delays on customers (the power stations) and that the average speeds are well below capability levels. Times also vary depending on time of day. Cancellation levels and regularity of service, however, remain good and indicate a generally high level of reliability.

Figure 9: Journey time and average train speeds: aggregated

Week commencing 13/04/2008	
1. Humber International Terminal to Drax Power Station (76 miles)	
Number of trains scheduled:	31
Number of trains ran:	27 (87% of scheduled trains)
Reason for cancellation:	Product quality (3), plant breakdown (1)
Planned running time (mean):	4.0 hours (lowest: 3.21 hrs; highest: 5.21 hrs)
Actual running time (mean):	3.8 hours (lowest: 2.51 hrs; highest: 5.33 hrs)
Average speed / mph (mean):	17.8 (lowest 14.2; highest: 22.4)
2. Humber International Terminal to Eggborough Power Station (73 miles)	
Number of trains scheduled:	19
Number of trains ran:	19 (100% of scheduled trains)
Reason for cancellation:	No cancellations
Planned running time (mean):	3.8 hours (lowest: 3.15 hrs; highest: 5.18 hrs)
Actual running time (mean):	3.4 hours (lowest: 2.40 hrs; highest: 6.30 hrs)

Source: Department for Transport (2008)

At the power station

- Although 53 minutes early on the amended schedule, the coal train arrives two hours late from the original schedule and has to wait 45 minutes at the power station before its load can be discharged.
- Discharging time at power stations takes between 75 minutes and two hours; the variance is due to the speed of the conveyor belt upon which the coal is discharged. Faster operations can discharge 4,000 tonnes per hour; others are typically 1,000 tonnes per hour
- The coal train travels at 1 mph above the conveyor belt while a power station operator walks with the train, opens the wagon, and discharges coal as it moves over the conveyor belt. Once emptied, the bottom doors of each wagon swing shut.
- The coal is moved by conveyor directly into the power station's furnaces. The stockpiles are only utilised if there is a gap in the supply of coal, hence the importance of keeping the power station informed of delivery.
- Inspection: once the coal train has discharged its load, the rail freight operator inspects the wagons to ensure that the bottom doors of each wagon have firmly closed.
- Departure: the empty coal train is then ready to depart and will wait for its path on the network. It returns to the port, and its next trip may be either the Aire or Trent valley power stations, but rail operators prefer to keep their train assets shuttling between the same points on a closed loop.

The environmental benefit of moving bulk solids by rail is significant. The movement of 1,470 tonnes of coal by train is the equivalent to approximately 53 artic tippers (44 tonnes).

Refuelling

Operators will only detach locomotives from wagons if required, and it is common for refuelling to occur at a depots en route between port and power station. This ensures that trains are not unnecessarily diverted from their itinerary and is coincided with drivers' facility breaks or changeovers.

Courtesy of Chris Wilson

The gypsum by-product

A by-product of coal-fired power stations is gypsum. Gypsum is used in the production of plaster, cement and fertiliser but there is no opportunity to transport it from the power station in the coal wagons that are returning to the port. This is because gypsum would contaminate the coal wagons, is a fine substance transported in sealed tanks (while coal wagons are open topped), and they are transported to different locations to coal.

Therefore, coal trains return to the port empty and are a dedicated service between port and power station. The advantage of this "closed loop" system is that the end-to-end journey is kept as simple as possible so that delays are more easily contained and recovered.

Stakeholder views

Listening to industry stakeholders in the context of the end-to-end journey we have heard the following from end users in the coal transport sector:

The current journey times permit only two loaded trips in a 24 hour period and ideally the freight operators would like to achieve three loaded trips per 24 hour period with each set of wagons. This cannot be achieved with the existing routing where the coal services must travel along the east Coast main Line and by a circuitous route to the power stations (as illustrated in the case study map at Figure 7).

It may be possible to shorten the route and reduce journey times by building a new junction at Shaftholme to eliminate the lengthy detour via the East Coast Main Line and keep freight segregated from passenger services.

It is also clear from our work that:

1. Investors in rail freight are seeking increasing certainty about the UK's future energy policy and needs in order to plan for future investments.

2. Access and capacity on the network is vital to ensuring on-time delivery of commodities and for rail freight to remain viable in the marketplace.

Summary

- **A majority of coal is now imported and the UK requires reliable and efficient ports and transport links to supply inland coal-fired power stations**

- **The transport of coal (and bulk solids generally) is the responsibility of the private sector. It is the UK Government's role to encourage and promote investment and best practice through the development of freight transport and energy policies.**

- **We have learnt from the end-to-end journey case study that the movement of bulk solids by rail is reliable but may have the potential to perform more efficiently, in part due to the interaction between freight and passenger trains on the network. Rail freight is perceived by operators as a marginal user on a predominantly passenger-based network. This is seen as influencing network operations priorities, and the capacity for freight is felt to be insufficient on key routes from the ports and main lines. There are clearly trade-offs between improving carbon outcomes further and ensuring timely and more reliable passenger journeys.**