GTR Decarbonisation Roadmap

March 2023

Great Northern

GX
GATWICK EXPRESS

SOUTHERN

ThamesLink/

WE'RE WITH YOU

Contents

Introduction

GTRs National Rail Contract (NRC) Commitments

GTR have the following obligations under the requirements of current National Rail Contract:

64.1 By no later than 31 March 2023 the Operator shall, working in collaboration with Network Rail, develop and submit to the Secretary of State a decarbonisation roadmap which shall include as a minimum:

(a) a long-term pathway towards total decarbonisation of both traction and non-traction energy by 2050; and

(b) the Operator's plan for establishing, by the end of the second Contract Year, a full set of milestones and validated science-based targets to be achieved by the Operator within the Contract Term.

64.2 By no later than 30 September 2022 the Operator shall provide a first draft of the decarbonisation roadmap to the Secretary of State. The Operator shall revise the draft roadmap to reflect any comments received from the Secretary of State.

This document is GTR's response to these requirements and will be constantly revised. It has been developed in collaboration with Network Rail and will continue to be reviewed at Alliance Board.

This roadmap categorises Scope 1 and Scope 2 emissions into traction and non—traction emissions.

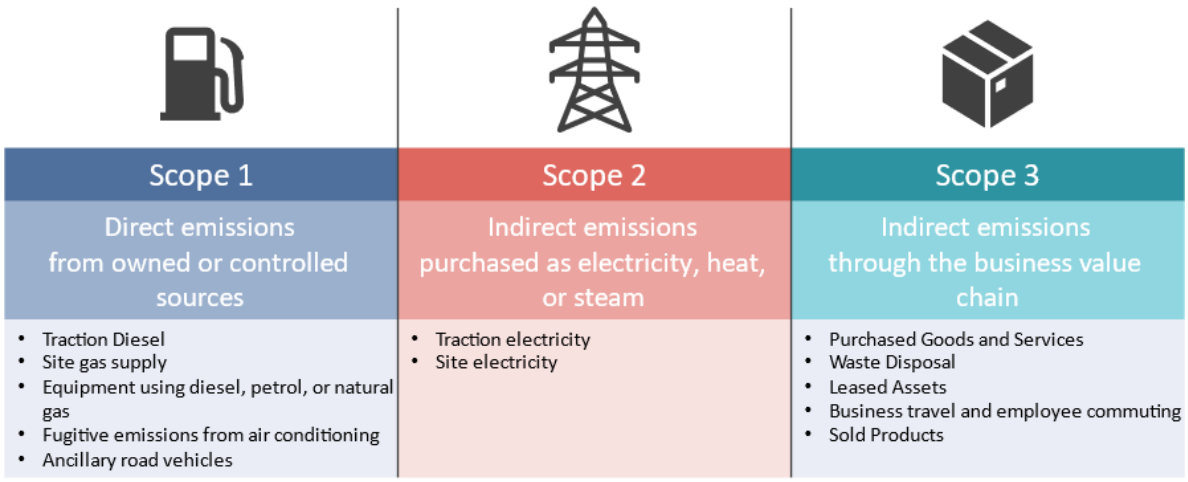
Traction emissions account for the energy used to run our trains. *Non-traction* emissions account for site energy, road vehicles, equipment running on petrol, diesel, or natural gas, and fugitive emissions.

Timescales for delivery have been categorised into Short, Medium, and Long Term. These timescales will be defined further as funding becomes available.

Short Term	***Medium Term***	***Long Term***
by the end of the current NRC	by 2035	by 2050

All milestones have been included in the Decarbonisation Roadmap Action Plan, which can be found in Appendix A.

The 3 Scopes of Carbon Emissions



Carbon Neutral vs Net-Zero

Definitions

Carbon Neutral is achieved through net zero carbon dioxide (CO_2) emissions. This is typically achieved by balancing emissions of CO_2 through the elimination of emissions, or removal. Being carbon neutral can cover all or a defined part of an organisation's operations and typically only accounts for CO_2 emissions.

Net-Zero is the reduction of all greenhouse gas emissions across the whole organisation, including the supply chain.

Carbon Offsetting

Carbon Offsetting is a means to reduce an organisational carbon footprint by directly funding projects to remove CO_2 from the atmosphere. These schemes can either be implemented here in the UK or abroad and vary in scale. Through these mechanisms emissions can be balanced and an organisation can be considered Carbon Neutral.

Currently the average cost off offsetting is between £10-£25 per tonne but can vary either way depending on the schemes involved and the delivery mechanism used. As we approach 2050 it can be expected that the cost of offsetting will increase.

Carbon offsetting is not a solution to carbon reduction and can sometimes be viewed as a greenwashing exercise. GTR will not use offsetting as an excuse to not implement primary emissions reductions. We will only use offsetting as either an interim measure along our path to net-zero, or to offset residual emissions that otherwise can't be completely mitigated in other ways. It will be used as a supporting function, not a solution.

PAS 2060

A key stepping stone to net-zero could be through "PAS 2060 Specification for the Demonstration of Carbon Neutrality". This specification provides a framework to help measure, reduce and offset an organisations impact on the climate.

The provisions for PAS 2060:2014 are to provide a clear definition and a credible means of determining and demonstrating an organisations carbon neutrality. This can be aligned to requirements of other management standards such as ISO 50001:2018 and ISO 14001:2015.

One of the benefits of PAS 2060 is the recognition that offsetting through a credible offsetting mechanism is required to balance out residual emissions and is not a solution in itself.

Roadmap Milestone	Target Date
Assess the implications and opportunities of becoming a carbon neutral business as a stepping stone to net-zero, through PAS 2060	Short Term

Traction Scope 1 Emissions

Current Situation and Overview

At the start of the National Rail Contract (NRC), GTR operated a fleet of 20 Class 171 'Turbostar' units in a mix of two- and four-coach formations . This was the equivalent of 2.2% of the total fleet of GTR vehicles in operation.

In autumn 2022, the fleet was reconfigured to operate as two and three coach units. The work to reform the units started in September 2022 and was completed for the December 2022 timetable change. At the same time, the fleet size was reduced by returning three of the sub-leased units to East Midlands Railway (a total of nine vehicles) in September 2022. This has reduced our diesel fleet size, and we now operate the following:

Fleet	Year Built	Fleet Size	Coaches per unit
Class 171/2	1999	1	3
Class 171/7	2003/2004	4	2
Class 171/8		12	3

They operated on two Southern routes with unelectrified sections:

Uckfield Line Uckfield – Oxted – London Bridge

Unelectrified between Hurst Green Junction and Uckfield

Mixture of two and three-car units with trains up to nine coaches.

East Coastway Eastbourne – Hastings – Ashford

Unelectrified between Ore and Ashford (known as the 'Marshlink')

Normally worked by single three-car units.

They also operate on the Brighton Mainline when travelling between Selhurst Depot and the East Coastway however they are not scheduled to carry passengers on these trips.

Class 171/7

Energy efficiency of the diesel fleet is measured using the metric ‘vehicle kilometres per diesel litre’. Vehicle kilometres are used rather than unit mileage to normalise the data for different lengths of unit. With reference to an appropriate conversion factor, diesel litres can be equated to kilowatt hours, or carbon equivalent, therefore mirroring the electric fleet figures.

Diesel is procured by the Go-Ahead Group through a group-wide contract and our fleet is fuelled at the GTR operated depot in Selhurst, and St Leonards Depot near Hastings which is operated independently.

At Selhurst, fuel is measured at point of delivery to the depot and the amounts delivered to each vehicle are recorded automatically and then entered into the asset management system.

St Leonards Depot is a private facility near Hastings operated by St Leonards Railway Engineering Limited. The amount of fuel dispensed to each vehicle is recorded by the depot entered into the asset management system. Around 30 per cent of our fuel is supplied from St Leonards.

These changes saw a slightly smaller fleet and a different carriage formation in order to better match the changing customer demand on our diesel routes. The remaining 17 units being converted into new formations has allowed greater capacity available for the rising number of leisure passengers using the Marshlink route.

Decarbonisation Options

Currently there are limited proven alternatives for traction power away from electrified routes however there is ongoing research and development into various technologies.

Hybrid solutions are being developed to improve the efficiency of current diesel engines capturing regenerative braking energy into batteries. Porterbrook are developing a system with Rolls-Royce for Turbostar trains, whilst Angel Trains are developing a system for the older Class 165 units.

Bi-mode Class 800 and 802 trains are currently operated by GWR, LNER and TransPennine Express. These are electric trains which also have diesel engines to provide electric power when away from electrified sections of the network. A tri-mode Class 769 (converted from former Thameslink Class 319 electric multiple units) was planned to be introduced on GWR's North Downs route between Reading and Redhill. This would have been powered by AC overhead wires, DC third rail or a diesel engine however the project has not gone ahead. All these solutions do mean that the train is carrying the additional weight of the diesel engine as well as the electric transmission.

Alternative solutions to diesel include:

Electrification Adding infrastructure to allow electric trains to operate is likely to the most appropriate solution for many routes in the UK. The vast majority will be electrified using the 25 kV AC overhead wires as seen on GTR's routes north of central London. For GTR's diesel operated routes the most likely solution will be 750 V DC third rail where power is collected via a 'shoe' mounted on the train's bogies. There are existing safety and legislative concerns with extending third rail electrification, although this is currently under review by the RSSB.

Batteries A trial of a battery powered Class 379 unit was carried out by Bombardier in 2015 on the Manningtree to Harwich Town line giving a range of around 60 miles. There were significant modifications needed to the unit which meant it was not suitable for regular use. Developments of the technology could allow charging to take place whilst on the electrified network or through a rapid recharging facility at a terminal station. Battery powered version of Class 230 units, reusing redundant London Underground vehicles, have been under development with GWR expected to trial the system in the near future. The trams used on the West Midlands Metro in Birmingham are fitted with batteries for operation on sections of the city centre route. There are additional challenges with battery operation in the form of capping capacity for weather impacts and warranty purposes, meaning that less of the usable battery can be utilised for service. Battery powered trains are a viable option for GTRs diesel routes, however additional infrastructure and electrical upgrades may be needed along the routes to provide sufficient charging facilities.

Flywheels Flywheels are used to store kinetic energy. The diesel Class 139 railcars, built by Parry People Movers and operated by West Midlands Railway in Stourbridge, use a form of this technology to capture energy when braking. The amount of energy able to be stored by this method is typically small.

Supercapacitors Supercapacitors are able to store relatively large amounts of energy and are typically used where rapid charge and discharge cycles are needed, for example to capture the energy from regenerative braking.

Hydrogen Hydrogen can be used as a fuel with the advantage that its only biproduct is water. Its energy density is however significantly lower than comparable fossil fuels meaning much larger fuel tanks are needed. Alston have developed the Coradia iLint, a hydrogen powered train operating in Germany, and have also produced

outline designs for a UK version. Porterbrook have developed a similar demonstrator in conjunction with the University of Birmingham, based on a Class 319. It should be noted that hydrogen can only be considered a low or zero carbon fuel if it is produced from low or zero energy sources. It is also relatively inefficient with studies indicating an efficiency rate of around 35% to 40%.

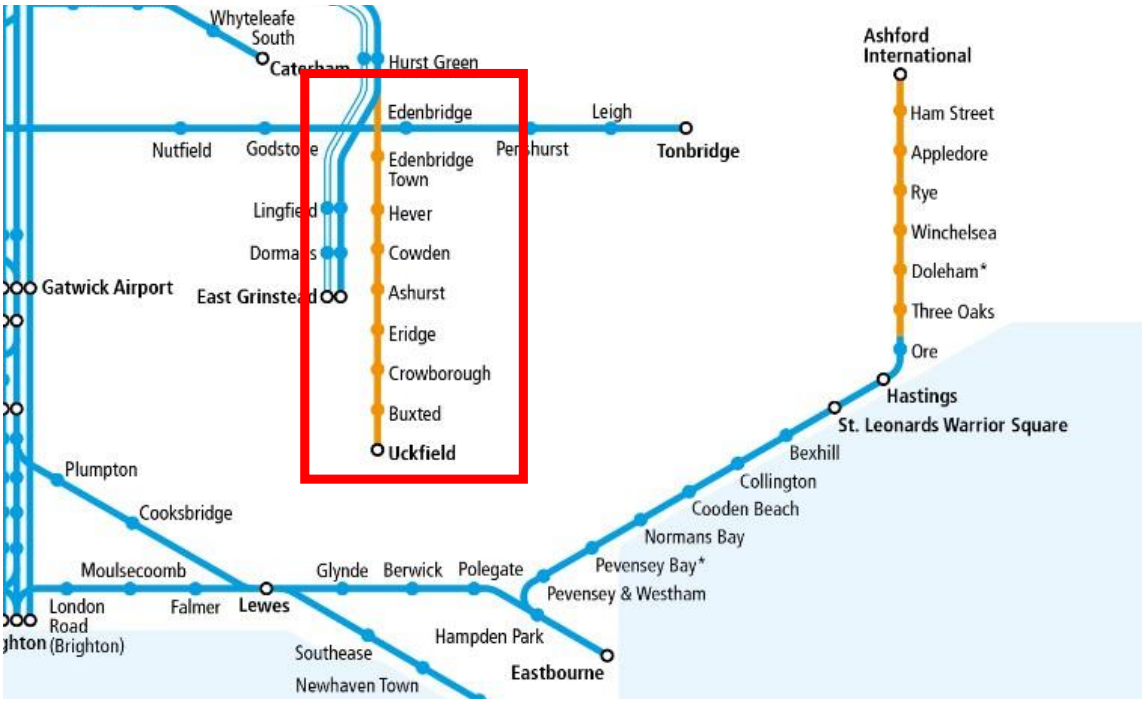
With the exception of electrification, all the above technologies are methods of storing energy and, unlike diesel, are not a source of energy. There are also challenges with the range between refuelling or recharging especially when considering a current Class 171 is capable of over 1,500 miles between fuelling. Of the alternatives listed above, the ones likely to be applicable to GTR's network are electrification and, potentially, battery operation.

Marshlink Line (Eastbourne - Hastings - Ashford)

Currently, Class 171 services run between Eastbourne and Ashford International, however it is only the track section between Ore and Ashford that is unelectrified.

Network Rail have identified that the Marshlink may be suited for battery or electrification, however strategic planning and a viable business case is required to identify a whole industry preferred solution, taking account of service enhancement aspirations. Additionally, a medium-term option for development and delivery of electrification or BEMU services is recognised as part of providing a High-Speed service to Hastings.

Uckfield Line (Uckfield – Oxted – London Bridge)



Class 171 services run between Uckfield, via Oxted, to London Bridge with the track section between Hurst Green Junction and Uckfield unelectrified.

Network Rail have identified that electrification of this line would release high quality diesel trains for other parts of the network and has a strong short term strategic and economic case based on Opex savings in addition to decarbonisation, recommending the progression and development of DC third rail scheme as soon as affordable.

GTR's route to total decarbonisation of scope 1 traction emissions will ultimately be dictated by the ability of Network Rail and the Department for Transport to fund and implement diesel alternatives on the 2 lines which we run our Class 171 Turbostars. Until such a time as a decision is made, milestones cannot be realistically set beyond the commitment to continue supporting wider industry decarbonisation. When a final decision is reached regarding electrification or alternative traction modes a set of milestones can be developed as a supplement to this roadmap.

Roadmap Milestone	Target Date
Support Network Rail to reduce their Scope 1 carbon emissions by 25%	End of CP6
Support Network Rail to reduce their Scope 1 carbon emissions by 47%	End of CP7
Work with Network Rail to understand GTR's role in achieving their targets	Short Term
Develop a set of milestone targets for diesel removal once a strategic decision has been made regarding Uckfield and Marshlink	Medium Term

Reducing emissions during transition

Fuel Density

The density of diesel fuel varies according to temperature. In hotter weather, the density of diesel fuel decreases leading to reduced efficiency when compared with winter months when the colder weather leads it to being denser.

Due to the relationship between mass, density, and volume, when fuel density is less, fuel mass will also be less for same volume. This means that when less mass of fuel is transferred to an engine for combustion, the stoichiometric ratio is affected and the fuel-air mixture becomes too light so fuel in the ignition chamber ignites with either too much air or too little fuel, reducing the efficiency of the engine. This is important within the context of climate change as we expect to see greater instances of extreme heat in the summer, and warmer winters in the future.

Fuel Husbandry

GTR view diesel as a precious commodity, one which requires constant management to ensure the greatest levels of efficiency. Through condensation, precipitation or hygroscopy water can enter the diesel fuel which then encourages microbial growth either at the interface between the oil and water or on the tank walls. Historically GTR's Class 171 fleet suffered blocked and damaged fuel system components due to accumulation of microbial contamination, which caused problems consistently until the tanks were finally removed. At this time there was a complete overhaul of all on-train fuel tanks, new bulk loaders valves were fitted as well as new sight glasses. Fuel tanks were cut open, cleaned, thickness checked, and doubler plates added to the base of the tanks where required. These doubler plates were needed due to the microbial reaction on the steel which resulted in material loss.

Diesel fuel has evolved considerably, and Diesel now has a much lower Sulphur content. The diesel we receive can also have up to 7% FAME (Fatty Acid Methyl Ester). Lower Sulphur content, and FAME allow the growth of biological contaminants in the fuel system. Our fuel is dosed with MB15 microbicide which combats this growth.

Accumulation of particulate matter can also significantly impact the performance of diesel engines. The fuel additive 'Ecoclean HDSI' is used to keep the engine cleaner for longer preventing the build-up of detritus and allowing the fuel system to function to specification, helping maintain engine efficiency for longer. In addition to the engineering benefits of this additive, Ecoclean HDSI also provides a 3-4% fuel economy saving and a regulated exhaust emissions reduction of up to 45%. Our fleet undergoes yearly on-train fuel tank flushing during scheduled maintenance to help remove any build ups of matter, and fuel flushing is carried out as required.

To ensure additives are applied at the correct consistency, GTR's Class 171 fleet have had fuel bunker tanks fitted with an inlet dosing pump for biocide, with additional modifications made to allow dosing of Ecoclean HDSI through the same process, allowing all fuel to be additised at delivery. In addition, GTR have fitted automated fuel polishing systems to the bunker tanks to further combat particulate matter.

Roadmap Milestone	Target Date
Review maintenance schedules including oil change frequencies and periodic sampling	Short Term
Improve understanding of fuel husbandry, and explore options to improve overall efficient use of fuels and oils	Short Term

Timetabling

Diesel usage could be reduced by running Marshlink services between Ashford International and Hastings eliminating the majority of running over electrified sections. GTR has met with rail users and discussed this potential change to assist with decarbonisation and the idea was firmly rejected on the basis of a move making the service less attractive and causing an adverse impact of existing travel demand and growth which is currently being experienced on the route. Our traincrew depot for the Marshlink route is based at Eastbourne so if the route was curtailed it would likely increase the number of taxis movements required between Eastbourne and Hastings to position staff.

In December 2022, GTR successfully reformed the Class 171 diesel fleet. This has enabled us to match capacity with demand better and reduce overall annual vehicle miles accounting for changed travel patterns and habits. Future timetable changes across the whole GTR network continue to be evaluated in response to passenger demand, matching capacity and ongoing DfT requirements.

Innovation

GTR attend the 'Independently Powered Traction Working Group' whose scope is to investigate generic issues affecting efficient operation and control of diesel engines and their exhaust emissions. Through this working group GTR have presented options for diesel efficiency that range from low to high complexity of implementation.

These include schemes such as Idling policies which have additional benefit of improving air quality, and maintenance optimisation through changes of process to areas such as periodic oil sampling to reduce frequency of changes. Both of these schemes are considered low cost and low complexity.

In addition, there are also medium complexity options such as stop-start technology, and fuel management and metering, which progresses to higher complexity and higher cost options such as hybridisation and BEMU.

Another potential opportunity for improving vehicle efficiency is through Driver Advisory Systems (DAS). These systems advise the driver about the most efficient speed at which to drive to keep to the timetable, taking account of speed limits, station stops, and other operational requirements. There are three key broad categories of DAS:

Standalone	Accounts for just the published timetable .
Network	Incorporates a live network connection allowing for TSRs, ESRs and timetables to be updated in real time. This has previously been trialled.
Connected (C-DAS)	Connects to the live signalling system, advising the driver in real time accounting for scenarios such as restricted aspects or signals at danger.

Roadmap Milestone	Target Date
Explore options to retrofit systems to improve efficiency, resilience, and air quality	Short Term
Evaluate the options for driver efficiency systems	Short Term

Industry Working Groups

It is important to recognise that GTR have a significant influencing voice within the wider industry decarbonisation workstream and as such we are members of several core industry working groups.

GTR are one of the two TOC representatives on RSSB's T1214 - 21st Century DC electrification infill project, the legal and regulatory work to use 3rd rail as electrification. This project aims to support the decarbonisation of traction in regions with a predominant third rail system by identifying the potential to remove diesel services by either enabling infills to the existing electric network or appropriate alternatives. It also aims to identify options to reduce the safety risk of third rail and explore how this can support the potential for approvals to appropriate infills to the electric network. Finally, this project seeks to support decision-making on infills to the third rail network or other alternatives to diesel traction through a decision-making framework to consider mitigation options alongside whole transport system safety, project, and economic risks.

GTR are a member of the Vehicle / Train Energy System Interface Committee (V/TE SIC), whose purpose it is to assist the rail industry in evaluating and managing the key power supply system interfaces. It also identifies losses, and likely remedies, in the energy transmission system; promote more efficient energy use; and develop longer-term, sustainable energy strategies. V/TE SIC provides the focus for the energy systems of the mainline railway and acts as a forum to support the resolution of cross-industry technical issues, including the contribution that future power supplies can make to the decarbonisation of the mainline railway.

The Southern Region of Network Rail hosts a bi-monthly South of England Diesel Replacement Programme meeting between DfT, Network Rail and GTR to review progress against RSSB's joint study T1214; review progress and options around 3rd rail electrification of the Uckfield line; consider options for battery train trials and review the lessons being learned from introduction of tri-mode stock on North Downs and hybrid IEP stock on GWR and LNER; and review decisions made regarding potential fleet cascade.

GTR were also a key member of T1188 - Analysis of air quality onboard trains (Project Clear), whose remit was to look at emissions from Diesel trains. Whilst this project has now concluded, GTR remain committed to support further develops resulting from the conclusions of this study.

Roadmap Milestone	Target Date
Continue to review fleet timetables in line with DfT operating requirements	Medium Term
Continue to support and influence Network Rail and DfT electrification planning	Short, Medium. Long Term
Continue influencing and supporting the wider rail industry through attendance and contribution to industry working groups	Short Term

Traction Scope 1 Roadmap

Scope 1 Traction Emissions

	Decarbonisation of the Uckfield and Marshlink Line	Industry Collaboration	Fleet Efficiency Improvements
Short Term	Continue to support and influence Network Rail and DfT with electrification planning	Continue influencing and supporting the wider rail industry through attendance and contribution to industry working groups Support Network Rail to reduce their Scope 1 carbon emissions by 25% Work with Network Rail to understand GTR's role in achieving their targets	Improve understanding of fuel husbandry, and explore options to improve overall efficient use of fuels and oils Evaluate the options for driver efficiency systems Review maintenance schedules including oil change frequencies and periodic sampling Explore options to retrofit systems to improve efficiency, resilience, and air quality
Medium Term	Continue to support and influence Network Rail and DfT with electrification planning Develop a set of milestone targets for diesel removal once a strategic decision has been made regarding Uckfield and Marshlink	Support Network Rail to reduce their Scope 1 carbon emissions by 47%	Continue to review fleet timetables in line with DfT operating requirements
Long Term	Continue to support and influence Network Rail and DfT with electrification planning		

Traction Scope 2 Emissions

Current Situation

GTR's electric fleet consists of 437 units, totalling 2,465 vehicles operating over a wide variety of routes and services, including metro, outer suburban and long-distance services. This equates to just over 98% of all train vehicles that GTR operate. The age of the fleet is broad, including some of the newest trains in the country (Class 717) as well as some of the oldest (Class 313). Substantial changes have occurred to the fleet over GTR's ownership, with a significant number of older trains having been replaced with new trains and existing units moving to operate on different routes. This has resulted in a reduction of around 200 vehicles, as our previous Class 365 and Class 455 fleets were removed from services. All GTR's electric units are equipped with energy meters recording the actual energy consumption of the train and this data is used for billing.

Fleet	Year built	Fleet size	Coaches per unit	Power system	Southern									Gatwick Express
					Brighton Mainline	West London	Metro	Oxted *	Redhill	Mainline West	Mainline East	Coastway West	Coastway East *	
Class 313/2	1976	19	3	DC	·	·	·	·	·	·	·	✓	✓	·
Class 377/1	2003 to 2005	62	4	DC	✓	●	✓	✓	✓	✓	✓	✓	✓	○
Class 377/2		15	4	AC/ DC	✓	✓	✓	✓	✓	✓	✓	✓	✓	·
Class 377/3		28	3	DC	✓	●	✓	✓	✓	✓	✓	✓	✓	·
Class 377/4		75	4	DC	✓	●	✓	✓	✓	✓	✓	✓	✓	○
Class 377/6	2013 to 2014	26	5	DC	○	·	✓	○	○	·	·	·	·	·
Class 377/7		8	5	AC/ DC	○	○	✓	○	○	·	·	·	·	·
Class 387/2	2016	27	4	AC/ DC	✓	·	·	·	·	·	·	○	✓	✓

✓ Normally work on this route.

● Occasionally work part of the route between Clapham Junction and Shepherds Bush.

○ Occasionally work on this route.

· Rarely or never work on this route.

* Excluding Hurst Green to Uckfield and Ore to Ashford International as these sections are not electrified.

Fleet	Year built	Fleet size	Coaches per unit	Power system	Great Northern					Thameslink				
					Kings Lynn & Cambridge	Cambridge Local	Peterborough	Hertford	Welwyn	Bedford, Brighton & Horsham	Luton, Wimbledon and Sutton	St Albans, Mitcham and Sutton	Kent via Catford	North Kent via Greenwich
Class 387/1	2014	29	4	AC/DC	✓	✓	✓	·	·	·	·	·	·	·
Class 387/3	2016	6	4	AC/DC	✓	✓	✓	·	·	·	·	·	·	·
Class 700/0	2015 to 2018	60	8	AC/DC	·	✓	✓	·	·	✓	✓	✓	✓	✓
Class 700/1		55	12	AC/DC	·	✓	✓	·	·	✓	·	·	·	·
Class 717	2018	25	6	AC/DC	·	·	·	✓	✓	·	·	·	·	·

✓ Normally work on this route.

○ Occasionally work on this route.

· Rarely or never work on this route.

We also operate a Class 73 locomotive (built around 1966) which is used for occasional rescue duties when required. It operates from DC power and also contains a small diesel engine for use when this is not available.

Class 313/2

Class 377

Class 387/2

Class 700

Class 717

Class 73

Decarbonisation Options

GTR's route to total decarbonisation of scope 2 traction emissions largely sits with traction energy procurement through Network Rail, as traction electricity is procured centrally for the rail industry. This is currently contracted to EDF Energy until 2024 under an agreement to supply energy from nuclear power. As a customer of Network Rail, GTR can only influence these procurement decisions.

Network Rail are currently developing the scope, schedule and costs for a programme that transitions all traction power needs to renewable sources within the remainder of CP6 to the end of CP7. The programme is forecasted to be a mix of Corporate Power Purchase Agreements (cPPA) and Direct Wire Power Purchase Agreements (dPPA) as part of the wider TraPPA (Traction Power Purchase Agreements) Project.

Roadmap Milestone	Target Date
Support Network Rail to reduce their Scope 2 carbon emissions by 25%	End of CP6
Support Network Rail to reduce their Scope 2 carbon emissions by 47%	End of CP7
Support Network Rail to achieve their target of 100% of Network Rail owned traction power will be procured from renewable sources through a mix of direct wire and power purchase agreements	End of CP7
Support Network Rail to deliver R&D opportunities for carbon reduction through re-control of ConRail heating and induction heating for points and ConRail	End of CP7
Work with Network Rail to understand GTR's role in achieving their targets	Short Term

Reducing emissions during transition

GTR's route to total decarbonisation of scope 2 traction emissions will ultimately be dictated by the ability of Network Rail to procure renewable sources of energy to power our electric fleet.

During this transition there will still be opportunities to improve efficiency and reduce the electrical load.

Regenerative Braking

Modern trains have the ability to return energy to the traction supply through regenerative braking. For GTR, these are the Class 377s, Class 387s, Class 700s and Class 717s. These trains have two types of braking available:

- Friction braking – traditional style of braking using a brake block applied to the wheel or a brake disc similar to a car.
- Dynamic braking – this comprises two subsystems:
    - Regenerative braking – using the train's electric motors in reverse as generators and returning the energy from braking to the third rail or the overhead wires for another train to use.
    - Rheostatic braking – similar to regenerative braking however the energy is diverted to a resistor bank on the train rather than returned to the traction supply.

The driver does not need to select between these modes as the train does this automatically. Generally regenerative braking will be used from speed with the friction brake used towards the end of the braking period to bring the unit to a complete stop. Friction braking is also used for emergency braking and if wheel slip is detected, for example at times of poor adhesion.

In order to be able to use regenerative braking, the electrical network must be 'receptive'. For the DC third rail network, this means there must be another train available in the same electrical section to accept the energy. If this is not the case, then the rheostatic brake will be used instead. On the AC network, in many cases the regenerated energy can be exported direct to the National Grid if there is no train present.

The amount of energy recovered through regenerative braking varies according to unit type and service pattern. For example, metro routes tend to have a higher level of regenerative braking due to the stop-start nature of the service pattern.

Fleet Cascade

During the life of the GTR contract there have been a number of changes to the fleet which are summarised below.

On Great Northern the former Class 317 and Class 365 fleets have been replaced by the Class 387/1 fleet. The Class 365 fleet was fully with withdrawn in May 2021. The Class 313 fleet on the Moorgate route was replaced with new Class 717 units during 2019.

On Gatwick Express the Class 442 units have been replaced by new Class 387/2 units, and on Southern the Class 377/2s previously operated on Thameslink returned to Southern in 2016.

On Thameslink the Class 700 units have replaced the previous fleets and have also taken over some former Southern and Southeastern routes.

In May 2022 the Class 455 fleet running on the Southern Metro services from London Bridge and London Victoria were replaced with the more efficient Class 377.

The remaining Class 313 fleet, which are used along the Brighton to Seaford route and Portsmouth to Ore line, will be withdrawn from service by Summer 2023 and replaced with more efficient units.

Roadmap Milestone	Target Date
Remove remaining Class 313 Fleet from service, and replace with more efficient rolling stock	2023

On-Board Efficiency Improvements

Power capacity is a growing concern across most of the UK. Whilst electricity draw to power trains is a very small amount of overall grid demand, the running of electric trains can still put significant pressure on the grid where local capacity is in short supply.

On-board efficiency improvements such as LED lighting, improved air conditioning, and efficiencies of other on-board systems can help reduce the draw from OHL or the third rail, enabling greater release of localised capacity. GTR have a good history with managing capacity as evidenced through our implementation of regenerative braking systems across our fleet, with our Southern brand being the first in the UK to implement such systems. Further opportunities will be explored through industry

working groups to improve on-board systems, power pick up, and reduce line loss. These opportunities will come into consideration as and when viable options become available.

To further help improve energy efficiency, like our diesel train fleet, DAS is also available for electric traction and is an option that will be further investigated.

Timetabling

Timetable changes will be evaluated in response to passenger demand and ongoing DfT requirements.

Roadmap Milestone	Target Date
Evaluate options for on-board efficiency measures to release local power capacity by reducing third rail and OHL power draw	Medium Term
Evaluate the options for driver efficiency systems	Short Term
Continue to review fleet timetables in line with DfT operating requirements	Medium Term

Traction Scope 2 Roadmap

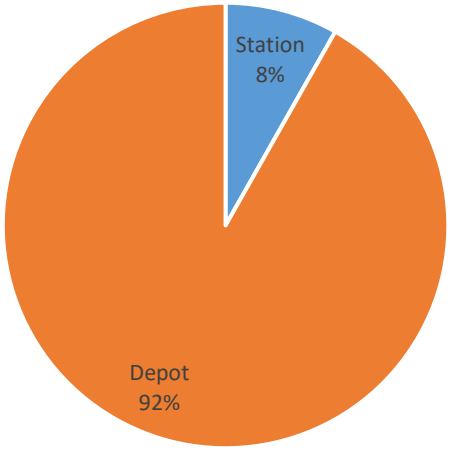
Scope 2 Traction Emissions		Decarbonisation of Electric Traction	Fleet Efficiency Improvements
	Short Term	Support Network Rail in their projects to reduce traction carbon emissions by 25%	Remove remaining Class 313 Fleet from service, and replace with more efficient rolling stock
		Work with Network Rail to understand GTR's role in achieving their targets	Evaluate the options for driver efficiency systems
	Medium Term	Support Network Rail in their projects to reduce traction carbon emissions by 47%	Evaluate options for on-board efficiency measures to release local power capacity by reducing third rail and OHL power draw
		Support Network Rail to achieve their target of 100% traction power procured from renewable sources through a mix of direct wire and power purchase agreements	Continue to review fleet timetables in line with DfT operating requirements
		Support Network Rail to deliver R&D opportunities for carbon reduction through re-control of ConRail heating and induction heating for points and ConRail	
	Long Term		

Non-Traction Scope 1 Emissions

Site Gas Supplies

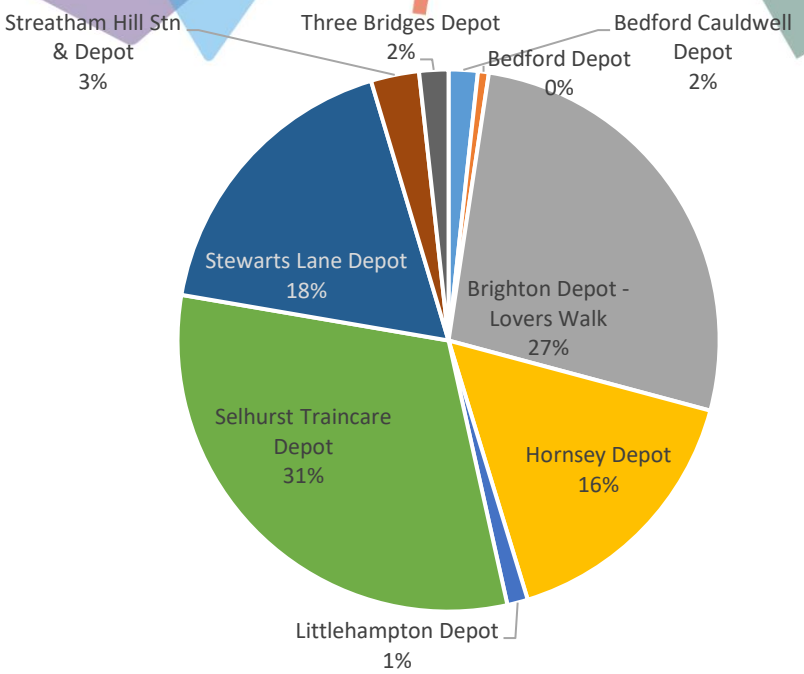
Although site gas only accounts for 1.85% of total energy use across the GTR network, in 2019-20 this amounted to over 15.7 million kWh across 43 active supplies.

When assessing gas consumption, we break the data down in to 2 areas: stations and depots.



Breakdown of non-traction gas consumption
(Baseline year – April 2019-March 2020)

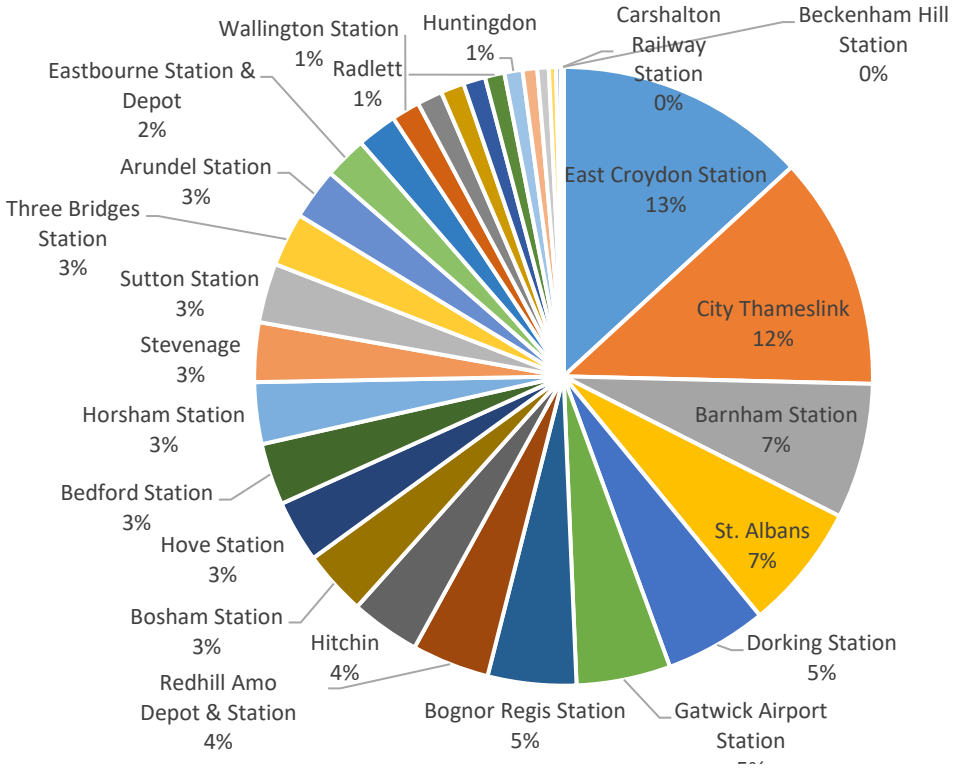
The majority of our gas is consumed across 9 engineering depots (92% of total GTR gas use), used primarily for space heating via fixed AmbiRad heaters. Selhurst Depot is the prime consumer on depots accounting for 31.18% of the total share, followed by Brighton Depot at 26.78%, Stewarts Lane Depot at 17.69% and Hornsey Depot at 16.11% (Streatham Hill has a joint supply shared between station and depot).



Breakdown of non-traction gas consumption on engineering depots

(Baseline year – April 2019-March 2020)

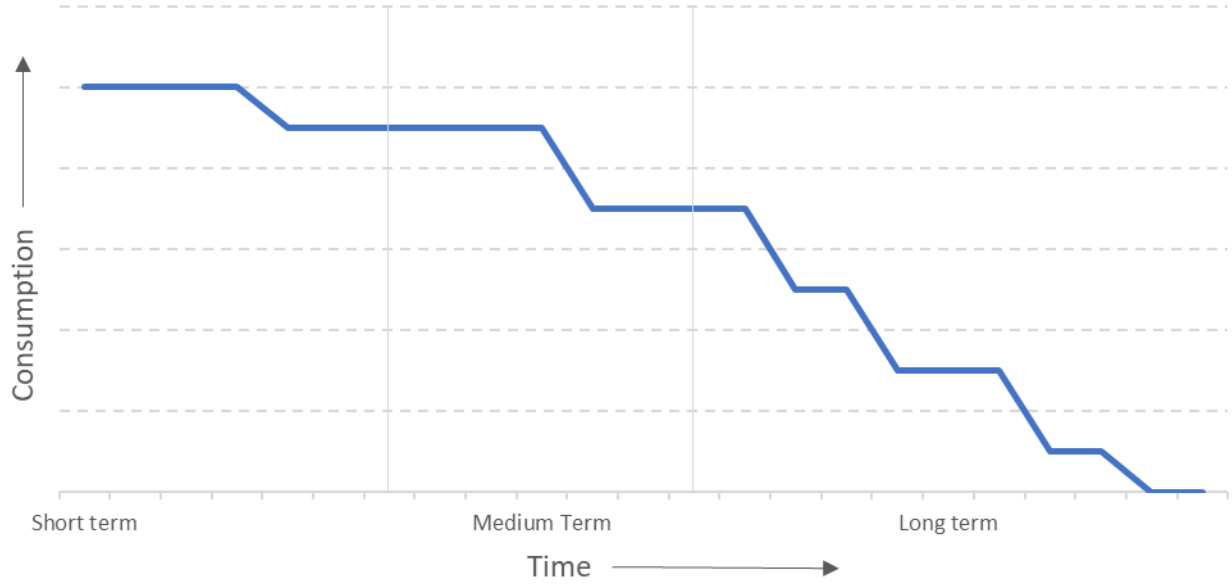
The remaining 8% of gas is used across 34 stations. A quarter of all station gas consumption is used at East Croydon and City Thameslink, representing a 13.18% and 12.21% consumption share respectively. These are followed by Barnham, St Albans, Dorking at Gatwick which cumulatively account for a further 25%, resulting in 6 sites which account for around 50% of all station gas usage.



Breakdown of non-traction gas consumption on stations
(Baseline year – April 2019-March 2020)

Energy Modelling

Over time, as supplies are replaced for electric and other carbon neutral alternatives, gas consumption will reduce.



In the short term GTR will undertake an assessment of all smaller supplies at stations using minimal amounts of gas (5% or less) and identify the costs and benefits of removing or replacing gas supplies. Gas supplies and equipment that becomes life expired or beyond economic repair will be replaced with a non-gas equivalent. This will be completed in partnership with Network Rail where it owns the asset.

In the medium-term larger supplies will be replaced as funding and new technologies become available, or when assets become life expired or beyond economic repair.

This will continue into the longer term, where it is expected that the significant consumers, which are larger and more complicated, will be replaced.

Across short, medium, and long term timescales, all gas appliances will be assessed for zero carbon alternatives at the end of their current product life. All gas supplies will be phased out by 2050.

As larger gas removal projects become financially viable, full timescales and projected reductions will be made available. Full reduction timescales cannot be provided due to the interdependencies and complexities between funding options and government approval. However, full feasibility on gas removal, including associated costs, will be developed in the short to medium term.

Gas removal

The majority of site gas usage is attributed to 4 engineering depots which account for 13,000,000 kWh (84% total gas consumption), and 6 stations accounting for 640,000 kWh (4% total gas consumption). Collectively these 10 sites account for almost 90% of GTR's natural gas consumption. A feasibility study to assess appropriability of gas replacement for space heating is required prior to any commitments being made to remove gas at larger sites, specifically engineering depots. Not all current gas systems will be compatible with existing options for zero carbon improvements such as air or ground source heating, therefore a move to electric only systems may be the only current viable alternative.

Whilst these supplies are considerably sized and complex, benefit will come from developing an agreed programme alongside Network Rail to replace smaller consuming station equipment that will become life expired during the course of the current NRC. These case studies can then be used to demonstrate value and build viable business cases for the larger supplies in the medium to longer term.

Whilst electric heating is generally considered more efficient than natural gas, with levels of improved efficiency varying, the move away from gas will result in an increase in electricity consumption. Prior to the 2022 energy crisis, the wholesale cost of gas to GTR averaged at 13.3 pence per kWh, this has now increased to an average of 28.4 pence per kWh. The cost of electricity to GTR pre-energy crisis was around 15 pence per kWh, which has now risen to an average of 32 pence per kWh. Whilst it's recognised that electricity is more efficient than natural gas, the cost of both electric and gas in the current economic climate has to be considered when assessing feasibility of gas removal.

Currently GTR pay a standing meter charge on all meters which are duplicated across both gas and electricity supplies. All locations with a gas supply also have an electricity supply, therefore by moving to an electricity only supply we will also gain the financial benefit from removing all gas standing charges.

Roadmap Milestone	Target Date
Conduct feasibility studies to assess 'quick win' locations for gas removal across stations and depots. These are likely to be locations where gas boilers are supplying small scale heating requirements such as single room heating, or water heating only.	Short Term
Develop an agreed programme with Network Rail to replace older gas systems and equipment that will become life expired during the current NRC period	Short Term
Conduct feasibility studies to assess appropriability of viable alternatives to natural gas at larger sites, where replacement of traditional boilers would not be enough to eliminate total supply.	Medium term
All natural gas fired boilers replaced	Medium Term

Gas efficiency improvements

Boiler thermostatic controls

Heating and associated controls have a significant role in reducing energy use and improving overall efficiency.

A recent study commissioned by the BEAMA (The British Electrotechnical and Allied Manufacturers' Association - the UK trade association for manufacturers and providers of energy infrastructure technologies and systems) found that replacing a standard room thermostat with an on/off load compensation thermostat can reduce gas use by up to 10% over the heating season. Where the boiler and switching control are able to talk to each other through a suitable communication protocol, a directly modulating load or weather compensating room thermostat can be installed to replace a standard one, delivering reductions of up to 12%.

Whilst it is our preference to remove gas supplies where feasible, improvements to system efficiency will help in the intermediate term to reduce consumption.

Roadmap Milestone	Target Date
Carry out full assessment of site heating to identify opportunities for boiler controls where feasible to limit changes in thermostatic range and encourage efficiency.	Short Term

Electric combi-boilers

Electric boilers are an alternative to traditional gas boilers in smaller locations where a gas supply is present, but minimal gas is used. Electric boilers work similar to kettles in that water is heated by passing over a heating element, before being distributed through the heating and/or hot water system. Electric boilers have a compact design, are quiet and are flexible in where they can be installed as there is no requirement for a flue pipe.

Whilst electric boilers can be more efficient than gas, the cost of electricity is greater therefore cost savings will not always be guaranteed. Additionally, whilst electric boilers are ideal for small locations, they are not at all suited for larger sites.

Roadmap Milestone	Target Date
Install electric boilers in small locations where gas is only used in minimal quantities	Short Term

Electric water heaters

Electric water boilers work in a similar way to a larger electric combi-boiler, except these are typically installed around kitchen areas to provide hot water only. At locations across GTR where gas is only being used to heat water, these smaller water heaters could provide an appropriate alternative.

Roadmap Milestone	Target Date
Install electric water heaters in locations where gas is only used for heating water	Short Term

Alternatives to gas for space heating

Electric

Traditional electric heating

Electric heating refers to any system that uses electricity as the main energy source to heat the premises. Specific to GTR, this includes panel heaters, fan heaters, and HVAC (Heating, Ventilation and Air Conditioning) systems. Electric heating is relatively straight forward to instal as it often requires a simple connection to the existing mains supply, or to just be plugged in via a standard three pin plug.

Through general grid decarbonisation and the shift from coal and gas to renewables, electricity is becoming an increasingly low carbon form of heating. Whilst the carbon intensity of grid electricity is projected to reduce as the UK continues with its Net Zero commitments, it currently remains expensive compared to gas.

Infrared heating

Traditional heating works through the process of convection. The air is heated, which circulates and warms the surrounding environment. Infrared heating panels work by emitting light in longer wavelengths at the lower energy end of the electromagnetic spectrum. This infrared energy is absorbed into solid objects causing molecules to vibrate and warm the object.

Due to being on the lower energy end of the electromagnetic spectrum, infrared heating panels are a highly effective method of heating, even more so than many convection heating systems. These systems do have some disadvantage.

Infrared light does not pass-through objects, therefore if something is placed between the heater panel and a person, the person will not feel the benefits of the heat. Infrared energy also does not warm the air as convection heaters do, so the room will feel colder immediately after the panel is switched off. The biggest drawback of infrared heating on railway premises (specifically depots) is that the panels have a short range of up to 3 metres, meaning that there can be significant ‘cold spots’, especially in the winter.

GTR currently uses infrared heating panels on some engineering depots and gate lines.

Heat Pumps

A heat pump is a system that uses electricity to absorb the natural thermal energy from one place (usually outside) and release it elsewhere (i.e., inside). This is done in a similar process to that of a refrigerator, only in reverse. Electricity is used to compress a refrigerant, when the pressure of the refrigerant increases, the temperature correspondingly increases. When the refrigerant pressure decreases, the temperature decreases. As the refrigerant’s heat is transferred to the premises through the heat exchanger, it cools down. The refrigerant is then allowed to expand, cooling it further. It is now cold enough to absorb more heat from outside and begin the process again. The relationship between pressure and temperature is defining feature of how a heat pump works. Certain designs of heat pump can work both ways, providing heating in the winter and cooling in the summer.

Heat pumps are a viable alternative to wet central heating systems. They are extremely efficient, capable of producing up to 4 times more heat than conventional electric heaters whilst using the same amount of electricity, and do not produce any climate damaging emissions as there is no combustion involved. They’re reliable, operate all year round, and are compatible with existing heating systems

with minimal additional infrastructure required. This makes them an excellent option for replacing gas boilers across the GTR network.

Although the initial cost of installation is high, it is not significantly higher than the cost of a new high efficiency gas boiler, and savings will be made over time due to reduced running costs. This makes heat pumps an ideal replacement for gas boilers when they reach their natural end of life.

There are 3 types of commercial heat pump currently available on the market: Air Source Heat Pumps (ASHP), Ground Source Heat Pumps (GSHP), and Water Source Heat Pumps (WSHP). Due to the location of our stations and depots, WSHP is not a viable option. The remaining two are discussed briefly below.

Air Source Heat Pumps (ASHP)

An ASHP transfers heat from the outside air to water which provides space heating through radiators and other 'wet' heating systems, and hot water stored in a hot water cylinder for hot taps and showers.

Through the process mentioned above, heat from the air is absorbed into a fluid which passes through a heat exchanger into the heat pump, raising the temperature, transferring heat to water.

Air source heat pumps are the most viable option for railway premises. Little additional space is required, and existing heating systems are widely compatible. One key disadvantage of air source heating is noise of emanating from the outside condensing unit. Local residents of railway premises are becoming increasingly susceptible to noise, with an increasing trend of noise related complaints being submitted. Consideration will need to be given to the location of condenser units if installed to limit the impact on our neighbours.

Ground Source Heat Pumps (GSHP)

Like air source heating, a GSHP is used to heat traditional radiators and water stored in a hot water cylinder for hot taps and showers. Instead of using latent heat stored in the air, a GSHP transfers heat from the soil outside the premises.

A mixture of water and antifreeze, known as thermal transfer fluid, flows around a loop of pipe buried in a suitable outdoor space. This loop can either be buried vertically in a borehole, which is more expensive, or laid horizontally. Heat from the ground is absorbed into the fluid, which then passes through a heat exchanger into the heat pump. This raises the temperature of the fluid and then transfers that heat to the water.

Whilst horizontal loops are more cost effective, the space required is about 2.5-3 times more than the floor area of the space being heated. This assumes a typical size of a residential home and would need bespoke calculations to assess viability for sheds found on railway engineering depots.

Ground Source Heat Pumps are better placed on engineering depots where space is available for boreholes/horizontal loops, and associated additional infrastructure required. Whilst there are a number of factors which influence overall efficiency between ASHP and GSHP, GSHP tend to be more efficient over the course of the year.

Roadmap Milestone	Target Date
Conduct feasibility studies to assess viability of replacing traditional gas boilers with alternatively fuelled heating at larger locations, taking into consideration efficiency of heating supplies and requirement of any additional infrastructure works	Medium Term
Conduct feasibility studies to assess viability of replacing traditional gas boilers with alternatively fuelled heating at smaller locations, taking into consideration efficiency of heating supplies and requirement of any additional infrastructure works	Medium Term
At the end of the products life, GTR will replace all remaining central heating and hot water systems using gas fired boilers with air/ground source heat pumps, or equivalent zero carbon technology	Long Term

Metering

Gas smart meters provide accurate billing to ensure we are paying the correct amount for the gas we use, reducing the number of estimated bills and negating the challenge of providing the supplier with regular meter reads. Smart meters also provide real-time energy usage data, the fundamental requirement to help identify ways to reduce gas consumption and associated spend.

GTR has 43 active gas supplies. As of August 2022, 17 supplies (34%) are smart metered.

Roadmap Milestone	Target Date
Install gas smart meters on the remaining conventionally metered supplies across the estate	Short Term

Ancillary Vehicles

GTR runs a fleet of 87 diesel vehicles consisting primarily of large, medium & small panel vans as well as some cars, all provided on a Contract Hire lease, a small number of vehicles are also hired on an ad hoc short term rental basis These vehicles are used by a range of functions throughout the business including site maintenance teams, Customer Information Teams, Engineering, Station Management and Rail Enforcement.

GTR is currently in the process of retendering the auxiliary fleet vehicle contract with the view of replacing the existing fleet with fully electric vehicles (EV) or hybrid electric vehicles (HEV) during the current NRC. Throughout the lifetime of the contract, we will look for opportunities to reduce the number of vehicles we rely on, and during future re-tenders we will look at options to transition remaining HEV to full EV as new tenders' progress.

Roadmap Milestone	Target Date
Assess vehicle fleet use and mileage annually to ascertain where vehicles are or are not required. Ensure controls are in place for new vehicle requests	Short Term
Develop a business plan for replacing ICE vehicles with hybrid and/or EV equivalents by 2025	2023
Install telematics on all long-term lease road vehicles	2023

Fugitive Emissions

Air conditioning presents an interesting case study into the conflict between the need to adapt to a changing climate, and the requirement to decarbonise. As the climate warms there will be greater demand for space cooling, presenting an ever-increasing risk of fugitive emissions which further contribute to global warming. At the same time, national and international efforts to achieve carbon neutrality and total decarbonisation pose an interesting challenge when considering this ongoing mandate for air conditioning. In addition, the requirement to decarbonise gas supplies presents additional risk of fugitive emissions, where preferred methods of gas replacement are in favour of air source heating, which also use the same refrigerants as air conditioning.

Whilst electrical load of air conditioning units is captured under scope 2 emissions for site electricity use, fugitive gases fall under our scope 1 responsibilities.

GTR has a growing number of air conditioning units in operation, with engineering depots accounting for 527 units, and stations accounting for 457. This is a total across the organisation of 984. The majority of the air conditioning units we use are joint heating and cooling systems.

Global Warming Potential (GWP) of refrigerant gases

Fugitive emissions are leaks of refrigerant gases from refrigeration and air-conditioning units. The refrigerant gases we use in our air conditioning are potent greenhouse gases, although shorter lived they can be thousands of times more damaging than carbon dioxide.

Between April 2021 and March 2022, fugitive emissions from air conditioning systems across GTR accounted for 2.5% of total non-traction carbon emissions.

The Global Warming Potential (GWP) allows comparisons of the global warming impacts of these different gases. It is a measure of how much energy the emissions of 1 tonne of a gas will absorb over a set period of time, relative to the emissions of 1 tonne of carbon dioxide (CO_2). The larger the GWP, the more that a given gas warms the atmosphere compared to CO_2 over that time period (typically 100 years).

Whilst different air conditioning refrigerants are made up of gaseous blends with varying GWP and atmospheric lifetimes, the overall GWP of the refrigerant is ultimately determined by the blend ratio and molecule mass of the different gases.

R410A

R410A is our most commonly used refrigeration gas. It is a zero-ozone depletion hydrofluorocarbon refrigerant blend of 50% difluoromethane (HFC-32) and 50% pentafluoroethane (HFC-125), developed as a replacement refrigerant for air conditioning previously designed for difluoromonochloromethane (HCFC-22) which was banned for use in new equipment in 2004.

The GWP of R410A is substantially worse than CO_2 for the time it persists. The resulting blend of HFC-32 and HFC-125 means that the fugitive emissions of 1kg of R410A is the equivalent of 2,088 tonnes of CO_2.

Whilst this refrigerant has a GWP higher than that of HCFC-22 (GWP 1,760) and an atmospheric lifetime of nearly 30 years compared with the 12-year lifetime of HCFC-22, R410A is considered to be a more efficient system and, assuming that atmospheric leakage is sufficiently managed, can have a lower climate impact than that of HCFC-22 systems.

R410A systems with less than 3kg charge will be banned from 2025, with equipment using R32 recommended as an alternative option. The requirement for this will not be a blanket replacement of

systems, instead unit replacement will be required as existing systems fail. Currently this impacts 223 units on stations, accounting for 48.79% of station HVAC systems.

R407C

R407C is a zeotropic blend of difluoromethane (HFC-32), pentafluoroethane (HFC-125), and 1,1,1,2-tetrafluoroethane (HFC-134a) blended at a ratio of 23/25/52 respectively. Like R410A, R407C was intended as a replacement for R22 and has a GWP of 1,774 meaning that 1kg of fugitive emissions is equivalent to 1,774 metric tonnes of CO_2.

R407C will be phased out in 2025 in systems with less than 3kg charge, with equipment using R32 recommended as an alternative option. Similar to R410A, the requirement for this will not be a blanket replacement of systems, instead unit replacement will be required as existing systems fail. Currently this impacts 17 units on stations, accounting for 3.72% of station HVAC systems.

R32

R32 (difluoromethane) is a hydrofluorocarbon refrigerant used as a replacement for R410A and R407C in refrigeration and air conditioning appliances. This refrigerant is a preferred replacement in new equipment as these systems use up to 20% less refrigerant, whilst maintaining an ozone depletion potential of zero. Where R410A has a GWP of 2,088 tonnes of CO_2 equivalent per kg, the GWP of R32 is 30% less at 675 kg CO_2 equivalent. It is not possible to transition an R410A or R407C refrigerant unit to an R32 unit, therefore new systems are required to be installed post 2025. Currently GTR has 30 HVAC units on stations using R32 refrigerant (6.56% of all station HVAC systems).

R290

R290 is a fossil fuel derived propane refrigerant gas, used primarily for smaller units. Whilst R290 has incredibly efficient thermodynamic properties, and a low GWP of 3, it is unsuitable for large units due to being highly flammable. GTR currently has 2 units using R290 across 2 locations, with a total charge of 10.69 T CO_2e.

R22

Otherwise known as HCFC-22, R22 was banned for use in new equipment in 2004 due to its role in significantly damaging the ozone layer. From 1st January 2015, it became illegal to use R22 to service industrial refrigeration and air conditioning. However, reliable and leak free R22 systems can still be legally operated until they fail.

GTR currently have 5 units across 3 locations using R22 for refrigeration, with a total charge of 6.2kg and associated GWP of 2,244 T CO_2e. These are being replaced as a priority.

Roadmap Milestone	Target Date
Review air conditioning maintenance schedule to reduce fugitive emissions	Short Term
Replace all R22 and R290 air conditioning units with R32 alternatives	Medium Term
Replace all R410A air conditioning units that have less than 3kg charge with R32 alternatives as existing units fail	2025
Replace all R407C air conditioning units that have less than 3kg charge with R32 alternatives as existing units fail	2025
Transition remaining air conditioning units to R32 (or alternative with lower GWP) at end of life, and/or incorporate into ASHP solution if appropriate and/or feasible	Medium and Long Term

On Site Equipment

Varying equipment is used across GTR that is powered through fossil fuels. These include items such as diesel jet washers, petrol leaf blowers, gas powered forklift trucks and various gas-powered welding equipment.

Contracted services such as the requirement for portable generators fall under our scope 3 emissions requirements and will be addressed through our scope 3 emissions reduction plan.

Over the next year GTR will carry out a full asset assessment to identify every piece of equipment running off these forms of power supply and generate a process for replacing those items when they become life expired. Where cost effective opportunities arise, these assets will in some instances be replaced sooner.

Roadmap Milestone	Target Date
Undertake a complete assessment of all GTR owned assets to identify those powered by natural gas, petrol, or diesel.	Short Term
Implement a process for zero carbon asset replacement when an asset reaches its end of life, or sooner.	Short Term
All natural gas assets replaced	Medium Term

Non-Traction Scope 1 Roadmap

Scope 1 Non-Traction Emissions

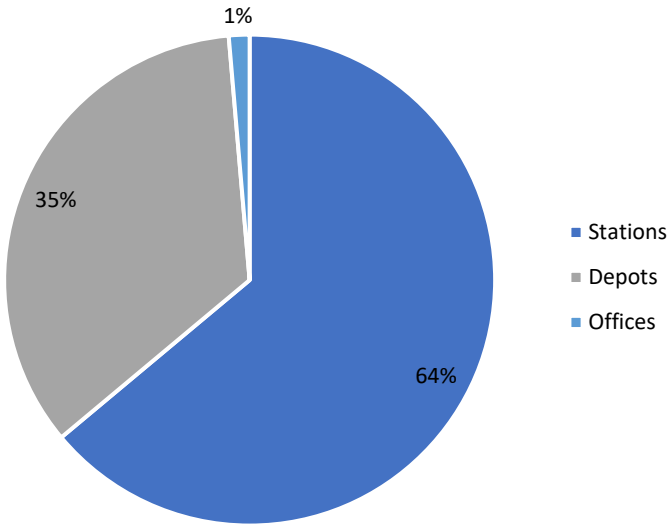
	Site Gas Removal	Ancillary Road Vehicles Fleet	Fugitive Emissions	Site Efficiency Improvements
Short Term	Install gas smart meters on the remaining supplies across the estate	Assess vehicle fleet use and mileage annually to ascertain where vehicles are or are not required. Ensure controls are in place for new vehicle requests	Review air conditioning maintenance schedule to reduce fugitive emissions	Undertake a complete assessment of all GTR owned assets to identify those powered by natural gas, petrol, or diesel
	Carry out full assessment of site heating to identify opportunities for boiler controls where feasible to limit changes in thermostatic range and encourage efficiency	Develop a business plan for replacing ICE vehicles with hybrid and/or EV equivalents by 2025	Replace all R410A air conditioning units that have less than 3kg charge with R32 alternatives as existing units fail	Implement a process for zero carbon asset replacement when an asset reaches its end of life, or sooner
	Conduct feasibility studies to assess 'quick win' locations for gas removal across stations and depots. These are likely to be locations where gas boilers are supplying small scale heating requirements such as single room heating, or water heating only.	Install telematics on all long-term lease road vehicles	Replace all R407C air conditioning units that have less than 3kg charge with R32 alternatives as existing units fail	
	Install electric boilers in small locations where gas is only used in minimal quantities			
	Install electric water heaters in locations where gas is only used for heating water			
	Develop an agreed programme with Network Rail to replace older gas systems and equipment that will become life expired during the current NRC period			
Medium Term	Conduct feasibility studies to assess viability of replacing traditional gas boilers with alternatively fuelled heating at larger locations, taking into consideration efficiency of heating supplies and requirement of any additional infrastructure works		Replace all R22 and R290 air conditioning units with R32 alternatives	All natural assets replaced
	Conduct feasibility studies to assess appropriability of viable alternatives to natural gas at larger sites, where replacement of traditional boilers would not be enough to eliminate total supply		Transition remaining air conditioning units to R32 (or alternative with lower GWP) at end of life, and/or incorporate into ASHP solution if appropriate and/or feasible	
	All natural gas fired boilers replaced			
Long Term	At the end of the products life, GTR will replace all remaining central heating and hot water systems using gas fired boilers with air/ground source heat pumps, or equivalent zero carbon technology		Transition remaining air conditioning units to R32 (or alternative with lower GWP) at end of life, and/or incorporate into ASHP solution if appropriate and/or feasible	

Non-Traction Scope 2 Emissions

Current Situation

Although non-traction electricity only accounts for 5.90% of total energy use across the company, this is not insignificant. In 2019-20 non-traction electricity amounted to over 50 million kWh.

When assessing electricity consumption, we break the data down in to 3 main areas: stations, depots, and offices. 64% of total electricity use is attributed to stations, with 35% and 1% attributed to depots and offices respectively.



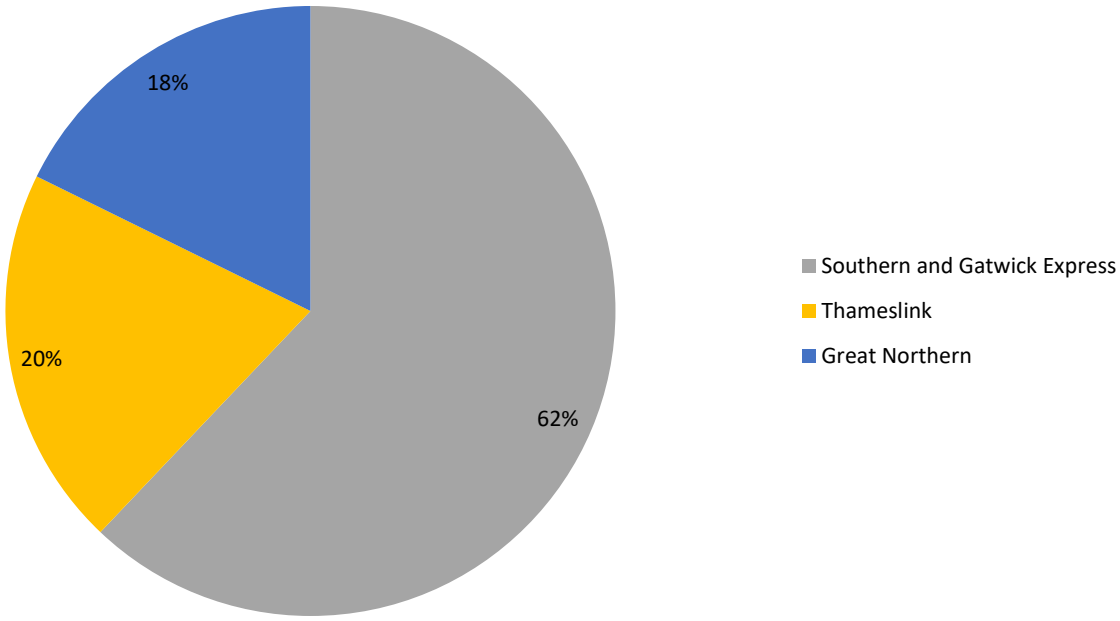
Breakdown of non-traction electricity consumption (Baseline year – April 2019-March 2020)

Stations

Across the GTR brands we operate 239 stations. These can vary in size from small, unmanned locations with minimal services per day, to large central exchanges such as East Croydon, Gatwick Airport, Brighton and Bedford. Included within stations are locations where we are tenants of other operators. These included London Terminals, Clapham Junction, Cambridge and Peterborough.

Southern and Gatwick Express	156 stations across south London, between central London and the south coast, through East and West Sussex, Surrey and parts of Kent and Hampshire; as well as Gatwick Airport.
Thameslink	33 stations between London and Bedford, Peterborough, and Cambridge; and between Luton and St Albans.
Great Northern	50 stations connecting King's Lynn, Cambridge and Peterborough, via Stevenage and Welwyn Garden City with London King's Cross.

Due to its number of stations, Southern accounts for 3/5 of total station consumption. This equates to just under 20 million kWh. Thameslink and Great Northern consume roughly the same amount, but despite Thameslink having less stations than Great Northern, Thameslink's consumption is slightly higher at just under 6 and a half million kWh, with Great Northern at just over 5 and a half million kWh. This is attributed to the relative sizes of stations operating under Thameslink which include the London Core (London Blackfriars through to St Pancras).



Non-traction station electricity consumption by brand

Total station electricity consumption by brand in 2019/20		
Southern and Gatwick Express	19,880,512 kWh	62%
Thameslink	6,462,118 kWh	20%
Great Northern	5,676,148 kWh	18%

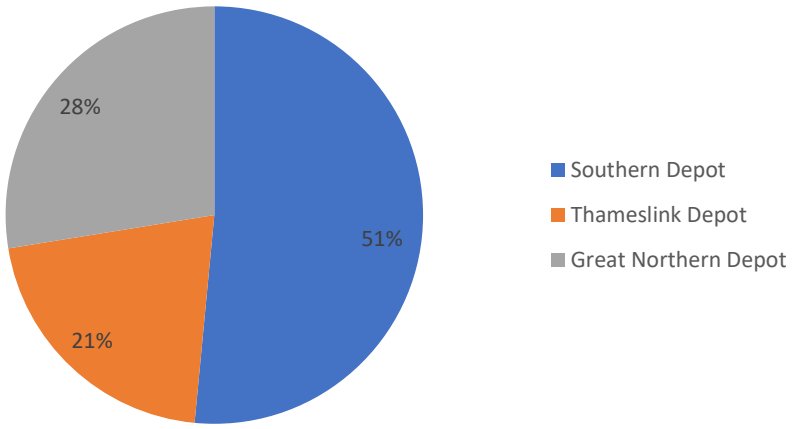
Many Stations have similar profiles regarding energy use, and broadly fall under 2 categories.

First-Party Consumption is the consumption that we as GTR are responsible for. This includes station office and mess room equipment; automatic ticket vending machines; gatelines; CCTV systems; tannoy and Customer Information Systems; ticket office and waiting room heating; and station, platform, car park and waiting room lighting. Whilst this list is not exhaustive, it gives a general view of what is used on a typical railway station.

Third-Party Consumption is the consumption that we influence, but do not directly control. This includes station tenants, Network Rail, and in some cases neighbouring residents. Ideally all third-party consumption should be sub-metered or transferred over to the consumer. This is not always possible therefore recharge arrangements are put in place where recognised.

Depots

As an organisation we operate 12 dedicated depot supplies. Like stations, these vary in size and have a range function across both Engineering and Train Presentation. Our 5 largest depots at Selhurst, Hornsey, Three Bridges, Brighton, and Stewarts Lane account for 90% of our non-traction electricity consumption on depots, and 31% of total non-traction electricity. Overall, depot electricity accounts for 35% of total non-traction electricity.



Non-traction depot electricity consumption by brand

Total depot electricity consumption by brand in 2019/20		
Southern and Gatwick Express	8,955,873 kWh	51%
Thameslink	3,640,169 kWh	21%
Great Northern	4,790,424 kWh	28%

Offices

Whilst GTR have a number of smaller office spaces across the network, from a consumption perspective it is the dedicated supplies for the 2 head offices that account for all our office consumption. These are Go-Ahead House in East Croydon, and Monument Place in central London.

Go-Ahead House spans 5 floors and has 266 registered staff located there.

Monument Place accounts for a single floor and has 219 registered staff located there.

Since the Covid-19 pandemic, a hybrid working environment has been implemented which has seen office consumption reduce by 27%. Post-pandemic Monument Place office space was reduced from 2 floors to 1.

Office consumption accounts for 1.36% of total non-traction electricity.

Shared assets

GTR have a number of locations which are owned by other leaseholders such as Network Rail, with areas rented to GTR. These include Kings Cross East Side Offices, and the Three Bridges Rail Operating Centre (ROC).

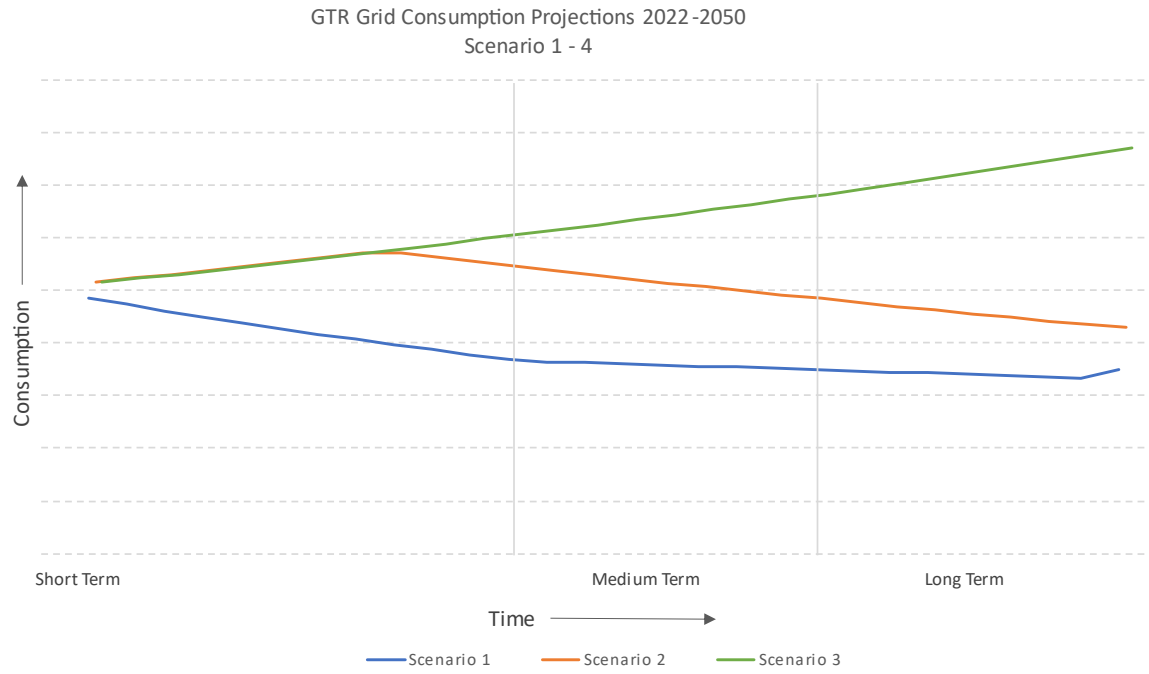
Energy Modelling

The UK government has committed to decarbonise the UK's electricity system by 2035 as part of the UKs net zero ambitions. This will be achieved by building a secure, UK based energy sector that reduces reliance on fossil fuels and exposure to volatile global wholesale energy prices.

This ambitious target is set to be achieved by utilising home-grown technologies such as offshore and onshore wind, hydrogen and solar, nuclear, and Carbon Capture and Storage.

Grid decarbonisation has improved by 40% over the last 5 years, with carbon intensity reducing from 0.35156 kg CO_2e per kWh in 2017, to 0.21233 kg CO_2e per kWh in 2021.

GTR's non-traction electricity consumption modelling has been based on 3 potential grid consumption scenarios as detailed below. In each scenario it is expected that emissions will reduce due to the natural decarbonisation of grid electricity, however we recognise that this is not a single solution, and measures will be taken to reduce overall draw on the national grid.



Scenario 1 Aggressive efficiency measures

This scenario assumes significant investment in efficiency measures, providing around 2.5% year on year reduction in consumption, leading to an overall reduction in grid consumption in the short term. Grid consumption is then predicted to plateaux as key efficiency measures are completed and smaller reductions are implemented. Whilst it is expected that longer term projects will produce reductions in grid draw (implementation of renewable energy etc), this reduction will be offset somewhat by the transition of gas supplies to electric resulting in a possible increase at the end of longer-term planning.

Scenario 2 2030 peak grid consumption

This scenario assumes a year-on-year short-term increase in grid consumption, reflecting the balance between efficiency measures and contractual requirements to introduce further on-site consumers, such as Ticket Vending Machines, Electric Vehicle Charging Points and Customer Information Systems. This increase is also reflective of the need to decarbonise gas supplies and move to electric alternatives for water and space heating. After the peak, the scenario assumes year-on-year reductions into the medium and long-term as infrastructure improvements are completed and further efficiency measures, including on-site renewable energy systems, are implemented.

Scenario 3 Business as Usual

This scenario assumes minimal investment in efficiency measures coupled with business requirements to implement more energy consuming assets such as electric vehicle charging facilities, and digital technologies.

Decarbonisation and Emissions Reductions

Electricity Procurement

Grid Electricity

In alignment with the Go-Ahead Groups Climate Change Strategy, all of GTR's non-traction electricity is procured through by Go-Ahead Group on a green electricity tariff.

Non traction energy is provided by SSE on a 100% renewable electricity contract, backed fully by Renewable Electricity Guarantee of Origins (REGOs) which are independently verified by EcoAct, a CDP Accredited Provider.

Consumption used is matched to an equivalent volume generated by wind and hydro assets then exported to the National Grid. The energy market regulator Ofgem provides SSE with a Renewable Energy Guarantee of Origin (REGO) certificate for each megawatt hour of renewable electricity they generate.

This provides assurance and transparency from the supplier that their processes comply with the stringent carbon reporting requirements of the Green House Gas (GHG) Protocol Corporate Accounting and Reporting Standard, and as such we are provided with an annual 'Assurance Statement' from EcoAct.

Roadmap Milestone	Target Date
Remain on a green electricity tariff to bridge the gap between efficiency improvements and reliance on grid electricity	Short Term

Power Purchase Agreements (PPA) for renewables

GTR currently procure electricity through a Group wide energy contract. Whilst the electricity we consume is billed on a green tariff, there could be opportunities to work with local renewable energy suppliers through the decentralisation of our electricity in favour of procuring electricity direct from local solar or wind farms through either localised Direct Wire Power Purchase Agreements, or other forms of Corporate Power Purchase Agreements.

The limitation with direct wire purchase is the location of GTR owned sites in relation to renewable energy generating sources, and the associated costs of additional infrastructure.

A direct wire PPA requires proximity of the generating facility to the offtaker's premises so that a direct wire can be laid between the two sites. The advantage of this arrangement is that the contractual relationship for the sale and purchase of power can be bilateral between the generator and the offtaker. The offtaker benefits from the direct supply of renewables, and both parties benefit from not requiring a licensed supplier to be involved, or the need to connect to a distribution or transmission network.

Despite the physical challenges of direct wire supply, there is opportunity to explore options for letting out roof space using a similar model to the Streatham Hill Depot Solar Project. This cooperative between GTR and the community benefit society “Energy Garden“ saw the installation of over 500 solar photovoltaic panels, with Energy Garden selling 42% of the generated electricity back to GTR, at significantly cheaper and protected tariffs than can be obtained on the open market, and the remainder exported. Over 20 years, this combined income is set to generate more than £100,000 which will fund Energy Garden’s delivery of schools’ education, youth training programmes and community gardens across the rail network.

Roadmap Milestone	Target Date
Explore cost implications of decentralised electricity procurement, in favour of local Power Purchase Agreements for renewable energy	Medium Term

Renewable Energy Generation

Through our National Rail Contract, GTR have a requirement to work in collaboration with Network Rail to identify opportunities to instal renewable energy systems across our network.

Our solar instal at Streatham Hill, in partnership with the cooperative energy firm Energy Garden, sees 42% of grid electricity replaced with renewable energy generated on-site by solar photovoltaics (PV).

Accounting for 35% of total non-traction electricity, and due to the infrastructure in place, our engineering depots are ideal candidates for on-site renewable generation in the form of solar PV.

Assuming 40% of depot electricity can be generated by on-site renewables, this could reduce GTR’s total grid load by 13.78%.

On stations GTR have worked in partnership with Network Rail to include 9 new solar PV arrays across the new platform canopies at Denmark Hill. This innovative design incorporated prefabricated solar film that could be peeled and stuck on the canopies during manufacture, the first station upgrade in Europe to use this technology.

Across Quarter 1 of 2022 (April-May-June) the arrays generated 3,466 kWh of electricity. Total grid draw from the station over the same period was 49,930 kWh meaning that the new solar PV film

accounted for 6.5% of total station consumption, and allowed the project works at Denmark Hill to deliver the first carbon positive upgrade on the UK rail network.

GTR is pursuing opportunities with Network Rail to use the same technology as Denmark Hill at other station enhancement programmes such as Peckham Rye.

Roadmap Milestone	Target Date
Work collaboratively with Network Rail and 3rd parties to identify viable renewable energy schemes at Stations and Depots	Short, Medium and Long Term
Prepare a renewable energy options paper with Network Rail detailing the potential opportunities for renewable energy schemes across Stations and Depots	2023

Devolved Budgets

Budgetary responsibility for supplies currently sits centrally within the Infrastructure Directorate.

Devolving budget responsibility to those who consume energy will provide localised ownership and help encourage efficiency and reductions.

Roadmap Milestone	Target Date
Explore options for devolving utility budgets directly to the site consumer	Short Term

Metering

Electrical smart meters provide accurate billing to ensure we are paying the correct amount for the electricity we use, reducing the number of estimated bills and negating the challenge of providing the supplier with regular meter reads. Smart meters also provide real-time energy usage data, the fundamental requirement to help identify ways to reduce electricity consumption and associated spend.

GTR currently have 27 out of 314 electricity supplies not being metered through smart metering. These supplies will be upgraded to smart meters.

Additionally, GTR have 28 stations where no supply data is available due to electricity being billed to us by Network Rail. In order to fully appreciate total consumption on our sites, we will work in collaboration with Network Rail to ensure these supplies are handed over to us.

Roadmap Milestone	Target Date
Using all reasonable endeavours, ensure that all electric meters measuring non-traction energy consumption across our estate are automatic meter reading (smart) meters	Short Term
In collaboration with Network Rail, transfer control of all station supplies to GTR where current supply data is missing	Medium Term

Equipment Efficiency

Efficiency of owned assets presents an opportunity to reduce overall consumption of electricity. LED lighting is around 75% more efficient than regular lighting and lasts up to 25 times longer. Whilst much of GTR's platform and canopy lighting has already been upgraded to LED's, there is potential to improve station concourse and booking hall lighting with LEDs, as well as within our engineering depots. Building insulation is also a key area of focus and provides a cost effective way of making our infrastructure more energy efficient.

Across our stations and depots, we use a considerable amount of equipment powered by electricity. This includes station equipment such as monitor screens, computers, Heating Ventilation And Cooling systems, gate lines, ticket vending machines, escalators, and air curtains. On Depots we also have the addition of heavy machinery used for train maintenance. As we transition away from natural gas, we will also see an increase in electric heating as gas boilers are replaced with electrically run heat pumps (or equivalent technology), and other electric options to replace direct gas fired heating.

Over the short, medium, and long-term all of these assets have the potential to be replaced with more energy efficient alternatives when they reach their natural end of life.

To understand where energy efficiency measures can be introduced, inspection and analysis of energy flows across our estate can be undertaken to tell us where we use energy, to allow informed decisions to be made on potential solutions to reduce consumption.

Roadmap Milestone	Target Date
Undertake site energy assessments to understand opportunities for improving site efficiency	Short and Medium Term
Implement a process for zero carbon asset replacement when an asset reaches its end of life, or sooner	Short Term
All site lighting to be converted to LED where feasible	Medium Term

Third Party Liaison

In locations where we rent office space, we will work with the landlord to ensure the energy we use is sourced from renewable supplies. In most cases our landlord is Network Rail who are under similar requirements to decarbonise. As such, we will continue to work with Network Rail and support them with their own decarbonisation targets

We will also work with our Commercial Team to ensure 3rd party users of our own supplies are either smart metered or provided with their own dedicated supplies. This includes station tenants and Network Rail assets fed from GTR supplies, and off site commercial and residential properties fed by the station or depot supply.

Roadmap Milestone	Target Date
Work collaboratively with Network Rail to rationalise the supplied estate to ensure correct consumers are assigned to the appropriate supplies	Medium Term
Work with our landlords where we share/rent office space to ensure the energy we use is sourced from renewable supplies	Medium Term
Undertake rationalisation of rented property to ensure 3rd party consumers are given responsibility for their energy usage	Short Term

Non-Traction Scope 2 Roadmap

Scope 2 Non-Traction Emissions

	Grid Electricity Procurement	Renewable Energy	Site Efficiency Improvements	Collaboration
Short Term	Using all reasonable endeavours, ensure that all electric meters measuring non-traction energy consumption across our estate are automatic meter reading (smart) meters	Work collaboratively with Network Rail and 3rd parties to identify viable renewable energy schemes at Stations and Depots	Explore options for devolving utility budgets directly to the site consumer	Undertake rationalisation of rented property to ensure 3rd party consumers are given responsibility for their energy usage
	Remain on a green electricity tariff to bridge the gap between efficiency improvements and reliance on grid electricity	Prepare a renewable energy options paper with Network Rail detailing the potential opportunities for renewable energy schemes across Stations and Depots	Implement a process for zero carbon asset replacement when an asset reaches its end of life, or sooner	
			Undertake site energy assessments to understand opportunities for improving site efficiency	
Medium Term	Explore cost implications of decentralised electricity procurement, in favour of local Power Purchase Agreements for renewable energy	Work collaboratively with Network Rail and 3rd parties to identify viable renewable energy schemes at Stations and Depots	Undertake site energy assessments to understand opportunities for improving site efficiency	Work collaboratively with Network Rail to rationalise the supplied estate to ensure correct consumers are assigned to the appropriate supplies
			All site lighting to be converted to LED where feasible	In collaboration with Network Rail, transfer control of all station supplies to GTR where current supply data is missing
				Work with our landlords where we share/rent office space to ensure the energy we use is sourced from renewable supplies
Long Term		Work collaboratively with Network Rail and 3rd parties to identify viable renewable energy schemes at Stations and Depots		

Science Based Targets, and Scope 3 Emissions

GTR have appointed Atkins (a subsidiary of SNC-Lavalin Group) to work with us to quantify our scope 3 emissions, develop and submit scope 3 carbon budgets in line with science-based targets, register with the Science Based Targets Initiative (SBTi) and develop a scope 3 decarbonisation roadmap. This roadmap will align with the Science Based Target as well as including measures to meet GTR's target of total decarbonisation by 2050. Reference to the UK 2050 net zero target will also be made and a business-as-usual scenario will also be included.

The proposal and roadmap of how this will be achieved has been included as Appendix B.

The completed narrative will be included in the final version of this report.

Roadmap Milestone	Target Date
Develop a plan for establishing a full set of milestones and validated science-based targets to be achieved within the Contract Term	31st Mar 2023
Deliver a full set of validated science-based targets, covering scope 1, 2 and 3 emissions	31st Mar 2024

Science Based Targets and Scope 3 Roadmap