Air Quality Strategy

Best Practice Guidance

For Inland Fleet Operators

August 2018

PORT OF LONDON AUTHORITY

Definitions

CO_2 – Carbon Dioxide
DEF – Diesel Exhaust Fluid
Draft – The vertical distance between the waterline and the bottom of the vessel hull
ECA – Emission Control Area
EGR – Exhaust Gas Recirculation
ESI - Environmental Ship Index
EU – European Union
GHG – Green House Gases
GLA – Greater London Authority
HFO – Heavy Fuel Oil
IMO – International Maritime Organisation
KW – Kilowatt
LNG – Liquefied Natural Gas
LSF / LSD / LSMGO – Low Sulphur Fuel/Diesel/Marine Gas Oil
MCR – Maximum Continuous Rating
NOx – Nitrogen Oxides
NECA– Nitrogen Emission Control Area
PM – Particulate Matter
SCR – Selective Catalytic Reduction
SOx – Sulphur Oxides
SECA – Sulphur Emission Control Area
TFL – Transport for London
ULSF / ULSD / ULSMGO – Ultra Low Sulphur Fuel/Diesel/Marine Gas Oil
WIF – Water-in-Fuel

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AIR QUALITY STRATEGY: INLAND FLEET OPERATORS

Introduction

As part of the PLA's Air Quality Strategy for the Tidal Thames, this guidance seeks to outline and deliver the best practice for inland fleets operating in the River Thames across 5 areas; Technology, Fuel, Design and Maintenance, Operation and Funding opportunities. The purpose of this best practice is to provide operators with information and evidence on how changing small parts of their operation could improve air emissions, reduce fuel consumptions and save money. These best practices are recommendations not requirements for reducing inland air emissions to reach PLA's Air Quality targets in Table 1.

1. Emission Goals

The PLA have been working with inland operators of the River Thames to investigate best practices to reduce emissions (NOx and PM) released into the air by vessels, as part of the Air Quality Strategy. This strategy has been created to address public health and environmental concerns in relation to air quality.

1.1 – Strategy Aim

The Reduction in harmful emissions to air from marine sources within the tidal River Thames, whilst facilitating the Port and London's future growth.

1.2 – Air Quality Targets

MARPOL Annex VI NOx emissions from diesel engines installed or constructed on or after 1st January in a NECA are limited to Tier III standards.

EU Regulations require that inland vessels must use 0.001% Sulphur content. The 2020 emission reductions were; 68% for SO_2, 49% for NOx, 39% for PM_{10} and 45% for $PM_{2.5}$ of the levels in 2000.

UK Merchant Shipping Act focuses on fuel, design and emissions for ships and inland waterway vessels in close proximity to urban areas and at berth which does not currently have an exhaust gas cleaner.

Non-road Mobile Machinery legislation sets emission parameters for engines which operate in inland waterways such as the river Thames.

2026	2031	2041	Overarching
• PM – 20% reduction • NOx – 20% reduction	• PM – 40% reduction • NOx – 40% reduction	• PM – 50% reduction • NOx – 50% reduction	Reduction in CO_2 Reduction in all other emissions produced on the Thames

Table 1: PLA air reduction targets adopted for the Air Quality Strategy. Source: PLA Air Quality Strategy, 2018.

2. Technological Solutions

2.1 – Engine Regulatory Systems

An engine regulatory system is a technology which improves the efficiency and reduces emissions from a diesel engine. Two main regulator systems could enable operators to reduce NOx emissions.

2.1.1 – Exhaust Gas Recirculation (EGR)

EGR reduces NOx from diesel engines by first cooling 30-40% of the exhaust gasses, then combining it with high pressure fresh air before being recirculated into the cylinder. Emission Control Area EGR mode which is Tier III compliant for inland regions can reduce emissions by:

Reduced emissions using ECA-EGR

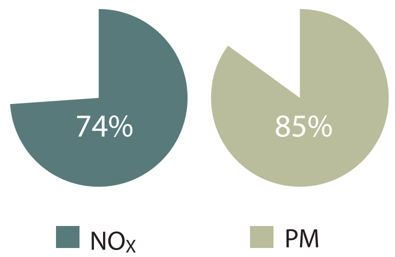


Figure 1: EGR Eemission savings

The EGR systems include an EGR valve, filter, cooler and pickup, which all must be inspected every 6 months and replaced every 12.

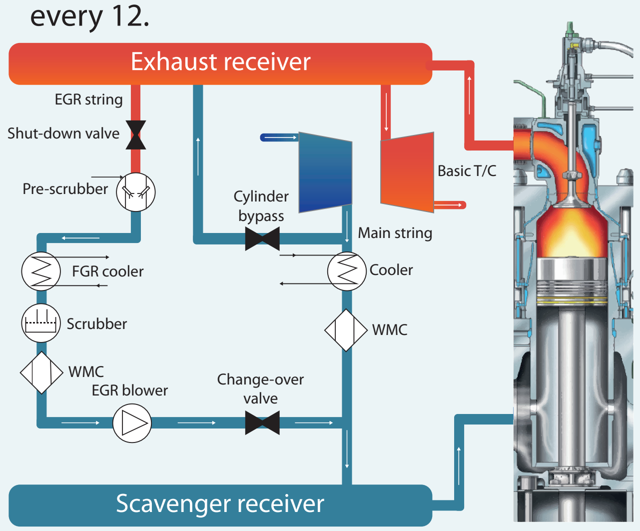


Figure 2: EGR components in a diesel engine. Source: Hasen et al

2.1.2 – Selective Catalytic Reduction (SCR)

SCR is an active emission regulator technology which injects Diesel Exhaust Fluid (DEF) through a special catalytic chamber into the hot exhaust stream of a diesel engine.

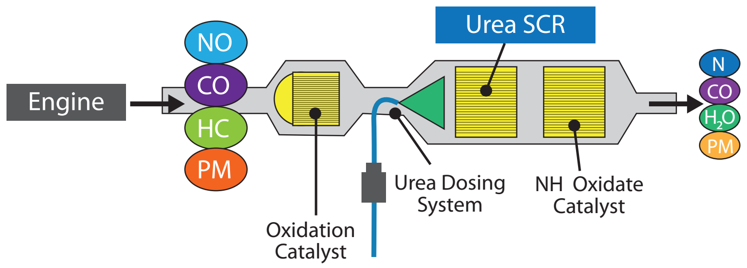


Figure 3: SCR components in a diesel engine

Reduced emissions using SCR

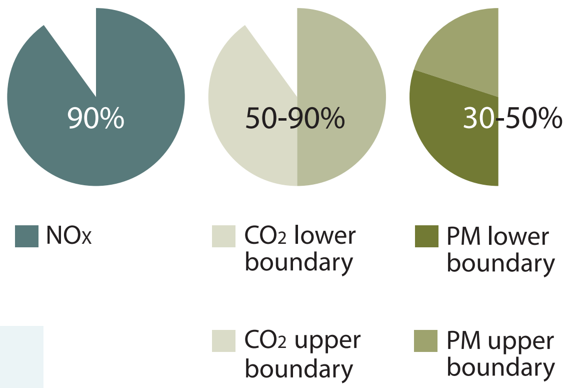


Figure 4: SCR emission savings

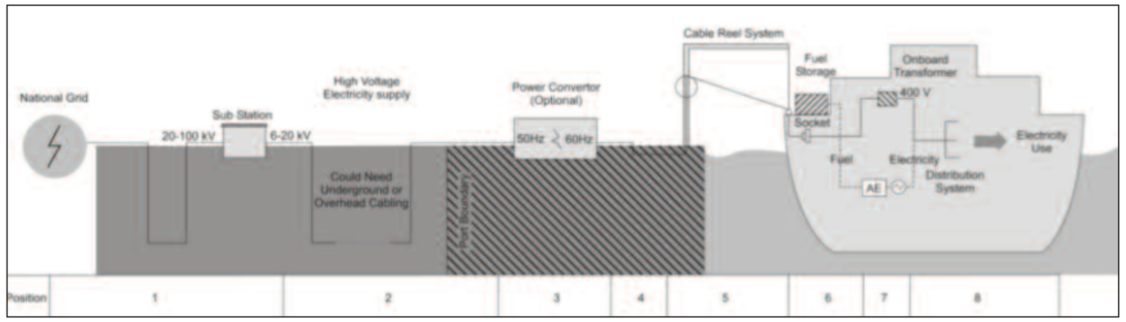
This system can reach operational temperature within 10-15 minutes if the engine has been previously run in the previous 6-10hours.

Both EGR's and SCR's come in various shapes and sizes and will work well with various engine types. However, additional space in the engine will be necessary and these extra engine components may add weight to the vessel which could impact the stability and speed of lightweight vessels. Operational changes are required for the use of Urea and maintenance of filters.

2.2 – Shoreside Power

Emissions at berth are often the result of auxiliary engines and boilers, used to power on-board activities. To reduce these at berth emissions, it is advised that inland vessel operators turn off their engines and take advantage of shoreside power. Shoreside power is where electricity is provided to the vessels from the grid, transferred from the shore to the vessel via a cable reel system.

Shoreside power has the ablitiy to contribute to reductions of NOx, PM and CO_2 emissions and is currently being used as a technological soultion by many inland operators. It may not be applicable at sites where the vessel does not stay long, i.e. at passenger piers or operational wharves.



Case study: Cory Riverside Energy

Cory River Energy vessels are connected to shore-side power when at berth at Charlton. This helps Cory Riverside Energy to reduce the level of fuel burnt and emissions released. From October 2017, Charlton has been powered by 100% renewable electricity as part of a zero-carbon power scheme organised by Ofgem. Cory Riverside Energy are also actively exploring other solutions, to improve their engines to Tier III standard.

2.3 – Bow Bulb Retrofit

For larger freight vessels with a high speed-length ratio on the inland Thames, a bow bulb may be necessary to produce a second wave which is designed to cancel out/reduce the wave produced by the boat, hence reducing drag resistance. These bulbs are commonly used in international shipping; however they can also be used in inland waterways.

10%

A bow bulb can reduce wave resistance by 10%, saving fuel and emissions (table 2). A cargo vessel between 250-400 tons benefits the most from a bulb, however due to bulbs coming in various shapes and sizes, working well with various vessel lengths, weight and style.

Ton/yr	Cargo vessel (250-400 ton)	Barge (450-650 ton)	Canal ship (max 1350)	Total
Fuel	109	258	518	885
CO_2	347	817	2,644	2,808
NO_x	5.65	13.32	26.78	45.7
PM_{10}	0.229	0.541	1.088	1.858
SO_2	0.371	0.876	1.761	3.009
%	3.1%	3.0%	1.8%	2.2%

3. Fuel Types

3.1 – Ultra Low-Sulphur Fuel

All inland vessels must use a fuel with a sulphur content that does not exceed 0.001 sulphur content.

3.2 – Other Current Fuel Options

LNG and Biofuels are currently a new opportunity for operators, with challenges relating to the lack of infrastructure and access to the fuel from the river. Successful trials are also limited to currently learn from, however as trials are carried out case studies will be shared on the PLA's website. Operators should carry out their own investigations when considering alternative fuels with the engine manufacturers.

LNG fuel is compatible with four-stroke (single fuel and compression ignition), two-stroke (with a premix chamber and direct injector) and steam turbine propulsion engines. LNG requires 70% more space than a HFO tank, therefore more appropriate for larger inland vessels. PLA are currently looking into the use LNG on the Thames. LNG can reduce **NOx** by:

85-90%

A synthetic biodiesel can be made entirely of vegetable oil products. Biofuels themselves are considered to be carbon neutral as the CO_2 produced from combustion balances the CO_2 extracted from the atmosphere as the fuel grows. Biofuels can reduce **PM** emissions by:

35%

3.3 – Fuel Additives

Water emulsion can be injected into the fuel in the combustion chamber to act as an additive. The water helps to break down the fuel into smaller droplets, improving complete combustion rate. ~1% NOx can be reduced with 1% of water emulsion. This is already currently being used by international shipping where 10% of water-in-fuel emulsion can save:

2-5% Fuel consumption saved

~3.8% Average cost saving

~20% NO_x reduction

Water-in-fuel (WIF) additives could be introduced into inland vessels along the Thames however the success of water added to the fuel depends on the engine load (as engine load and WIF increases so does NO_x emission reductions, Figure 5). The WIF injectors which inject the water into the fuel have a life time of ~4 years, whereas the remaining WIF equipment has a life time of ~12 years. Installation costs for marine vessels are shown in figure 6:

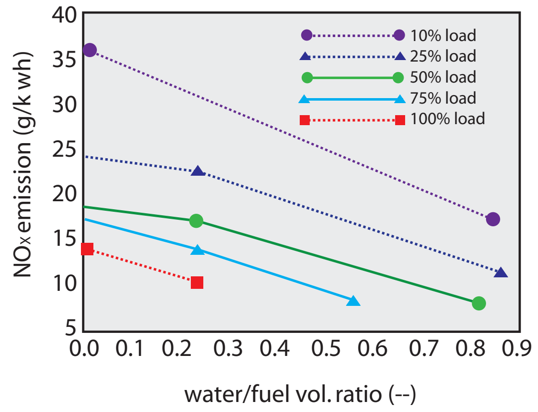


Figure5: Measured NOx reductions from exhaust gas at various engine loads and WIF concentrations. Source: Andresen and Nyggard, 2011.

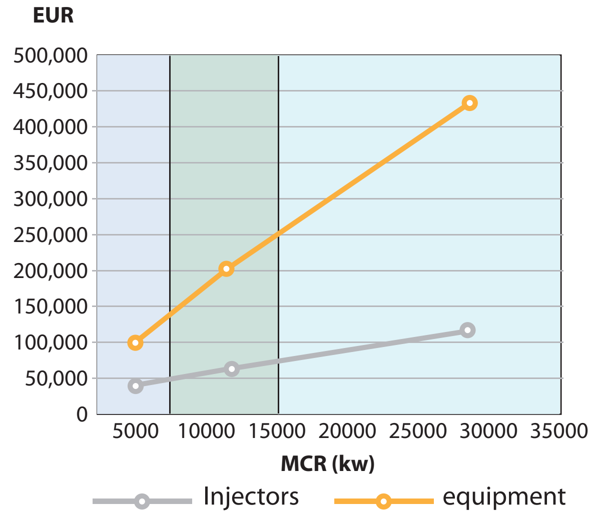


Figure 6: Installation costs of WIF NOx reduction system for small (<6,000 KW), medium (>6,000-<15,000) and large (>15,000) engines.

3.4 – Future Alternative Fuels

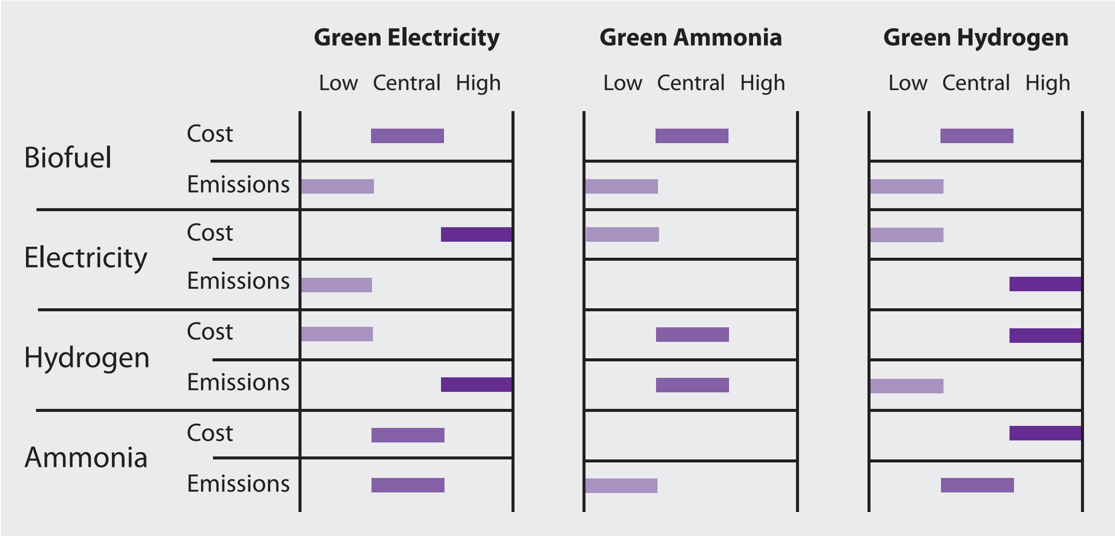


Table 4: Appraisal of alternative fuel emissions and cost under each green scenario. Source: Lloyd's Register Group Limited and UMAS. 2017.

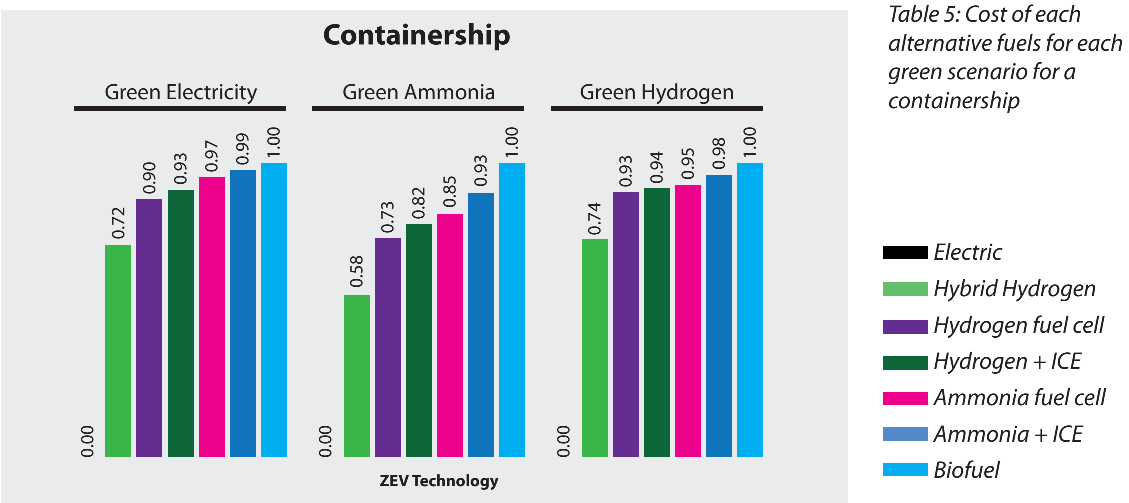


Table 5: Cost of each alternative fuels for each green scenario for a containership

In each scenario biofuels consistently have low emissions and medium costs; therefore they appear to out-compete other alternative fuels (Table 4). There is potential for significant emission savings in the future for use of Electric fuel, producing the largest **CO_2** reductions overall.

Biofuels are the most profitable and electric is the least due to the cost of electric batteries (Table 5). Profitability includes the savings in operational expenditure and investment of new technology for the operator over a vessels lifetime.

Trials and implementation of electric hybrid vessels are becoming interestingly popular within European urban waterways in an effort to reduce GHG's by at least 50% by 2050. These vessels can improve fuel efficiency up to 70%.

4. Design and Maintenance

4.1 – Hull Design

The hull of a boat is where the most friction occurs. A monohull vessel of a given weight will have a deeper draft than a multihull vessel, therefore creating more friction. As a result, multihull vessels are able to move faster with the same engine power, saving fuel consumption, which will be advantageous particularly for vessels which require higher speed or transport passengers to timetables

Case Study: MBNA Thames Clippers

Their current hull design is a high speed, low wash twin-hull design which is designed to reduce their drag to the lowest coefficient value possible. When this design is compared to a vessel of similar design with a higher drag coefficient, they show quantifiable fuel consumption reductions.

Additionally, the fleet use either propeller or waterjets which are annually inspected to ensure that optimum vessel operating parameters are met. This is then combined with annual hull cleaning and use of anti-fouling coating to reduce marine growth in order to achieve minimal drag and reductions in fuel consumption and emissions.

4.2 – Anti-Fouling Paints

Anti-fouling paints prevent the growth of fouling organisms by releasing biocide, minimalizing the bonding of fouling to the vessel hull.

Anti-foul paints can prevent micro and hard-shell fouling, reducing drag up to 40% and allowing a vessel to recover propulsion power between:

21-86%

Therefore to increase fuel efficiency and reduce emissions through lowing fuel combustion, some non-toxic anti-fouling paints are:

- Tin-free self-polishing coating
- Silicone-based foul-release coating
- Hydrophilic marine anti-fouling coating
- Hydrophobic foul-release coating

4.3 – Maintenance

Some guidelines to keep a well maintained engine to reduce fuel consumption and emissions are:

- Check cooling system strainer is not plugged
- Ensure freshwater circuits have enough antifreeze to prevent rust
- Check the flow of coolant to prevent damage to rubber impellers and cylinders
- Annual check the hose connections and bands
- Check water pump seals/ values for corrosion
- Check filters regularly to ensure are clean and blocked
- Ensure valves are working and replace them if possible (not all valves can be replaced)
- Ensure there is enough lubrication to prevent corrosion to internal workings

5. Operational Solutions

5.1 – Vessel Idling

Some marine engines need a warm up period, which has lead to behavior habits to leave the engine running when a vessel is idle. When this happens NOx and PM emissions can double and cause up to 38% increase in fuel consumption when compared to the emissions emitted from a vessel traveling at 75% engine power.

This is a major source of air pollution and needs to be minimalized through pre-heating equipment whilst slowly moving the vessel along the Thames, unloaded, before adding any strain and power demand on the engine. This warm-up period can also be reduced if the engine has previously run in the previous 6-10 hours. Many engines can be started sooner and can warm.

To tackle idling vessels, operators are recommended to:

- Reduce the time a vessel is left idling at berth.
- A newer vessel requires less warm-up time.
- A vessel with a pre-warming heater will also reduce idling.
- Turn off the engine and switch to shore power or generator power when not needed.

5.2 – Driving in Transit

5.2.1 – Efficient Driving

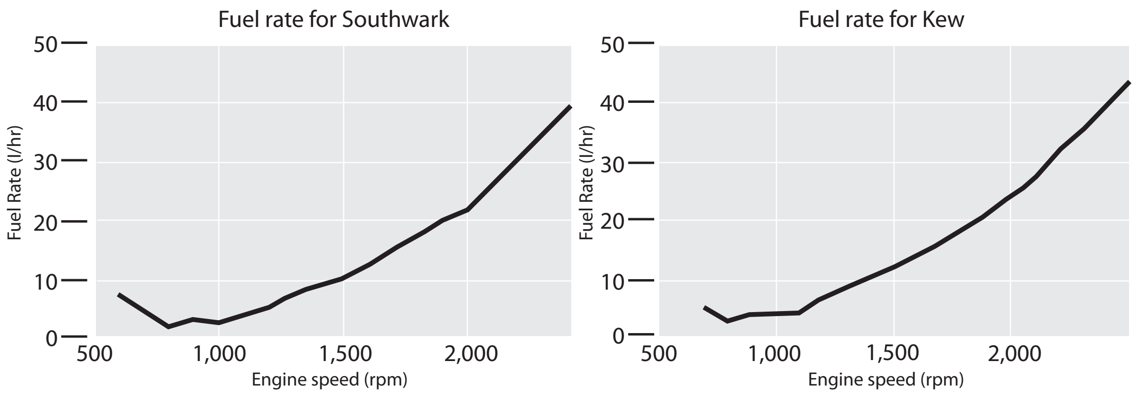


Figure 6: PLA energy curves for bridge harbour launches

Reducing speed or rpm will reduce fuel consumption, fuel costs and emissions created for each trip. An engine can be run at a high rpm with no additional benefit on its speed.

Recommendations for operators are:

- Drive at a lower rpm.
- Try to keep between ~700-1050rpm (<10 knots) to drive the most efficiently, when able to i.e. not in services.
- Use energy curves to identify the efficient areas of engine activity.

5.2.2 – Working with the Tides

The direction of the tides can affect the frictional force of the water on the boat, influencing the drag and engine power. When a vessel works against the tide, engine power is lost as the engine tries to overcome the tidal force. Whereas, if a vessel works with the tide, less engine power is required resulting in reduced emissions and savings in fuel consumption and cost. This may require operators to adapt their scheduled timetable in order to work with the tides. This may not appropriate if operating to a timetable in both directions, or for safety reasons but can be used by operators maneuvering with the tide or able to adapt.

Working with the tides can potentially:

Save 70% in Fuel Consumption

This can be done via reducing engine power from:

662KW/1850rpm *to* **380KW/1050rpm**

This is the equivalent of reducing their speed from:

8.5 knots *to* **6.5 knots**

5.2.3 – Push Vs Pull Tugs

Tugs and Barges can be transported either from being pushed from behind or pulled from in front. Using a tug to push, operators could see a:

~30 **Save in energy needed to transport a load.**

~13 **Shorter journey time and speed increase.**

~25- **Reductions in NOx and CO_2 emissions**

However, these results must be considered with caution due to the lack of available literature and the need for further research for a conclusive result. Safety of the operation must also be considered before this option is used.

5. Funding Opportunities

Air Quality and Environment Programme by TFL

This fund is for transport network projects within London which show reductions in NOx, PM and CO_2 to improve public health, over the next 5 years (2017-2022).

This could be important for expanding inland river services on the Thames.

This fund is to encourage the London transport network to become zero-emissions by 2050 and support the acceleration of the uptake of zero emission technologies.

Air Quality Project Funding by Borough's

There is a grant scheme subject to meeting criteria:

- Reducing air pollution emissions.
- Reducing exposure of emissions to humans.
- Increasing awareness of air pollution.
- Have measurable impact on air quality.
- Have wider benefits for local area.

Many London, Kent and Essex boroughs have their own air quality funds which could apply to inland operators.

Mayor's Air Quality Fund by the GLA

A £20 million funding scheme to fund (over 10 years) for London Borough air quality projects to lower emissions, introduce electric charging points and create low emission construction partnerships.

Summer 2018, funding for boroughs to introduce new air quality projects in London will be open for applications. Inland vessel operators are therefore able to contact their boroughs with air quality projects to incorporate into these applications.

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CUSTODIANS OF THE TIDAL THAMES

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