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PROJECT

REPORT

Specialist Fleet Review

North West Leicestershire District Council

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Document Revisions

No.	Details	Date
1	Initial release, for Cenex Review	16/06/2021
2	Peer reviewed copy for release	24/06/2021
3	Final release	06/08/2021

Contents

Abbreviations

BEV	Battery Electric Vehicle
CH_4	Methane
CI	Compression Ignition
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DF	Dual Fuel
DNO	Distribution Network Operator
FAME	Fatty Acid Methyl Ester
FC REEV	Fuel Cell Range Extended Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GVW	Gross Vehicle Weight
GWP	Global Warming Potential
HGV	Heavy Goods Vehicle
HRS	Hydrogen Refuelling Station
HVO	Hydrotreated Vegetable Oil
ICE	Internal Combustion Engine
LCV	Light Commercial Vehicle
LEV	Low Emission Vehicle
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MPV	Multi-Purpose Vehicle
N_2O	Nitrous Oxide
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter
PTO	Power Take-Off
RCV	Refuse Collection Vehicle
REEV	Range Extended Electric Vehicle
RRV	Resource Recovery Vehicle
RTFO	Renewable Transport Fuel Obligation
SI	Spark Ignition
TCO	Total Cost of Ownership
TTW	Tank-to-Wheel
ULEV	Ultra-Low Emission Vehicle
WTW	Well-to-Wheel
ZEV	Zero Tailpipe Emission Vehicle

1. Executive Summary

Low emission options for specialist equipment and plant are at a lower level of product maturity and availability than those used in road vehicles. Therefore, the evaluation of specialist fleet options within North West Leicestershire District Council (NWLDC) and the resulting implementation strategy and recommendations in this report have been undertaken at higher level than that used for other operational road vehicles.

The focus of this high level review was aimed at mobile specialist fleet items; hand tools and similar items were deemed out of scope.

Methodology

This specialist fleet review is based on relevant operational data supplied by NWLDC supplemented by supplier interviews. The review was delivered through the following steps which commenced upon receipt of initial fleet data following a project initiation meeting delivered via a web conference.

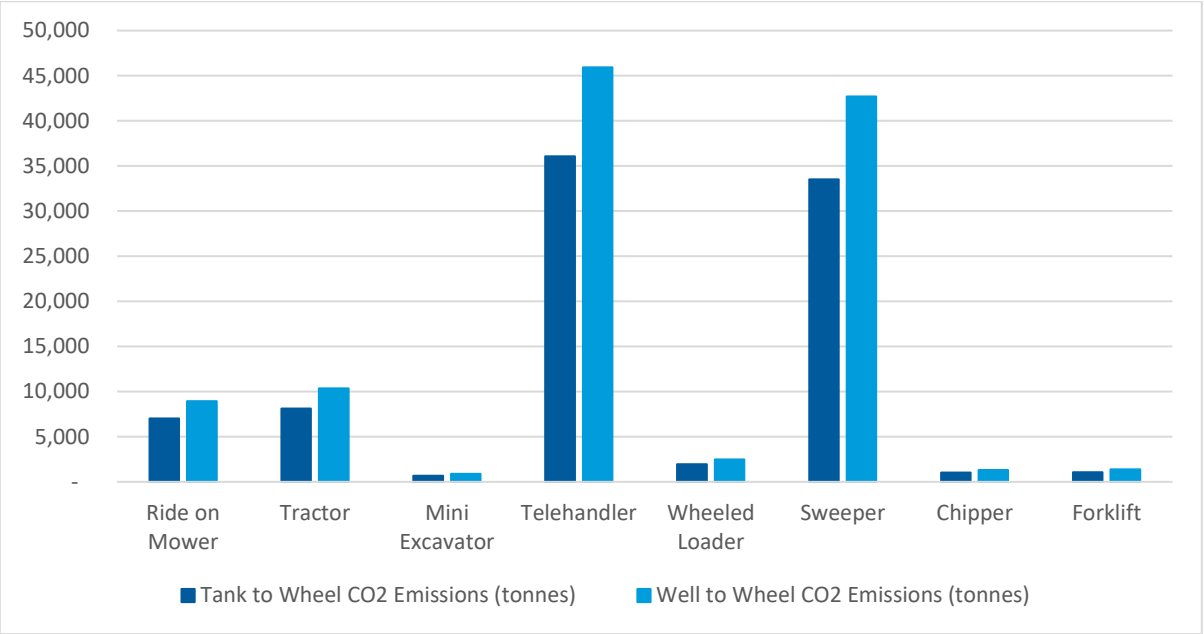
- Summary of Current Specialist Fleet: using the data provided, Cenex segregated the list into key groups, with each group baselined to show the current position including the number of units, fuel consumption, and carbon emissions.
- Low Emission Technology Options: The currently available (2021) lower carbon technology options are then reviewed for each identified equipment group commenting on the effect of the alternative options on product fit, emissions, operability, ease of refuelling, and cost. Other alternatively fuelled lower carbon technology options, expected to be available in 2030, are examined based on technology trends and development road maps.
- Recommended Replacement Technologies: based on the outcomes of the Technology Options review, recommendations are presented identifying those options that could be implemented into the NWLDC specialist fleet through trials to establish capability and performance of alternative options in 2021.

Summary of Current Plant Equipment

There are 20 specialist fleet vehicles on the NWLDC fleet, dominated by Mowers, Sweepers, Telehandlers and Tractors. The specialist fleet operates primarily on diesel, with fuel consumption data provided on a per vehicle basis where available, outlined in the table below.

	Number	Fuel Consumption (litres/ annum)
Ride on Mower	6	3,234
Tractor	3	3,748
Mini Excavator	1	318
Telehandler	3	16,632
Wheeled Loader	1	895
Sweeper	4	15,454
Chipper	1	470
Forklift	1	500
Total	**20**	**41,251**

The annual carbon dioxide emissions associated with specialist fleet operations have been derived using the 2020 UK Government GHG Conversion Factors for Company Reporting. Based on these calculations, the NWLDC emits some 91 tonnes of Tank to Wheel (TTW) and 117 tonnes of Well to Wheel (WTW) CO_2 emissions. The figure below illustrates the annual WTW CO_2 emissions associated with each specialist fleet category; the majority of emissions are associated with the use of telehandlers and sweepers due to a combination of high usage patterns and high fuel consumption.



Recommended Options

The completed Low Emission Technology Options review has indicated that biodiesel, hydrotreated vegetable oil (HVO), electric and alternative hydrocarbon fuels such as compressed natural gas (CNG) and biomethane (bio-CNG) have some applicability across the identified groups of specialist fleet vehicles.

However, both biodiesel and CNG/ bio-CNG are likely to experience increased costs in terms of capital and operational expenditure. These alternative options have therefore not been recommended for further investigation. In terms of HVO, while there is an operating expenditure increase compared to diesel this is expected to be outweighed by the emission reduction, and operational benefits of this fuel coupled with no impact on capital expenditure. While electric is significantly more expensive, in terms of capital expenditure, than the equivalent diesel variant, with some operational changes required, these should be outweighed by the emission reduction, and operational expenditure benefits of this technology.

It is therefore recommended that NWLDC further investigate the options to trial electric variants of the following specialist fleet equipment:

- Ride on Mowers
- Tractors
- Telehandlers
- Compact & Truck Mounted Sweepers

Where electric variants prove incompatible with existing working practices within NWLDC the use of HVO is recommended as an alternative.

However, prior to the wider deployment of low emission alternatives, it is recommended that NWLDC undertake a more detailed investigation into the operational, environmental, and economic impacts of those options highlighted. This would include the development of appropriate total cost of ownership (TCO) models similar to those generated through the main operational fleet review. In addition, such deployments need to take into consideration the outcomes of the operational fleet review in terms of charging and refuelling infrastructure provision to ensure that vehicles can maintain their operational duties.

It is further recommended that NWLDC remain attentive to relevant innovation demonstration opportunities from funded research and development programmes, for example though Innovate UK or the Advanced Propulsion Centre.

2. Specialist Fleet Review

Low emission options for specialist equipment and plant are at a lower level of product maturity and availability than those used in road vehicles. Therefore, the evaluation of specialist fleet options within North West Leicestershire District Council (NWLDC) and the resulting implementation strategy and recommendations in this report have been undertaken at higher level than that used for other operational road vehicles.

The focus of this high level review was aimed at mobile specialist fleet items; hand tools and similar items were deemed out of scope.

It should be recognised that in the Budget 2020, the UK Government announced that it will remove the entitlement to use duty discounted 'red' diesel from non-agricultural NRMM in April 2022, therefore the NWLDC specialist equipment fleet will be required to transition to standard road diesel at a duty rate of 57.95ppl compared to the current 11.14ppl for red diesel.

2.1 Methodology

This specialist fleet review is based on relevant operational data supplied by NWLDC supplemented by supplier interviews. The review was delivered through the following steps which commenced upon receipt of initial fleet data following a project initiation meeting delivered via a web conference.

- Summary of Current Specialist Fleet: using the data provided, Cenex segregated the list into key groups, with each group baselined to show the current position including the number of units, fuel consumption, and carbon emissions. Where fuel consumption data was not available estimated fuel consumption and associated emission factors have been applied.
- Low Emission Technology Options: The currently available (2021) lower carbon technology options are then reviewed for each identified equipment group commenting on the effect of the alternative options on product fit, emissions, operability, ease of refuelling, and cost. Other alternatively fuelled lower carbon technology options, expected to be available in 2030, are examined based on technology trends and development road maps.
- Recommended Replacement Technologies: based on the outcomes of the Technology Options review, recommendations are presented identifying those options that could be implemented into the NWLDC specialist fleet through trials to establish capability and performance of alternative options in 2021.

2.2 Equipment Baselining

The baselining process allows the usage, fuel consumption, emissions, and operating patterns to be understood before the low emission vehicle technology assessment takes place. The baselining process also allowed for the identification of those items of equipment that were the highest carbon emitters, and therefore the focus of the alternative technology review.

There are 20 pieces of specialist fleet vehicles on the NWLDC fleet as highlighted in Table 1; these have been categorised according to nearest equipment type.

Item	Number
Ride on Mower	6
Tractor	3
Mini Excavator	1
Telehandler (e.g. Yard Vehicles)	3
Wheeled Loader (e.g. Cat Loader)	1
Sweeper	4
Chipper	1
Forklift	1

Table 1 - Numbers of Specialist Equipment

It is noted that NWLDC operate a HIAB/crane, which is associated with a Tipper on the operational fleet. As the HIAB is operated via a power-take off coupling it is difficult to accurately calculate the emissions associated with its operational use. This piece of equipment has, therefore, been discounted as part of this review.

2.3 Estimated Fuel Consumption and Emissions

The NWLDC specialist fleet operates primarily on diesel, with fuel consumption data provided on a per vehicle basis where available. Where fuel consumption data was not available it was estimated based on the engine size of the equipment and similar equipment operations.

The calculated fuel consumption for the NWLDC specialist fleet is outlined in Table 2.

Table 2 - Estimated Annual Fuel Consumption

	Number	Fuel Consumption (litres/ annum)
Ride on Mower	6	3,234
Tractor	3	3,748
Mini Excavator	1	318
Telehandler	3	16,632
Wheeled Loader	1	895
Sweeper	4	15,454
Chipper	1	470
Forklift	1	500
Total	**20**	**41,251**

The annual carbon dioxide emissions associated with specialist fleet operations have been derived using the 2020 UK Government GHG Conversion Factors for Company Reporting. Based on these calculations, the NWLDC emits some 91 tonnes of Tank to Wheel (TTW) and 117 tonnes of Well to Wheel (WTW) CO_2 emissions. Sweepers and Telehandlers are the largest emitters, accounting for around 78% of fuel consumption and emissions, with Mowers and Tractors also identified as significant emitters. These four vehicle categories have been taken forward for a more detailed assessment as part of this review.

Figure 1, below illustrates the annual TTW and WTW CO_2 emissions of each specialist equipment type within the NWLDC fleet.

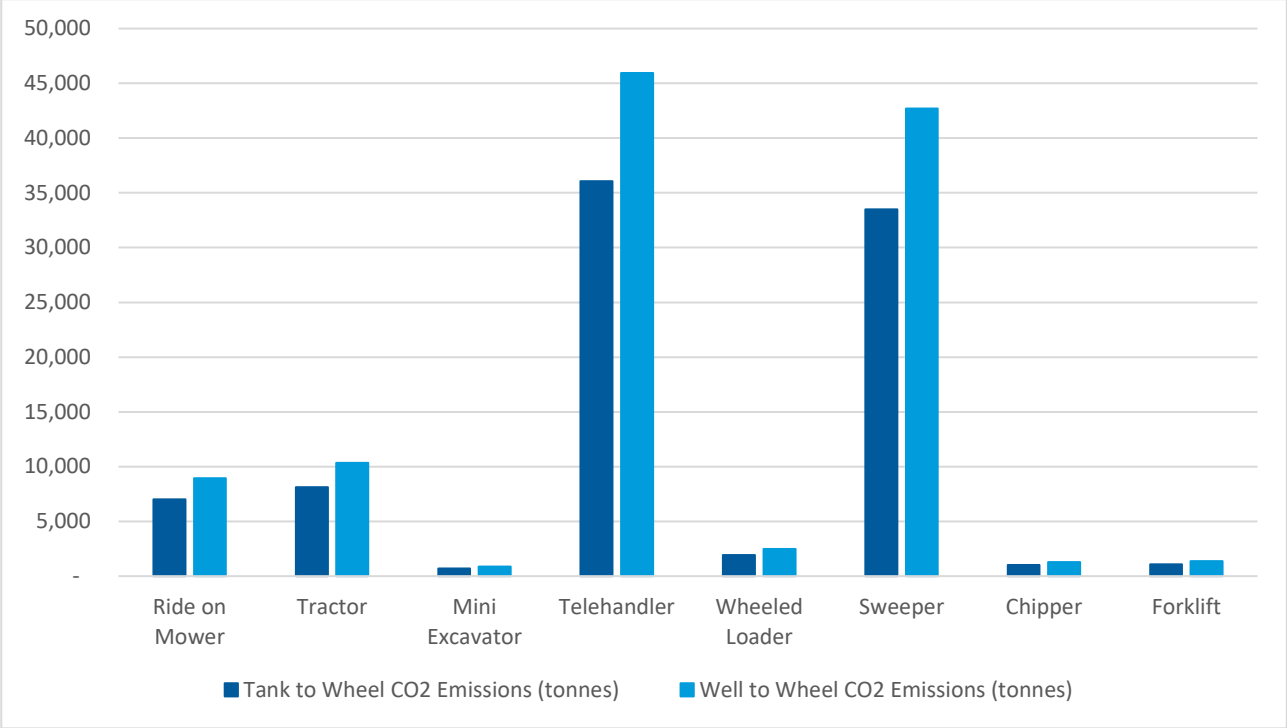


Figure 1 – Specialist Fleet Annual CO_2 Emissions

2.4 Regulatory Emission Standards

Emission standards for specialist equipment and plant machinery is known as Non-Road Mobile Machinery (NRMM); these standards have traditionally lagged behind road transport in terms of emission reduction. However, recent action is addressing this in part, due to legislative pressures to clean up all aspects of modern society to reach key regional, national, and global emission targets. NRMM regulations are an internationally standardised set of emission controls, with the date when a piece of plant machinery was manufactured determining which standard a given item of machinery must comply with.

At the time of writing Stage V is in effect, with Figure 2 illustrating the reduction in permitted emissions per emission stage for high power NRMM diesel engines.

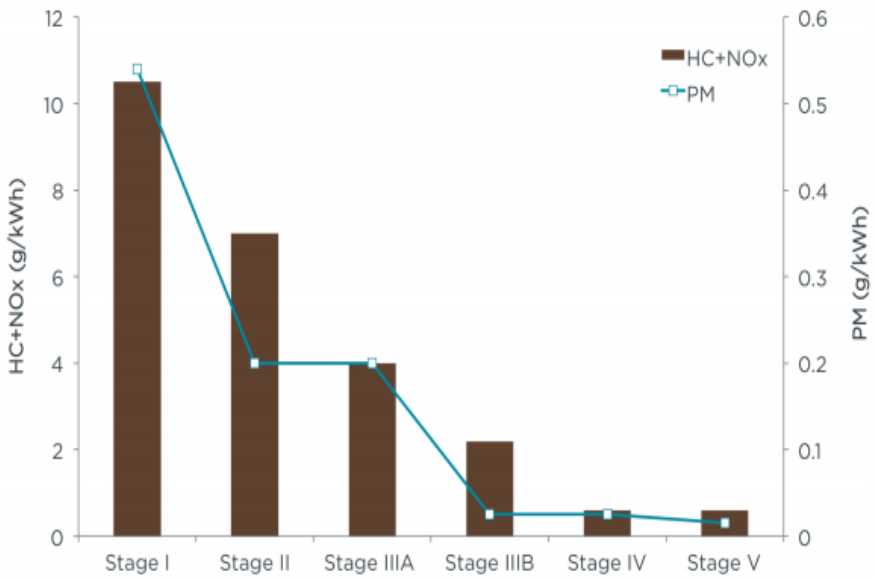


Figure 2 - NRMM Emission Reduction Standards

The latest Stage V engines offer increased fuel efficiency compared to previous emission stage compliant engines. For example, Scania Stage V engines are noted to report up to a 5% reduction in fuel costs compared to their Stage IV compliant engines. Off cycle emission control is also further controlled by Stage V regulation which has effectively mandated Diesel Particulate Filters on all but the lowest power engines.

The current NWLDC specialist fleet emission stages are shown below in Figure 3. It should be recognised that the replacement of older early-stage equipment with Stage V equipment will both reduce regulated emissions (CO, NOx, HC & PM) and is highly likely to reduce the machines CO_2 emissions.

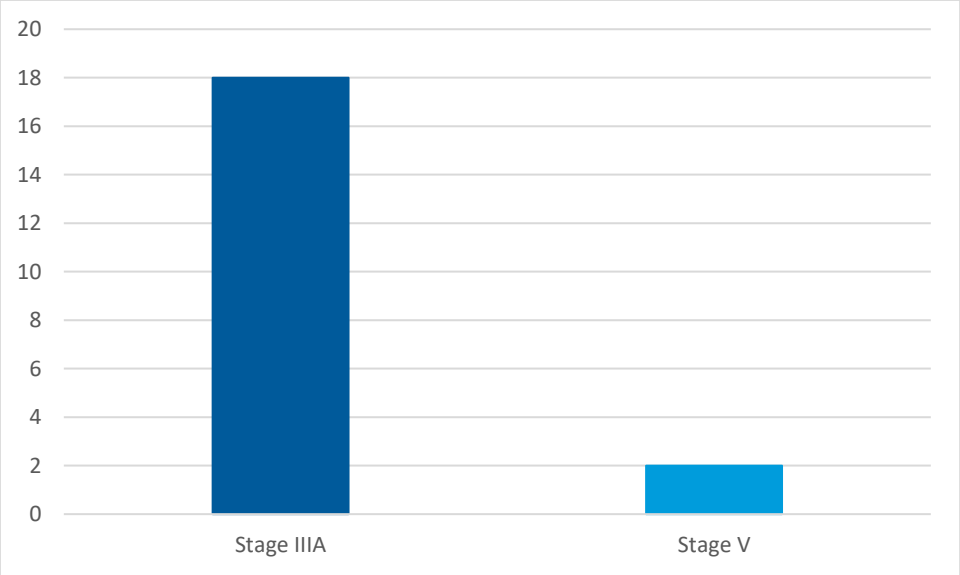


Figure 3 – NWLDC Specialist Equipment Emission Stages

2.5 Low Emission Technology Options Review

This section assesses the lower carbon alternative technologies available for each of the identified specialist equipment categories. Each category of has been assessed regarding their suitability against the following fuels/powertrain options.

- Bio & synthetic diesels (biodiesel (FAME) & hydrotreated vegetable oil (HVO))
- Diesel-electric hybrid
- Electric
- Alternative hydrocarbon (HC) fuel (e.g. CNG, Bio-CNG)
- Hydrogen

The low emission technologies review firstly presents the identified equipment category and its operational requirements. Next the review examines each of the above technology options, where the maturity of the alternative technology is assessed to focus the review on eligible options. This assessment of eligible technologies examines:

- Operational restrictions and benefits
- Range
- Refuelling/ recharging time
- Emission reduction potential
- Cost (operational and capital)

An example of this assessment, for Mowers is presented below, with assessments of the other identified specialist fleet vehicle categories outlined in Appendix A – Alternative Technology Data Tables.

Specialist Fleet Category: Mowers	
 	
No of Vehicles	4 units
Typical Operating Pattern	Seasonal, spring to autumn. Mowing of playing fields and park lands.
Technology Maturity	• **Biodiesel (FAME & HVO)**: Available • **Diesel-Electric Hybrid**: Not available • **Electric**: Available • **Alternative Fuel (HC)**: limited CO_2 benefit, some air quality improvement. • **Hydrogen**: Not available Options for detailed review: **Biodiesel (FAME & HVO)** and **Electric**.
Operational Restrictions and Benefits	• **Biodiesel:** FAME: Increased maintenance regime, mineral diesel fuel and engine flush required before use, fuel quality requires monitoring and managing. HVO: drop in fuel equivalent to diesel. • **Electric**: Reduced maintenance regime, some potential performance improvements over diesel/petrol equivalent.
Range	• **Biodiesel**: Like-for-like replacement (~75 miles on a 15 litre tank). • **Electric**: Mean Green have large electric mowers with (claimed) up to 7-hour operational time.
Refuelling/ Recharging Time	• **Biodiesel**: Same as diesel. • **Electric**: 7 hours at 240v 13 amps, Mean Green (standard outlet).
Emission Reduction	• **Biodiesel**: FAME: Variable depending on blend (approx. 18% WTW and 23% TTW CO_2 reduction available from B25 blend). Engine design, fuel quality and operational cycles essential in assessing total emission with biodiesel – with some authors reporting increases in emitted NOx, particulates and CO. HVO: approx. 91% WTW CO_2 reduction available. • **Electric**: Zero TTW emissions, WTW CO_2 emissions depend on energy generation, with ~50-60% reductions based on current grid mix.
Additional Notes	• **Biodiesel**: FAME: Manufacturer approaches vary depending on emission stage for example all John Deere engines can use biodiesel blends. Stage V engines operated within the European Union may use blends up to 8 percent (B8). Concentrations up to 20 percent (B20) can be used for all other John Deere engines providing the biodiesel used in the fuel blend meets European Standard (EN) 14214. HVO: May require manufacturer approval before use. • **Electric**: Operational information suggests charging will not limit operations. Mean Green is a small manufacturer, quality and reliability should be investigated.

Specialist Fleet Type: Mowers	
Costs	• **Diesel**: At the Budget 2020, the government announced that it will remove the entitlement to use red diesel from non-agricultural NRMM in April 2022 • **Biodiesel**: FAME: Equipment Costs: For high biodiesel blend use manufacturers may require a biodiesel upgrade package to be installed, typically costing a few hundred pounds. For B100 use, the vehicles require a conversion to include a simple system for warming the fuel. Various conversions are available either at factory or retrofitted. These typically cost from £6,500 - £8,000 per vehicle but may not be available for small equipment items. Fuel Costs: Comparable to Road Diesel. Maintenance Costs: Some vehicle manufacturers suggest modified routines such as increased fuel filter and oil changes. Infrastructure Costs: Biodiesel blends up to B30 can be stored in and dispensed from existing infrastructure for diesel vehicles at no extra cost. B100 however needs to be kept at an appropriate temperature to ensure it remains liquid in the colder months. This will result in some additional energy costs. FAME has a shelf life of around 3 months so requires constant usage to ensure fuel quality is maintained. HVO: Equipment Costs: No impact on vehicle cost. Fuel Costs: Cost of fuel per litre is typically 10-15p/l higher than diesel. Maintenance Costs: Maintenance costs are identical to that of diesel vehicles. Infrastructure Costs: No specialist equipment is needed to store HVO. FAME and HVO fuel costs rely on minimum order quantities would ned to be factored into any wider deployment of these fuels across the operational fleet. • **Electric**: Equipment Costs: significantly higher than diesel. Fuel Costs: significantly lower that diesel. Maintenance Costs: Lower than that of identical diesel mowers. Infrastructure Costs: Slow charge (13A) no cost; higher charging rates will require specific infrastructure at additional cost.

A ‘Traffic Light’ approach was utilised to summarise the above alternative technology review. This approach rates the suitability of the identified alternative technology options in the following areas: Operational, Emissions, Capital Expenditure (CapEx) and Operational Expenditure (OpEx) in a **RED AMBER GREEN** traffic light matrix, as shown in Table 3.

Table 3 - Plant Equipment Traffic Light Criteria

Factor	Red	Amber	Green
Operational	Fails to meet operational requirements	Meets some operational requirements	Meets all operational requirements
Emissions	Higher CO_2 emission (in comparison to Stage-V)	Reduced CO_2 emission (in comparison to Stage-V)	Zero emissions at tailpipe
CapEx	Significantly higher plant + infrastructure CapEx	Broadly similar plant + infrastructure Capex	Potential CapEx saving (in comparison to Stage-V)
OpEx	Significantly higher operating costs	Broadly similar operating costs	Lower operating costs (in comparison to Stage-V)

Note, where the technology was not deemed eligible for the specialist equipment group or there is no information available the Cell will be shown in **GREY**. The summary traffic light analysis for the Mowers group is shown below in Table 4.

The assessments for the other relevant specialist fleet groups can be found in Appendix A – Alternative Technology Data Tables.

Table 4 - Traffic Light Analysis - Mowers

Fuel	Factor	Mowers
Biodiesel	Operational	
	Emissions	
	CapEx	
	OpeEx	
HVO	Operational	
	Emissions	
	CapEx	
	OpeEx	
Diesel-Electric Hybrid	Operational	
	Emissions	
	CapEx	
	OpeEx	
Electric	Operational	
	Emissions	
	CapEx	
	OpeEx	
Alternative Hydrocarbon-based Fuels	Operational	
	Emissions	
	CapEx	
	OpeEx	
Hydrogen	Operational	
	Emissions	
	CapEx	
	OpeEx	

The summary traffic light analysis for all selected NWLDC specialist fleet categories is shown in Table 5 below.

Table 5 – NWLDC Specialist Fleet Summary Traffic Light Analysis

Fuel	Factor	Sweeper	Mowers	Telehandler	Tractor
Biodiesel	Operational				
	Emissions				
	CapEx				
	OpeEx				
HVO	Operational				
	Emissions				
	CapEx				
	OpeEx				
Diesel-Electric Hybrid	Operational				
	Emissions				
	CapEx				
	OpeEx				
Electric	Operational				
	Emissions				
	CapEx				
	OpeEx				
Alternative Hydrocarbon-based Fuels	Operational				
	Emissions				
	CapEx				
	OpeEx				
Hydrogen	Operational				
	Emissions				
	CapEx				
	OpeEx				

2.6 Recommendations

This section of the report makes recommendations based on the traffic light assessment of the alternative technologies that could be currently deployed (from 2021 onwards) for each identified specialist equipment group within the NWLDC fleet.

The traffic light review has indicated that biodiesel, HVO, electric and alternative hydrocarbon fuels (in this case CNG) have some applicability across the identified groups of specialist equipment. However, both biodiesel and CNG are likely to experience increased costs in terms of Capital expenditure (e.g. machine modification and fuel storage infrastructure) and Operational expenditure (e.g. additional maintenance requirements). These alternative options have therefore not been recommended for further investigation.

In terms of HVO, while there is an Operating Expenditure increase compared to diesel this is expected to be outweighed by the emission reduction, and operational benefits of this fuel coupled with no impact on capital expenditure.

While electric options are significantly more expensive, from a capital expenditure, than the equivalent diesel variant, with some operational changes required, these should be outweighed by the emission reduction, and operational expenditure benefits of this technology.

It is therefore recommended that NWLDC further investigate the options to trial electric variants of the following specialist fleet equipment:

- Ride on Mowers
- Tractors
- Telehandlers
- Compact & Truck Mounted Sweepers

Where electric variants prove incompatible with existing working practices within NWLDC the use of HVO is recommended as an alternative.

However, prior to the wider deployment of low emission alternatives, it is recommended that NWLDC undertake a more detailed investigation into the operational, environmental, and economic impacts of those options highlighted. This would include the development of appropriate total cost of ownership (TCO) models similar to those generated through the main operational fleet review. In addition, such deployments need to take into consideration the outcomes of the operational fleet review in terms of charging and refuelling infrastructure provision to ensure that vehicles can maintain their operational duties.

It is further recommended that NWLDC remain attentive to relevant innovation demonstration opportunities from funded research and development programmes, for example though Innovate UK or the Advanced Propulsion Centre.

Small items further analysis: It is noted the small non-wheeled plant items, such as chainsaws, were out of scope for this study. A further technology review would present the zero emission options for these small items.

2.7 Future Technologies Review

Considering the longer term, this section examines the direction of low and zero emission technology towards 2030. This will allow a procurement strategy to be identified NWLDC to adopt the relevant low and zero emission specialist fleet items as they come to market.

Figure 4 and Figure 5 below shows the Advanced Propulsion Centre Heavy Goods and Off-Highway Vehicle product technology road map. These road maps are developed by the Automotive Council Technology group, which is a collaboration between the UK Government and industry, where the road maps represent a shared vision of technology developments from UK manufacturers and suppliers and provide a consensus both to facilitate collaboration and to help inform policy making in technology support.

The relevant areas of the maps have been highlighted, from which the following can be seen:

- Low and medium power NRMM: Electrification is likely to be widespread, with reduced cost and increased operability. Hydrogen fuel cell technology may be available for machines requiring rapid refuelling or high levels of utilisation.
    - BEV total cost of ownership likely to be close to diesel.
    - Fuel cell total cost of ownership likely to remain above diesel (excluding infrastructure costs)
- Medium to high power NRMM: Some electrification likely, ICE with alternative fuels and Fuel cells for high utilisation or specific fleet operations.
    - BEV total cost of ownership likely to be above diesel.
    - Alternative HC fuels are cost effective, with local fuel supply they can be net zero in a closed loop. Infrastructure requires operational scale.
    - Fuel Cell total cost of ownership likely to remain above diesel (excluding infrastructure costs).

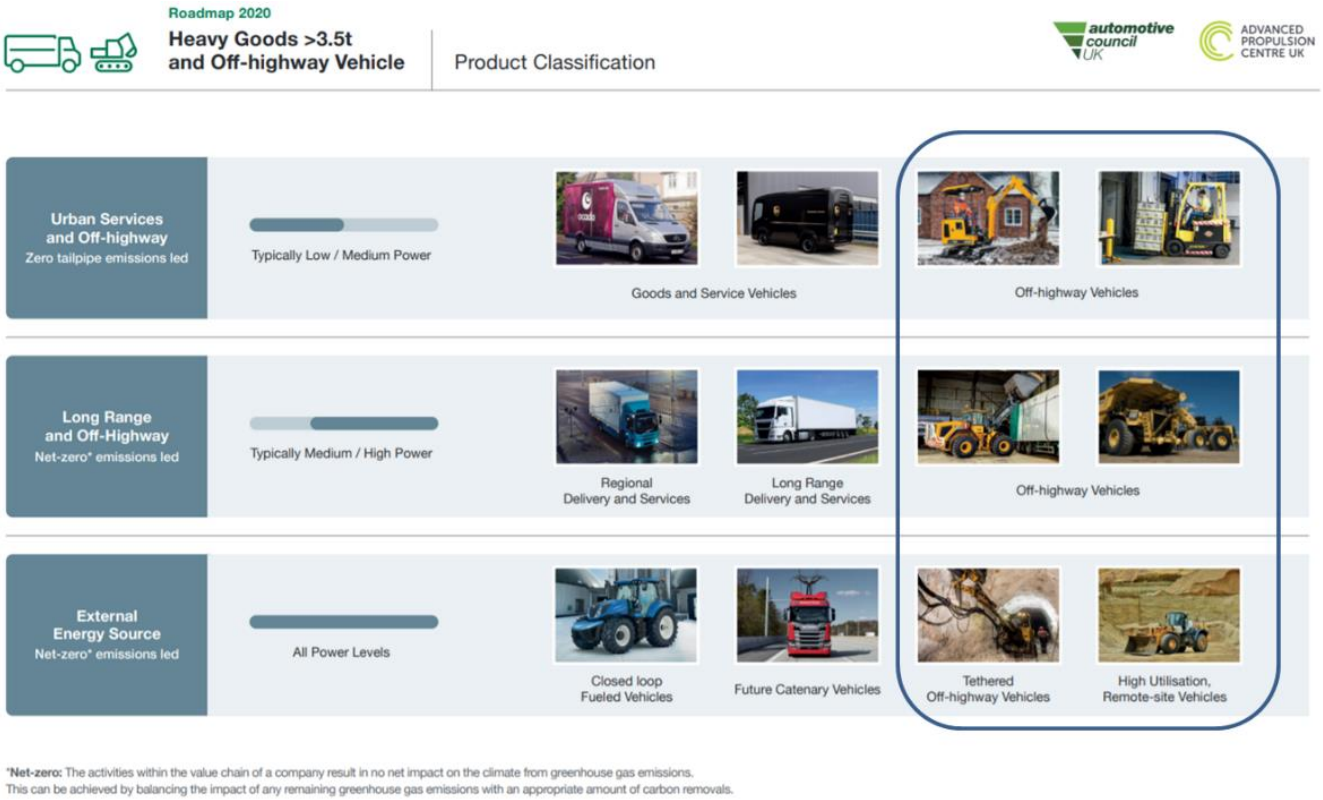


Figure 4 - APC Roadmap - Product Classification

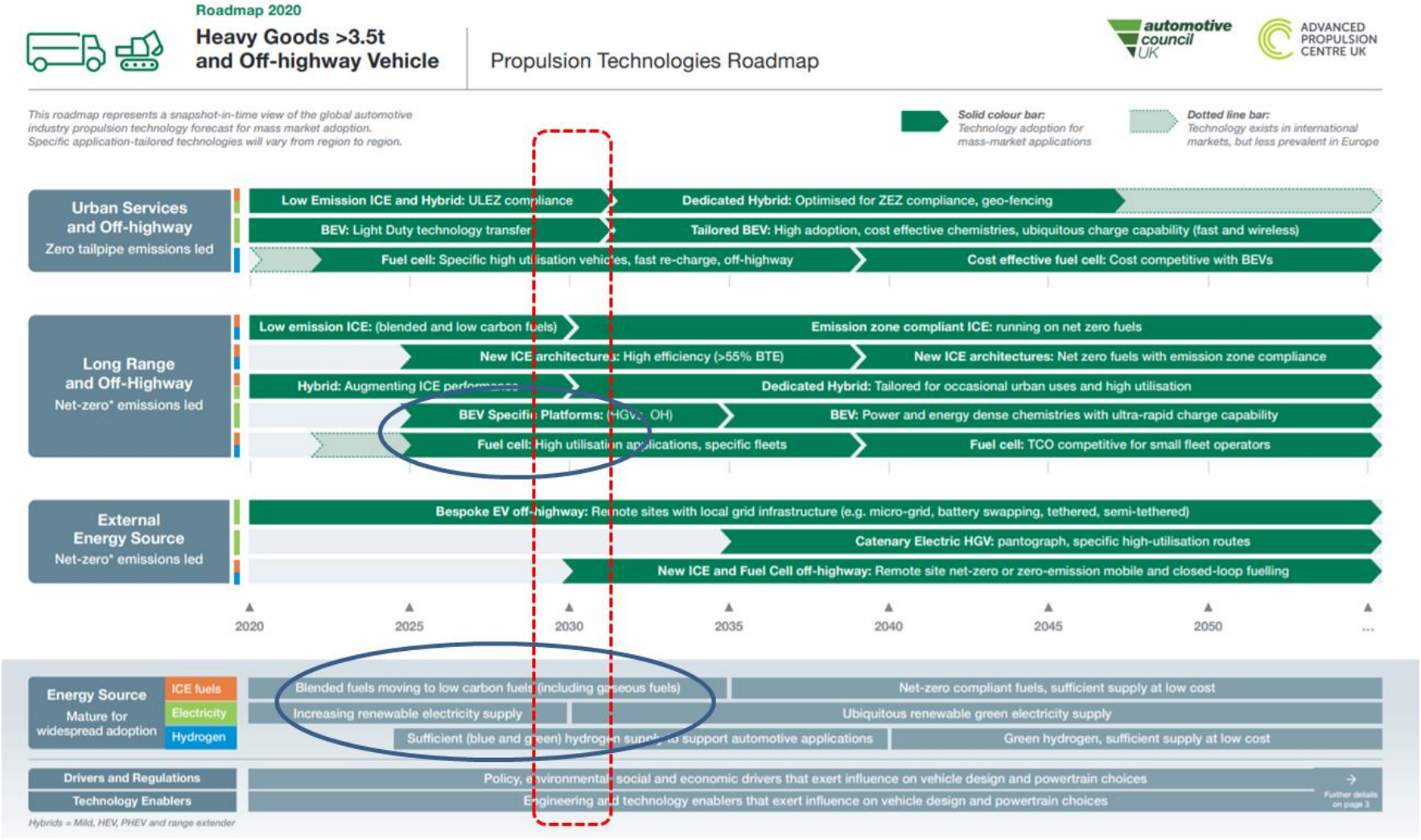


Figure 5 - APC Roadmap - Propulsion Technologies

3. Appendix A – Alternative Technology Data Tables

Specialist Fleet Category: Telehandler	
	
No of Vehicles	3 units
Typical Operating Pattern	Year round, depot loading e.g. salt loading for road spreading
Technology Maturity	• **Biodiesel (FAME & HVO):** Available. • **Diesel-Electric Hybrid:** Past product, reduced case with EV available. • **Electric:** Available. • **Alternative fuel (HC):** After-market CNG only. • **Hydrogen:** Not available. Options for detailed review are **Biodiesel (FAME & HVO) & Electric**.
Operational Restrictions and Benefits	• **Biodiesel:** FAME: Increased maintenance regime, mineral diesel fuel and engine flush required before use, fuel quality requires monitoring and managing. HVO: drop in fuel equivalent to diesel. • **Electric**: Reduced maintenance and operating costs thanks to the elimination of many service points compared to diesel machines. Operational time is limited, see below.
Operating Time	• **Biodiesel**: Same as diesel. • **Electric**: JCB 525-60E Indicative run time: 8 hours, 24 kWh battery.
Refuelling/ Recharging Time	• **Biodiesel**: Same as diesel. • **Electric**: JCB 525-60E 240V 8 hours (standard outlet) or 415V rapid charge available, 60 mins for 80% (additional infrastructure required).
Emission Reduction	• **Biodiesel**: FAME: Variable depending on blend (approx. 18% WTW and 23% TTW CO_2 reduction available from B25 blend). Engine design, fuel quality and operational cycles essential in assessing total emission with biodiesel – with some authors reporting increases in emitted NOx, particulates, and CO. HVO: approx. 91% WTW CO_2 reduction available. • **Electric**: Zero TTW emissions, WTW CO_2 emissions depend on energy generation, with ~50-60% reductions based on current grid mix.
Additional Notes	• **Biodiesel**: FAME: Manufacturer approaches vary depending on emission stage for example all John Deere engines can use biodiesel blends. Stage V engines operated within the European Union may use blends up to 8 percent (B8). Concentrations up to 20 percent (B20) can be used for all other John Deere engines providing the biodiesel used in the fuel blend meets European Standard (EN) 14214. HVO: May require manufacturer approval before use. • **Electric**: JCB 525-60E used as illustration other options exist.

Specialist Fleet Category: Telehandler	
Costs	• **Diesel**: At the Budget 2020, the government announced that it will remove the entitlement to use red diesel from non-agricultural NRMM in April 2022. • **Biodiesel**: FAME: Equipment Costs: For high biodiesel blend use manufacturers may require a biodiesel upgrade package to be installed, typically costing a few hundred pounds. For B100 use, the vehicles require a conversion to include a simple system for warming the fuel. Various conversions are available either at factory or retrofitted. These typically cost from £6,500 - £8,000 per vehicle. Fuel Costs: comparable to Road Diesel. Maintenance Costs: Some vehicle manufacturers suggest modified routines such as increased fuel filter and oil changes. Infrastructure Costs: Biodiesel blends up to B30 can be stored in and dispensed from existing infrastructure for diesel vehicles at no extra cost. B100 however needs to be kept at an appropriate temperature to ensure it remains liquid in the colder months. This will result in some additional energy costs. FAME has a shelf life of around 3 months so requires constant usage to ensure fuel quality is maintained. HVO: Equipment Costs: No impact on vehicle cost. Fuel Costs: Cost of fuel per litre is typically higher than road diesel. Maintenance Costs: Maintenance costs are identical to that of diesel vehicles. Infrastructure Costs: No specialist equipment is needed to store HVO. FAME and HVO fuel costs rely on minimum order quantities would ned to be factored into any wider deployment of these fuels across the operational fleet. • **Electric**: Equipment Costs: Research suggests a significant price premium JCB 525-60E ~ 60% higher that diesel equivalent. Fuel Costs: Estimated running cost for operators using an industrial electricity supply, will be around 50% lower than for diesel. Maintenance Costs: Lower than that of identical diesel telehandlers. Infrastructure Costs: Slow charge (13A) no cost; higher charging rates will require specific infrastructure at additional cost.

Fuel	Factor	Telehandler
Biodiesel	Operational	
	Emissions	
	CapEx	
	OpeEx	
HVO	Operational	
	Emissions	
	CapEx	
	OpeEx	
Diesel-Electric Hybrid	Operational	
	Emissions	
	CapEx	
	OpeEx	
Electric	Operational	
	Emissions	
	CapEx	
	OpeEx	
Alternative Hydrocarbon-based Fuels	Operational	
	Emissions	
	CapEx	
	OpeEx	
Hydrogen	Operational	
	Emissions	
	CapEx	
	OpeEx	

Specialist Fleet Category: Tractor	
 	
No of Vehicles	3 units
Typical Operating Pattern	Year round, large area grounds maintenance.
Technology Maturity	• **Biodiesel (FAME & HVO):** Available. • **Diesel-Electric Hybrid:** Not available. • **Electric:** Small tractor only. • **Alternative Fuel (HC):** Large tractor CNG. • **Hydrogen:** R&D prototypes only. Options for detailed review are **Biodiesel (FAME & HVO), Electric & Alternative Fuel (HC).**
Operational Restrictions and Benefits	• **Biodiesel:** FAME: Increased maintenance regime, mineral diesel fuel and engine flush required before use, fuel quality requires monitoring and managing. HVO: drop in fuel equivalent to diesel. • **Alternative Fuel (HC):** CNG/Bio-CNG tractor requires a CNG/Bio-CNG refuelling station on site on within close driving range. • **Electric:** Reduced maintenance and operating costs thanks to the elimination of many service points compared to diesel machines. Operational time is limited see below. Small tractor only, 15kw electric motor, small and light-duty work.
Operating Time	• **Biodiesel**: Same as diesel. • **Alternative Fuel (HC):** CNG/Bio-CNG tractor similar to diesel. • **Electric**: Farmtrac FT25G electric indicative run time: 6 hours.
Refuelling/ Recharging Time	• **Biodiesel**: Same as diesel. • **Alternative Fuel (HC):** Same as diesel. • **Electric**: Farmtrac FT25G electric 240V 5 hours (standard outlet).
Emission Reduction	• **Biodiesel**: FAME: Variable depending on blend (approx. 18% WTW and 23% TTW CO_2 reduction available from B25 blend). Engine design, fuel quality and operational cycles essential in assessing total emission with biodiesel – with some authors reporting increases in emitted NOx, particulates, and CO. HVO: approx. 91% WTW CO_2 reduction available. • **Alternative Fuel (HC):** approx. 10% WTW CO_2 reduction available from CNG; Bio-CNG CO_2 emissions depend on production route, but typically near zero. Very significant PM & NOx reduction. • **Electric**: Zero TTW emissions, WTW CO_2 emissions depend on energy generation, with ~50-60% reductions based on current grid mix.

Specialist Fleet Category: Tractor	
Additional Notes	• **Biodiesel**: FAME: Manufacturer approaches vary depending on emission stage for example all John Deere engines can use biodiesel blends. Stage V engines operated within the European Union may use blends up to 8 percent (B8). Concentrations up to 20% (B20) can be used for all other John Deere engines providing the biodiesel used in the fuel blend meets European Standard (EN) 14214. HVO: May require manufacturer approval before use. • **Alternative Fuel (HC):** Large tractor, New Holland T6.180 Methane Power, used as illustration only option available. • **Electric**: Farmtrac FT25G electric used as illustration used as illustration only option available.
Costs	• **Diesel**: At the Budget 2020, the government announced that it will remove the entitlement to use red diesel from non-agricultural NRMM in April 2022 • **Biodiesel**: FAME: Equipment Costs: For high biodiesel blend use manufactures may require a biodiesel upgrade package to be installed, typically costing a few hundred pounds. For B100 use, the vehicles require a conversion to include a simple system for warming the fuel. Various conversions are available either at factory or retrofitted. These typically cost from £6,500 - £8,000 per vehicle. These are not likely to be available for small plant like an ATV. Fuel Costs: comparable to Road Diesel. Maintenance Costs: Some vehicle manufacturers suggest modified routines such as increased fuel filter and oil changes. Infrastructure Costs: Biodiesel blends up to B30 can be stored in and dispensed from existing infrastructure for diesel vehicles at no extra cost. B100 however needs to be kept at an appropriate temperature to ensure it remains liquid in the colder months. This will result in some additional energy costs. FAME has a shelf life of around 3 months so requires constant usage to ensure fuel quality is maintained. HVO: Equipment Costs: No impact on vehicle cost. Fuel Costs: Cost of fuel per litre is typically higher than road diesel. Maintenance Costs: Maintenance Costs are identical to that of diesel vehicles. Infrastructure Costs: No specialist equipment is needed to store HVO. FAME and HVO fuel costs rely on minimum order quantities would ned to be factored into any wider deployment of these fuels across the operational fleet. • **Alternative Fuel (HC):** Equipment Costs: Research suggests a 10% price premium. Fuel Costs: dependent on CNG/Bio-CNG prices and supply. Infrastructure Costs: Very significant (Minimum £30k), only viable if combined with other users. • **Electric**: Equipment Costs: Research suggests a significant price premium; Farmtrac FT25G electric ~ 100% higher that diesel equivalent. Fuel Costs: Estimated running cost for operators using an industrial electricity supply, will be around 50% lower than for diesel. Maintenance Costs: Lower than that of identical diesel tractor. Infrastructure Costs: Slow charge (13A) no cost; higher charging rates will require specific infrastructure at additional cost.

Fuel	Factor	Tractor
Biodiesel	Operational	
	Emissions	
	CapEx	
	OpeEx	
HVO	Operational	
	Emissions	
	CapEx	
	OpeEx	
Diesel-Electric Hybrid	Operational	
	Emissions	
	CapEx	
	OpeEx	
Electric	Operational	
	Emissions	
	CapEx	
	OpeEx	
Alternative Hydrocarbon-based Fuels	Operational	
	Emissions	
	CapEx	
	OpeEx	
Hydrogen	Operational	
	Emissions	
	CapEx	
	OpeEx	

Specialist Fleet Category: Sweeper	
 	
No of Vehicles	4 units
Typical Operating Pattern	Year round, inner and outer rounds.
Technology Maturity	• **Biodiesel (FAME & HVO):** Available. • **Diesel-Electric Hybrid:** Not available. • **Electric** – Compact and truck mounted. • **Alternative Fuel (HC)** – CNG • **Hydrogen** – R&D prototypes only. Options for review are **Biodiesel (FAME & HVO), Electric & Alternative Fuel (HC).**
Operational Restrictions and Benefits	• **Biodiesel:** FAME: Increased maintenance regime, mineral diesel fuel and engine flush required before storage, fuel quality requires monitoring and managing. HVO: drop in equivalent for diesel fuel. • **Alternative fuel (HC):** CNG/Bio-CNG Sweeper requires a CNG/Bio-CNG refuelling station on site on within close driving range. May have reduced bin/hopper capacity depending on siting of gas tanks. • **Electric:** Reduced maintenance and operating costs thanks to the elimination of many service points compared to diesel machines. Operational time is limited, see below. Compact (45 – 63 kWh battery) and truck mounted (up to 200 kWh battery).
Operating Time	• **Biodiesel**: Same as diesel. • **Alternative Fuel (HC):** CNG/Bio-CNG has similar operating time to diesel • **Electric**: Bucher CityCat VS20e (45 kWh) run time of 6 hours; Bucher CityCat V20e (63 kWh) run time of 8 hours; Bucher V65e (200 kWh) available range of 200 km.
Refuelling/ Recharging Time	• **Biodiesel**: Same as diesel. • **Alternative Fuel (HC):** Similar to diesel. • **Electric**: Dependant on battery pack; typically, 4-9 hours on 22 kW chargepoint
Emission Reduction	• Biodiesel: FAME: Variable depending on blend (approx. 18% WTW and 23% TTW CO_2 reduction available from B25 blend). Engine design, fuel quality and operational cycles essential in assessing total emission with biodiesel – with some authors reporting increases in emitted NOx, particulates, and CO. HVO: approx. 91% WTW CO_2 reduction available. • Alternative Fuel (HC): approx. 10% WTW CO_2 reduction available from CNG; Bio-CNG CO_2 emissions depend on production route, but typically near zero. Very significant PM & NOx reduction. • Electric: Zero TTW emissions, WTW CO_2 emissions depend on energy generation, with ~50-60% reductions based on current grid mix.

Specialist Fleet Category: Sweeper	
Additional Notes	• **Biodiesel**: FAME: Manufacturer approaches vary depending on emission stage. Typically Stage V engines operated within the European Union may use blends up to 8 percent (B8), with concentrations up to 20 percent (B20) used providing the biodiesel used in the fuel blend meets European Standard (EN) 14214. • **Alternative Fuel (HC):** Dulevo 6000 CNG used as illustration only, other option are available. • **Electric:** Bucher electric variants used as illustration only, other options are available.
Costs	• **Diesel**: At the Budget 2020, the government announced that it will remove the entitlement to use red diesel from non-agricultural NRMM in April 2022 • **Biodiesel**: FAME: Equipment Costs: For high biodiesel blend use manufacturers may require a biodiesel upgrade package to be installed, typically costing a few hundred pounds. For B100 use, the vehicles require a conversion to include a simple system for warming the fuel. Various conversions are available either at factory or retrofitted. These typically cost from £6,500 - £8,000 per vehicle. Fuel Costs: comparable to Road Diesel. Maintenance Costs: Some vehicle manufacturers suggest modified routines such as increased fuel filter and oil changes. Infrastructure Costs: Biodiesel blends up to B30 can be stored in and dispensed from existing infrastructure for diesel vehicles at no extra cost. B100 however needs to be kept at an appropriate temperature to ensure it remains liquid in the colder months. This will result in some additional energy costs. FAME has a shelf life of around 3 months so requires constant usage to ensure fuel quality is maintained. HVO: Equipment Costs: No impact on vehicle cost. Fuel Costs: Cost of fuel per litre is typically higher than road diesel. Maintenance Costs: Maintenance costs are identical to that of diesel vehicles. Infrastructure Costs: No specialist equipment is needed to store HVO. FAME and HVO fuel costs rely on minimum order quantities would ned to be factored into any wider deployment of these fuels across the operational fleet. • **Alternative Fuel (HC):** Equipment Costs: Research suggests a 10% price premium. Fuel Costs: Dependent on CNG/Bio-CNG prices and supply. Infrastructure Costs: Very significant (Minimum £30k), only viable if combined with other users. • **Electric**: Equipment Costs: Research suggests a significant price premium compared to diesel equivalent, dependant on variant and battery capacity. Fuel Costs: Estimated running cost for operators using an industrial electricity supply, will be around 50% lower than for diesel. Maintenance Costs: Lower than that of identical diesel sweeper. Infrastructure Costs: Slow charge (13A) no cost; higher charging rates will require specific infrastructure at additional cost.

Fuel	Factor	Sweeper
Biodiesel	Operational	
	Emissions	
	CapEx	
	OpeEx	
HVO	Operational	
	Emissions	
	CapEx	
	OpeEx	
Diesel-Electric Hybrid	Operational	
	Emissions	
	CapEx	
	OpeEx	
Electric	Operational	
	Emissions	
	CapEx	
	OpeEx	
Alternative Hydrocarbon-based Fuels	Operational	
	Emissions	
	CapEx	
	OpeEx	
Hydrogen	Operational	
	Emissions	
	CapEx	
	OpeEx	

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