MAYOR OF LONDON

THE LONDON CURRICULUM

CHEMISTRY KEY STAGE 3

LONDON REFUELLED

UCL
Institute of Education

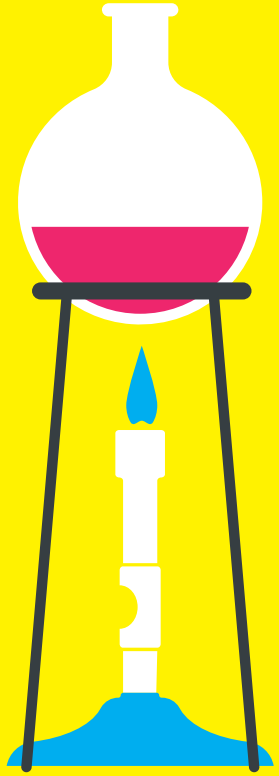
THE LONDON CURRICULUM

PLACING LONDON AT THE HEART OF LEARNING

The capital is the home of innovations, events, institutions and great works that have extended the scope of every subject on the school curriculum. London lends itself to learning unlike anywhere else in the world. The London Curriculum aims to bring the national curriculum to life inspired by the city, its people, places and heritage.

To find out about the full range of free resources and events available to London secondary schools at key stage 3 please go to:

www.london.gov.uk/london-curriculum.



STEM in the London Curriculum

London provides numerous historical and contemporary cutting edge examples of scientists, engineers and mathematicians who have worked in their fields to create innovative solutions to problems throughout the world. Population growth, trade, communication, transport, health, food, water supply and many other aspects of life in London have driven technology-based innovations. London Curriculum science, maths, design & technology teaching resources aim to support teachers in helping their students to:

DISCOVER the application of their subject knowledge to the life of the city.

EXPLORE their neighbourhood and key sites around London, learning outside the classroom to see and understand how STEM subjects have shaped many aspects of the city.

CONNECT their learning inside and outside the classroom, analysing situations and using their subject knowledge to create and present solutions.

CONTENTS

FUELS AND TRANSPORT OVERVIEW

UNIT AIMS AND ACTIVITIES

With a population of over 8 million and many people commuting to London for work every day, transport is a key issue for everyone. London has seen amazing transport developments in terms of the DLR, River boats, the Javelin trains used during the 2012 Olympics and Paralympics and Cross Rail. London's iconic symbols, London buses, London taxis, the London Eye and the Emirates, show the amazing nature of modern technology and how this has developed to cope with the movement of such large numbers of people. However the reliance on combustion for transport over time has resulted in problems of pollution. To address this new technologies have been developed, such as electric cars and catalytic converters for buses. Social solutions, intended to change behaviours, have also been implemented, including the Congestion Charge Zone and the Low Emission Zone.

Students will study the basic chemistry of combustion, looking at different fuels and their energy output as well as possible contribution to pollution. Their ability to represent reactions using words diagrams and symbols will be developed. Students will study the carbon cycle and consider how transport adds carbon dioxide to the atmosphere.

Throughout the topic key questions will be considered:

- What is the chemistry behind transport in today's city and in the past?
- What are the solutions for the future?
- Should buses and taxis be banned from Oxford Street and other major shopping streets where air quality is currently very poor.
- What fuels should we use to reduce air pollution?

CONDUCTING A RISK ASSESSMENT

For learning outside the classroom

It is the responsibility of each institution, delegated to the class teacher, to make risk assessments for a given class and a given location. Guidance can be found through the membership organisation CLEAPSS for all school science.
www.cleapss.org.uk

More general guidance on risk assessment for school trips can be found here:
www.atl.org.uk/health-and-safety/off-site-trips/risk-assessment-school-trips.asp

For practical work

A general guide for health and safety guidance and risk assessment of practical work can be found here:
www.nuffieldfoundation.org/standard-health-safety-guidance

If any additional specific guidance is necessary for particular practicals, this will be found within the instructions for each practical.

KEY STAGE 3 NATIONAL CURRICULUM

This unit covers some of the subject content of the new key stage 3 science national curriculum. Students will learn about:

Atoms, elements and compounds

- chemical symbols and formulae for elements and compounds
- conservation of mass and chemical reactions

Chemical reactions

- chemical reactions as the rearrangement of atoms
- representing chemical reactions using formulae and using equations
- combustion
- what catalysts do

Energetics

- exothermic... chemical reactions (qualitative)

Earth and atmosphere

- the carbon cycle
- the composition of the atmosphere
- the production of carbon dioxide by human activity and the impact on climate

KEY STAGE 3 NATIONAL CURRICULUM

In addition to these specific chemistry objectives this unit will provide opportunities to work scientifically as follows:

Scientific attitudes

- pay attention to objectivity and concern for accuracy, precision, repeatability and reproducibility
- understand that scientific methods and theories develop as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review
- evaluate risks

Experimental skills and investigations

- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- make predictions using scientific knowledge and understanding
- select, plan and carry out the most appropriate types of scientific enquiries to test predictions, including identifying independent, dependent and control variables, where appropriate
- use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
- make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements
- apply sampling techniques

Analysis and evaluation

- apply mathematical concepts and calculate results
- present observations and data using appropriate methods, including tables and graphs
- interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions
- present reasoned explanations, including explaining data in relation to predictions and hypotheses
- evaluate data, showing awareness of potential sources of random and systematic error
- identify further questions arising from their results

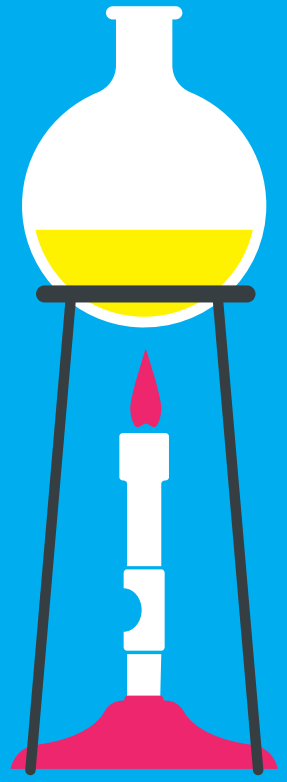
Measurement

- understand and use SI units and IUPAC (International Union of Pure and Applied Chemistry) chemical nomenclature
- use and derive simple equations and carry out appropriate calculations
- undertake basic data analysis including simple statistical techniques

DISCOVER

Students will study the basic chemistry of combustion, looking at different fuels used across London's transport, and their energy output as well as their possible contribution to pollution. Their ability to represent reactions

using words diagrams and symbols will be developed. Students will study the carbon cycle and consider how transport adds carbon dioxide to the atmosphere.



LESSON 1
WHAT POWERS LONDON TRANSPORT?

THE BIG IDEA

Different fuels are considered and how energy to move transport is released during combustion. This lesson also looks at the story of steam tube trains and our changing understanding of the effects on human of emissions from combustion.

LEARNING OUTCOMES

Could represent combustion reactions using symbol equations.

Should be able to explain why burning fuel with sulphur in it created problems for steam driven tube trains.

Should be able to describe the products of combustion of carbon and sulphur and represent this as word equations.

Must describe how combustion reactions are used to provide energy for most transport.

RESOURCES

Resource 1.1: Modes of transport images

Resource 1.2: Comparing different modes of transport

Resource 1.3: Imagine you are a Victorian traveller in London

KEY WORDS

- Combustion
- Fuel
- Energy transfer
- Hydrogen
- Pollution

MATHEMATICAL CONCEPTS

- Graphical representation

LESSON 1
WHAT POWERS LONDON TRANSPORT?

YOU WILL ALSO NEED

For: Main 2

- Teacher demo
- Equipment
- x2 gas jars of oxygen
- x2 Deflagrating spoon
- Charcoal lump or carbon powder
- Sulphur roll pieces
- Distilled water
- Universal indicator solution
- Fume cupboard

LESSON 1: WHAT POWERS LONDON TRANSPORT?

SETTING THE SCENE

A STEAM TRAIN WHICH CARRIED PASSENGERS IN THE 19TH CENTURY HAS RETURNED TO THE GREAT PORTLAND STREET TUBE STATION ON A JOURNEY TO MARK 150 YEARS SINCE THE FIRST LONDON UNDERGROUND JOURNEY.

Transport in London has developed over time, growing and changing in response to the needs of the population and visitors.

Today London is the site of a massive new engineering project, Crossrail, to link East to West via a tunnel under central London. This will help meet the growing demand for transport in the city - over 26 million trips are made in London each day.

The first tube trains ran on the Metropolitan line and were steam trains running underground. These were developed in response to the development of intercity train lines including St Pancras and Paddington etc. and the need for people to move quickly between them on arrival into London. At the time, the streets were very congested with horses and carts and very dirty so a journey through a tunnel had its advantages although some people were very worried about the idea.

In order to keep our transport system moving, we need to have sufficient energy available at the point of travel. Throughout history this has largely been dependent on the combustion of fuels: coal, oil and petrol. Of course this brings with it the problems of air pollution which is not a modern problem but one that is exacerbated by the sheer number of people travelling. Our modern day solutions to these problems are numerous. Engineers and scientists have developed clean air technology to reduce the polluting outputs from combustion engines, trains have been developed to run on electricity and we now have electric cars. Hydrogen buses are now seen on London streets and there is still work needed to develop other clean technologies. Alongside technologic solutions, strategies aimed at changing people's behaviour have also been implemented, such as the Congestion Charge Zone, Low Emission Zone and restrictions on diesel engines in some boroughs.

ZERO EMISSION HYDROGEN FUELCELL BUS IN LONDON. THE 'EXHAUST' SEEN HERE AT THE TOP OF THE VEHICLE IS ONLY PURE WATER VAPOUR.

Image by S. Miller

LESSON 1: WHAT POWERS LONDON TRANSPORT?

ACTIVITIES

STARTER: GIVE ME FIVE

Students list five or more methods of transport that might be used to get to school in London, on mini white boards or scrap paper. Share with the class.

Conduct a straw poll on which types of transport were used by students this morning or over the last week. You can put the results into a spreadsheet and ask the students to decide how best to display the result
i.e. leading to a bar chart.

Differentiation

Brainstorm to determine previous knowledge – open ended task.

MAIN 1

Hand out Resource 1.1: Modes of transport images (page 13) to groups of students. Each group is challenged to explain how a given type of transport is able to move i.e. where does the energy come from (the level of detail that can be provided here will depend on whether they have studied energy or not). List as many pros and cons as possible of their given mode of transport.

For reporting back, ask the students to form a timeline with their given picture to show the order in which these forms of transport were developed/used in London.

Get feedback from each group about pros and cons.

Ask the students to think about what types of transport will be developed in the future and why? Are there any forms of transport that were once used that are no longer in use?

Differentiation

This can be achieved in the examples given to different groups and by outcome. The aim of the starter is to assess students' prior knowledge about the topic, as well as setting the scene.

Resource 1.2: Comparing different modes of transport (page 17) could be used for extra support.

MAIN 2: THE FIRST TUBE TRAINS

Hand out Resource 1.3: Imagine you are a Victorian traveller in London (page 18). Students consider how and why the tube was developed.

Watch video from bbc news:
bbc.co.uk/news/uk-england-london-21005813

MAIN 3: BURNING CARBON AND SULPHUR IN OXYGEN

Demonstrate burning carbon and sulphur in oxygen. For instructions, see video of sulphur demo:
youtube.com/watch?v=d1yvjeYo4sA

Use the same method for carbon.

See the following for student support:
bbc.co.uk/bitesize/ks3/science/chemical_material_behaviour/compounds_mixtures/revision/6

Students should be able to write word equations for the gas jar experiment.

Differentiation

Instead of writing word equations more able students could write symbol equations for reactions.

Plenary

Connect the experiment to the issue of transport with the following questions:

- What fuel was used in the steam tube trains?
- What impact does this kind of fuel have on the atmosphere?
- Why might people be worried about these gases being added to the air?
- Why was this worse for the underground trains?

Differentiation

Describe how the experiment is a model for the reaction happening in trains.

Homework ideas

Find out what the main pollutants are in air in London and where they come from.

Find out about the environmental and health problems caused by air pollution.

Further reading

News item from daily mirror on steam tube train:
mirror.co.uk/news/uk-news/steam-trains-runs-on-london-underground-1494853

LESSON 1: WHAT POWERS LONDON TRANSPORT?

RESOURCE 1.1: MODES OF TRANSPORT IMAGES

LONDON BLACK CAB
© Jimmy Barrett **CC BY-SA 2.0**

CONTAINER BARGE, RIVER THAMES, LONDON
© Charlotte Gilhooly
CC BY-SA 2.0

LONDON UNDERGROUND C STOCK TRAIN FORMING A HAMMERSMITH & CITY LINE TRAIN AT HAMMERSMITH
© Charlotte Gilhooly
CC BY-SA 3.0

LESSON 1: WHAT POWERS LONDON TRANSPORT?

RESOURCE 1.1: MODES OF TRANSPORT IMAGES CONTINUED

NORTH LONDON OVERGROUND TRAIN
STOPPING AT HIGHBURY & ISLINGTON

NISSAN CAR NORTH LONDON

HIRE BYCYCLE IN LONDON

LESSON 1: WHAT POWERS LONDON TRANSPORT?

RESOURCE 1.1: MODES OF TRANSPORT IMAGES CONTINUED

NEW ADDINGTON TRAMSTOP LOOKING SOUTH TOWARDS BUFFERS

AT A CHARGING POST ON A STREET BETWEEN COVENT GARDEN AND THE STRAND.

MOTORSCOOTERS ON WHITEHALL

LESSON 1: WHAT POWERS LONDON TRANSPORT?

RESOURCE 1.1: MODES OF TRANSPORT IMAGES CONTINUED

A 2010 SINGLE-DECK FUEL CELL BUS PICTURED STANDING AT THE TERMINUS IN COVENT GARDEN

Image by Spsmiler

METRO BUS IN REDHILL

LESSON 1: WHAT POWERS LONDON TRANSPORT?

RESOURCE 1.2: COMPARING DIFFERENT MODES OF TRANSPORT

MODE OF TRANSPORT AND ESTIMATED DATE OF FIRST USE IN LONDON.	WHERE DOES THE ENERGY COME FROM TO MAKE IT MOVE?
ADVANTAGES	**DISADVANTAGES**

LESSON 1: WHAT POWERS LONDON TRANSPORT?

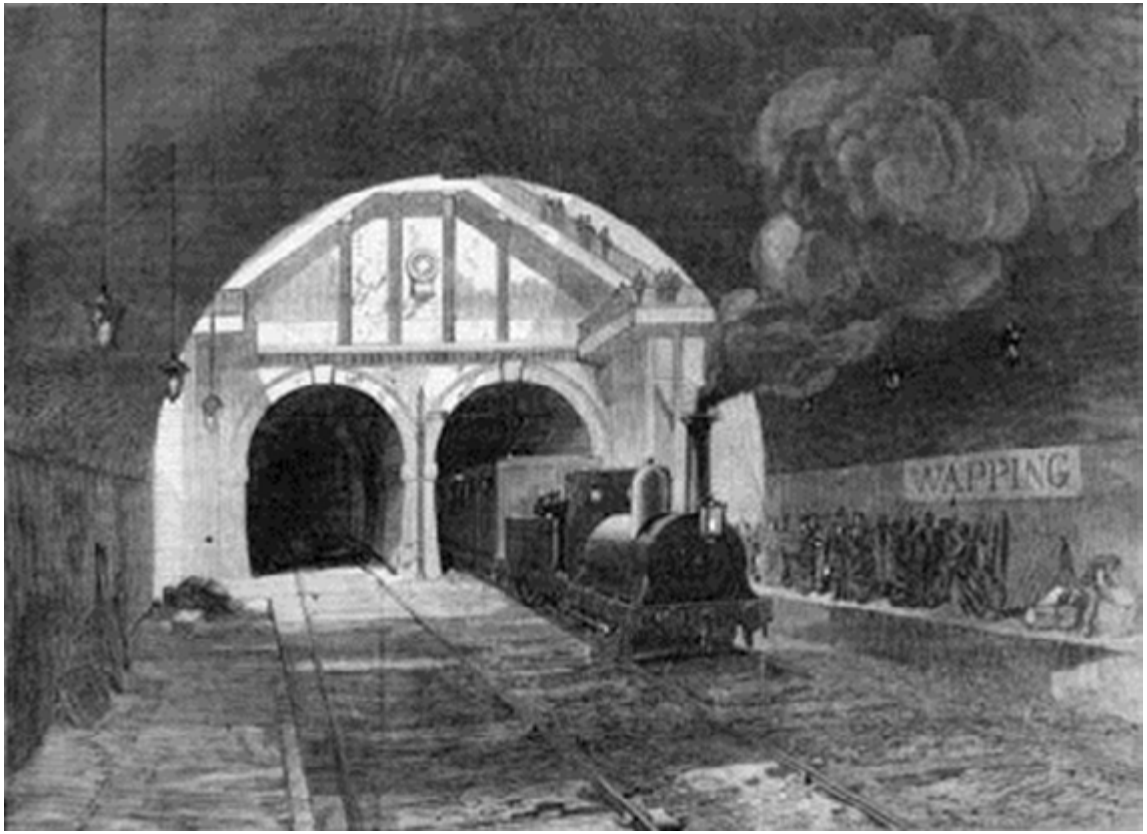
RESOURCE 1.3: IMAGINE YOU ARE A VICTORIAN TRAVELLER IN LONDON

Imagine the scene the train comes out of the tunnel billowing smoke and steam. How would you feel if you had never seen this before?

The streets above are packed with people, horses and carts, lots of noise, dirt from horses on the roadway.

If you are trying to travel across London how do you feel?

Why might the underground train be a good idea?



LESSON 2
WHY HAS LONDON INTRODUCED THE CONGESTION CHARGE ZONE AND LOW EMISSION ZONE?



THE BIG IDEA

This lesson will introduce more ideas about combustion/incomplete combustion and the production of carbon monoxide, particulates and their relationship to health.

LEARNING OUTCOMES

Could produce and write symbol equations for the combustion of carbon and methane using models.

Should explain how combustion results in the production of carbon dioxide, carbon monoxide and carbon particles.

Should describe the health effects of a build up of carbon monoxide and particulates in the environment.

Must be able to name combustion as the reaction producing energy to drive transport vehicles.

RESOURCES

Resource 2.1: Combustion of methane by Bunsen burner

Resource 2.2: What is particulate matter?

KEY WORDS

- Combustion
- Exothermic
- Heat energy
- Fuel
- Hydrocarbon
- Oxygen
- Chemical reaction
- Congestion zone
- Low emission zone

LESSON 2
WHY HAS LONDON INTRODUCED THE CONGESTION ZONE AND LOW EMISSION ZONE?

YOU WILL ALSO NEED

For: Starter

- Eye protection
- Cut down mineral water bottle with tube to connect to gas tap
- Soap solution
- Metre ruler with clothes peg attached by tape
- Wooden splints

For: Main 1

- Eye protection
- Glass funnel (about 6 cm in diameter)
- x2 Boiling tubes
- x2 Two-holed rubber bungs to fit the boiling tubes, and fitted with one long and one short piece of glass tubing
- Pump
- Glass or plastic tubing for connections
- Candle
- Piece of blue cobalt chloride paper (TOXIC)
- Limewater (treat as IRRITANT), about 20 cm^3

LESSON 2: WHY HAS LONDON INTRODUCED THE CONGESTION ZONE AND LOW EMISSION ZONE?

SETTING THE SCENE

London buses, taxis and cars run mainly on the hydrocarbon fuels, petrol and diesel. Some mainline trains are still diesel trains. Combustion reactions are exothermic and the energy generated by these chemical reactions is used to drive our transport systems. However, additional outputs from these reactions include carbon dioxide, carbon monoxide and carbon particulates as well as a series of nitrogen oxides. Unfortunately these products of combustion are damaging to the environment and the health of Londoners. This lesson focuses on the basics of understanding combustion of hydrocarbons, the products of incomplete combustion and the impact on health.

A 'SPECIAL TRAIN PASSES SOUTH THROUGH SOUTH QUAY DLR STATION

LESSON 2: WHY HAS LONDON INTRODUCED THE CONGESTION ZONE AND LOW EMISSION ZONE?

ACTIVITIES

STARTER: BURNING METHANE BUBBLES

Remind students that most transport relies on combustion reactions directly.

For instructions and standard risk assessment see Conducting a Risk assessment (page 2). Students write down two sentences to describe what they know about combustion using keywords from the list.

MAIN 1

Demonstrate burning hydrocarbon fuels. For instructions see:

nuffieldfoundation.org/practical-chemistry/identifying-products-combustion

Ask the students to construct word equations.

Differentiation

Extend students with a modelling activity to make symbol equations with carbon and oxygen, and methane and oxygen. Students can watch the videos and animations on the following website before making their own models using sweets eg cocktail sticks:

11567.stem.org.uk/v1_1.html

MAIN 2

Model complete and incomplete combustion reactions using Resource 2.1: Combustion of methane by Bunsen burner (page 24).

Possible discussion should include the amount of oxygen in the engine during burning so this can lead to students explaining why carbon and carbon monoxide can be found in exhaust gases of London buses.

Differentiation

To support students give some guidance on how to record observations from the experiment.

MAIN 3

Why is it important to understand combustion reactions for our health?

What impact does the Congestion Charge Zone have on this?

Resource 2.2: What is particulate matter (page 25) gives information on particulates (products of hydrocarbon combustion) and health. Students can read the sheet and watch one of the videos.

Plenary

Students list three new facts they have learnt about combustion in transport and one question they still have.

Further reading

Some careers related sites:

learn.org/articles/What_is_Combustion_Engineering.html

Combustion Engineering Association:

cea.org.uk

Report on air pollution from diesel trains:

londonair.org.uk/london/reports/KCL_Air_pollution_emissions_from_diesel_trains_in_London.pdf

News items on the success of the Congestion Charge Zone can be found at:

bbc.co.uk/news/uk-england-london-21451245

LESSON 2: WHY HAS LONDON INTRODUCED THE CONGESTION ZONE AND LOW EMISSION ZONE?

RESOURCE 2.1: COMBUSTION OF METHANE BY BUNSEN BURNER

Using the Bunsen Burner to model complete and incomplete combustion reactions. You will need:

- Bunsen Burner
- Tripod
- Gauze
- Benchmat
- Tongs

1. Look at the gauze on both sides and write down a description.
2. Set up the Bunsen burner tripod and gauze and light it leaving the air hole closed.
3. After two minutes use the tongs to pick up the gauze (careful very hot). Place upside down on the bench mat. Describe what you can see and what you think has happened to the gauze.
4. Using tongs place the gauze back as it was on the tripod. Now open the air hole on the Bunsen fully and leave for another two minutes.
5. Repeat number 3 above.

What has happened?

Think about the following questions:

- What gas is burning in the Bunsen? What is the gas made from?
- What might happen if there is not enough air for the gas to burn completely?
- When is there more air available for burning in the Bunsen – i.e. air hole open or closed?
- What do you think was left on the gauze after you burnt the gas with the air hole closed?
- What happens when carbon burns in oxygen?
- Why was the gauze clean again at the end?

LESSON 2: WHY HAS LONDON INTRODUCED THE CONGESTION ZONE AND LOW EMISSION ZONE?

RESOURCE 2.2: WHAT IS PARTICULATE MATTER?

There are things floating around in the air. Most of them, you cannot even see. They are a kind of air pollution called particles or particulate matter. In fact, particulate matter may be the air pollutant that most commonly affects people's health.

These particulates are formed in the exhaust of cars and other petrol or diesel forms of transport.

© Transport for London

Breathing it in.

When you inhale, you breathe in air along with any particles that are in the air. The air and the particles travel into your respiratory system (your lungs and airway). Along the way the particles can stick to the sides of the airway or travel deeper into the lungs.

Your body responds to the particulate invasion!

Your lungs produce mucous to trap the particles, and tiny hairs wiggle to move the mucous and particles out of the lung. You may notice something in the back of your throat (this is the mucous); the mucous leaves the airway by coughing or swallowing. If the particle is small and it gets very far into the lungs, special cells in the lung trap the particles and then they can't get out.

Exposure to particulate matter leads to increased use of medication and more visits to the doctor or hospital. Health effects include the following:

- Coughing, wheezing, shortness of breath
- Aggravated asthma
- Lung damage (including decreased lung function and lifelong respiratory disease)
- Premature death in individuals with existing heart or lung diseases

LESSON 3
WHICH FUEL IS THE BEST SOURCE OF ENERGY FOR LONDON BUSES?

THE BIG IDEA

In this lesson students will investigate different fuels both practically and as a research project. This will include energy output, ease of combustion, the cost to environment in extraction, economic cost, ease of delivery and related factors.

LEARNING OUTCOMES

Could calculate the energy output from combustion of methane and other fuels.

Should describe and experiment to calculate the temperature rise from the combustion of different fuels.

Should choose appropriate criteria with which to judge the best fuel.

Must research and record some information about a given fuel.

KEY WORDS

- Combustion
- Exothermic
- Heat energy
- Fuel
- Hydrocarbon
- Oxygen
- Chemical reaction
- Congestion zone
- Low emission zone

MATHEMATICAL CONCEPTS

- Calculating energy output for different fuels as temperature rise per g and kg of fuel
- Converting temperature change into energy in kJ

LESSON 3
WHICH FUEL IS THE BEST SOURCE OF ENERGY FOR LONDON BUSES?

YOU WILL ALSO NEED

For: Main 1

- Spirit burner containing ethanol with lid
- Bench mat
- Candle
- Balance
- Clampstand
- Copper calorimeter
- Heat shield if available
- Measuring cyclinders
- Thermometer
- Glass rods

LESSON 3: WHICH FUEL IS THE BEST SOURCE OF ENERGY FOR LONDON BUSES?

SETTING THE SCENE

LONDON BUS ROUNDEL AND FUEL CAP.

Transport in London mostly runs using hydrocarbon fuels (petrol or diesel) or electricity produced from combustion reactions in power stations. There is increasing pressure to search for alternatives to combustion of hydrocarbons due to increasing carbon dioxide emissions and its effect on global warming. The energy output from fuels is one aspect in decision making about which fuels to use, as are the effects of the fuel from production to disposal of waste products i.e. the life cycle of the fuel. Students are encouraged to conduct a practical and library investigation to consider the criteria on which we should judge a fuel. This lesson aims to develop student knowledge in different sources of energy that could be used for transport.

LESSON 3: WHICH FUEL IS THE BEST SOURCE OF ENERGY FOR LONDON BUSES?

ACTIVITIES

STARTER

Demonstrate how combustion can result in motion. For instructions, see:

rsc.org/learn-chemistry/wiki/Expt:The_methane_rocket

Teachers could show how methane burns well with the right amount of oxygen.

Differentiation

More able students who can understand the symbol equation could explain why the ratio of methane to oxygen is 1:2.

MAIN 1

This is a well known experiment with a set method. Rather than ask students to come up with a method, students should design a way to carry out the experiment as accurately as possible.

The aim is to find out how much energy is available from different fuels e.g. wax, ethanol. Students should be encouraged to consider the accuracy of their results and how to reduce errors e.g. through heat loss. They should consider repeating the experiment to look at the repeatability of their methods.

A simple way to discuss the set up for a liquid with students is given here:

bbc.co.uk/schools/gcsebitesize/science/add_ocr_gateway/chemical_economics/energyrev2.shtml

A more detailed description for teachers:

www.rsc.org/learn-chemistry/resource/res00001733/heat-energy-from-alcohols

Differentiation

Methane (if the school has a gas meter) could be added as an extension which would involve a density calculation to work out the temperature rise/energy output per g.

Support investigation sheets may be appropriate for some students.

MAIN 2: BEST FUEL FOR MY BUS

Allocate students into groups and ask each group to research a given fuel:

- petrol
- diesel
- biofuels
- electricity for electric cars
- hydrogen fuel cells

These groups will become the expert groups for the connect lesson.

Access to a range of text books and the internet would be needed for this activity. You could also incorporate a visit to the school library.

Encourage the class to decide on success criteria for research e.g. source of fuel, energy output, ease of distribution, cost, damage to the environment in production, damage to the environment when used etc.

Differentiation

Allocate the groups carefully, some energy sources will be more difficult to understand – listed above in order of increasing difficulty.

Plenary

Students present initial ideas about each source of energy to the class to be peer reviewed.

Homework ideas

Groups allocate research tasks to members of the team and give the list to the teacher for accountability purposes.

Complete presentation.

LESSON 4
WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

THE BIG IDEA

Students will investigate and evaluate the development of new technologies to reduce pollution from combustion i.e. catalytic converters, electric cars & fuel cells. Cradle to grave cycles of use of resources will be considered e.g. in the use of incineration of waste to produce electricity for transport.

LEARNING OUTCOMES

Could critically evaluate the information on different technological solutions to pollution due to transport.

Should describe the natural carbon cycle and human contribution to this.

Should describe how some technological developments are able to clean up fuel emissions.

Must name technological developments for the reduction of pollution from public transport.

RESOURCES

Resource 4.1: A circus of activities

Resource 4.2: Circus record sheet

Resource 4.3: Circus record sheet

KEY WORDS

- Catalyst
- Hybrid
- Diesel
- Electricity generation
- Incineration

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

SETTING THE SCENE

The carbon cycle describes how carbon moves through the world. Humans have an impact on this natural cycle mainly through the use of hydrocarbon fuels. There have been many technological developments over the last 150 years to improve the efficiency and reduce the damaging effects of transport. As this is a large complex issue there is not one right answer and even scientists and technologists cannot agree on one solution. Nevertheless there have been concerted efforts to reduce air pollution throughout the city. There has been widespread electrification of trains and tubes. Catalytic converters have been developed to reduce the production of harmful emission from the combustion of hydrocarbons. Hybrid engines and alternate fuels are being developed.

A 2010 SINGLE-DECK FUEL CELL BUS PICTURED STANDING AT THE TERMINUS IN COVENT GARDEN

Image by Spsmiler

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

ACTIVITIES

STARTER

Groups report on their findings from the homework activity.

MAIN 1

How can engineers improve air pollution caused by London transport?

Consider inviting an Engineering Ambassador in to bring this discussion to life. For more information, see:

tfl.gov.uk/info-for/schools-and-young-people/inspire-engineering

An ambassador could be asked to support the students' enquiry into the various 'big questions' and then to answer questions raised at the end. Alternatively, you can act in the role of the expert for students to ask their questions.

MAIN 1

Big Questions
Set up a circus of activities for students to explore the following questions, rotating in groups. Base the circus of activities on the information provided.

- What effect would a catalytic converter have on air pollution? Resource 4.1 (page 35)
- Would your bus be better if it was a hybrid bus? Resource 4.2 (page 36)
- Should we re-route traffic and make certain roads pedestrian-only?

  www.cityam.com/218453/booming-west-end-will-be-fatally-undermined-unless-we-pedestrianise-oxford-street
- Should we ban diesel engines?

  www.bbc.co.uk/news/business-31823252
- Has the congestion zone worked?

  www.london24.com/london_congestion_charge_a_success_10_years_on_1_1936089
- Where does the electricity come from to run electric cars and buses? Resource 4.3 (page 37)
- Video of EcoPark:

  www.londonwaste.co.uk

Ask students to fill in Resource 4.4: Big question record sheet (page 39).

Ask each group to report back on the big question that they tackled first.

Differentiation

Students should be allocated their first station in the circus according to ability as some may be more difficult than others to report back on.

Plenary

Allocate groups for the explore visit.

Homework ideas

Student groups can continue research on their given fuel.

Further reading

Technological innovators in London could be used as an introduction to the main task.

Hellen Storey foundation:

www.catalytic-clothing.org

Denis Johnson built the first bicycle in London:

www.londonremembers.com/memorials/hobby-horse-bicycle

1831, Electrical Generator Michael Faraday built the first electric generator (similar to a dynamo) at the Royal Institution:

en.wikipedia.org/wiki/Electrical_generator

Fred Bremer built the first four wheeled internal combustion car in Walthamstow, East London:

en.wikipedia.org/wiki/Frederick_Bremer

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

RESOURCE 4.1: WHAT EFFECT WOULD A CATALYTIC CONVERTER HAVE ON AIR POLLUTION?

If you look under your car you will see something like this on the exhaust pipe of the car. It is there to reduce the amount of polluting gases that your car puts out.

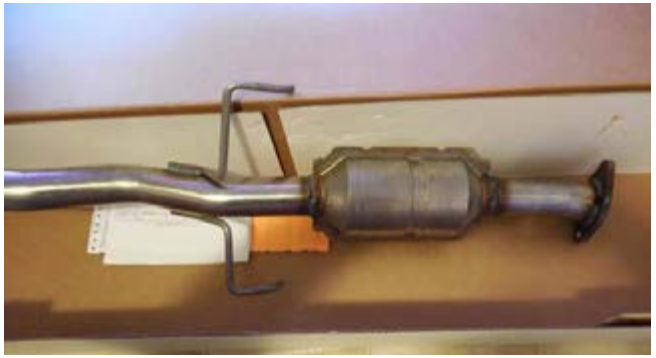
A catalyst is a chemical which speeds up a reaction which otherwise might be too slow.

Harmful gases from the cars exhaust include:

- carbon monoxide which is converted to carbon dioxide
- hydrocarbons which are convereted to carbon dioxide and water; and
- nitrogen oxides which are converted to nitrogen.

The catalytic converters are very expensive to produce as they contain precious metals which act as the catalyst. As the space through which the gases pass is very small they can get blocked and the converter will stop working. After the end of its life it may be possible and advisable to remove the precious metal and recycle it as these metals are in short supply.

Catalytic converters need to be hot enough to work properly. This may be difficult in heavy traffic such as congested London streets.



CATALYTIC CONVERTER

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

RESOURCE 4.2: WOULD YOUR BUS BE BETTER IF IT WAS A HYBRID BUS?

More than 1200 hybrid buses operate in London. The first hybrid bus was introduced on route 360 in March 2006 and over 300 were in passenger service by July 2012. The world's first double-deck hybrid bus was introduced in London from January 2007.

Hybrid electric buses use a combination of an electric battery pack and a diesel engine to provide power, and produce around 40% less carbon dioxide (CO^2) emissions than traditional diesel engined buses. Energy generated during braking is used to charge the batteries of hybrid vehicles. Later in 2006 the vehicles were temporarily withdrawn from service when their diesel engines overheated.

Transport is responsible for around 20% of London's CO^2 emissions; buses make up 5% of the transport total. The city has set a target of a 20% reduction in emissions by the year 2020. Converting London's entire bus fleet to hybrid vehicles would reduce CO^2 emissions by around 200,000 tonnes per year.

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

RESOURCE 4.3: WHERE DOES THE ELECTRICITY COME FROM TO RUN ELECTRIC CARS AND BUSES?

What's our rubbish got to do with cleaning up transport?

Edmonton Incinerator (officially London EcoPark) is a municipal waste incinerator and waste-to-energy power station which burns London's waste to provide electricity for the National Grid. It is located on the River Lee Navigation and bordered by the North Circular Road, in Edmonton in the London Borough of Enfield.

The incinerator is currently Britain's largest and it handles unrecycled waste from seven London Boroughs: Barnet, Camden, Enfield, Islington, Hackney, Haringey, and Waltham Forest. The waste is converted into electricity, bottom ash, air pollution control residue, and flue gases. 55 megawatts (MW) of electricity are generated, sufficient power to meet the needs of 24,000 households.

The site has been the scene of a demonstration by Greenpeace, who are against all incinerators because of concerns that they emit "a cocktail of chemicals that can cause cancers and asthma attacks", and that incineration "undermines targets for waste reduction and recycling". In October 2000 they scaled and occupied the station's chimney, shutting its operations down for four days. The incinerator has also been campaigned against by Friends of the Earth and Londoners Against Incineration.

LONDONWASTE ECOPARK

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

RESOURCE 4.3: WHERE DOES THE ELECTRICITY COME FROM TO RUN ELECTRIC CARS AND BUSES? CONTINUED

The EcoPark says:

"Waste considered unsuitable for other methods of recycling is sent to the Energy Centre. Here waste is incinerated to produce energy.

The heat generated from the process turns water into steam which drives turbines to create electricity. This is fed in to the National Grid. We export around 85 per cent of the electricity we generate – that's enough to power 72,000 homes throughout the year – the remaining 15 per cent powers all the centres on the EcoPark.

From 1994, when LondonWaste Ltd was awarded the NLWA contract, up to the end of 2013, more than 9 million tonnes of waste has been diverted from landfill.

Facilities such as ours are amongst the most tightly monitored for environmental performance. The Environment Agency regulates and monitors the Energy Centre to ensure emissions are as low as possible in order to protect the environment and human health. The operation of the Energy Centre is also subject to the European Union Integrated Pollution Prevention and Control (IPPC) regime. The IPPC aims to prevent, reduce or eliminate pollution at source."

See:
www.londonwaste.co.uk/community/ecopark-energy

LESSON 4: WHAT IS THE CARBON CYCLE AND HOW CAN WE REDUCE THE HUMAN CONTRIBUTION TO AIR POLLUTION IN LONDON?

RESOURCE 4.4: BIG QUESTION RECORD SHEET

BIG QUESTION	PLUS	MINUS	INTERESTING	QUESTION I HAVE
What effect would a catalytic converter have on air pollution?				
Would your bus be better if it was a hybrid bus?				
Should we re-route traffic and make certain roads pedestrian-only?				
Should we ban diesel engines?				
Has the congestion zone worked?				
Where does the electricity come from to run electric cars and buses?				

EXPLORE

Through a visit to a museum, exhibition or local site, students will be encouraged to find out about fuel use through time and about the consequences of the use of those fuels. They will be set tasks to gather information to support the connect lesson, in which they will be set the question, 'Which fuel should we use in the future?'.

EXPLORE
FUEL USE THROUGH TIME

THE BIG IDEA

Students will be encouraged to find information about fuel use through time and about the consequences of the use of those fuels. They will be set tasks to gather information to support the connect lesson where they will be asked to suggest which fuel should we use in the future?

LEARNING OBJECTIVES

Could evaluate the different technological innovations to produce a ranked list in terms of solutions for the future.

Should be able to describe how engineers are involved in shaping the use of fuels for transport in London.

Should be able to describe how different fuels are used to power different forms of transport and record details found.

Must collect images of vehicles mentioned or displayed at the chosen site.

EXPLORE

POSSIBLE SITES

Science Museum

Exhibition Road, SW7 2DD

020 7942 4777
ebookings@science museum.ac.uk

Relevant galleries include: the Energy Hall, Energy Fuelling the Future, The Atmosphere and Engineering your Future. The galleries allow students to explore the story of steam power and the ways energy empowers every aspect of our lives and to question how we will meet the planet's growing energy demands. As each gallery needs between 30 minutes to an hour student can visit two or three and gather images (sketches or photos) related to the topic to incorporate into their presentation back at school.

EXHIBITION ROAD
© Olivia Woodhouse

London Waste EcoPark

Advent Way, N18 3AG

020 8803 1322
recycling@londonwaste.co.uk

London Waste uses the refuse collected across nine London boroughs to produce electricity in the incineration plant. They have recently undergone a local consultation regarding the building of a new incinerator and students could fact find about the views and fears of local people. They could seek to weigh these views against the benefits of using waste to produce electricity as an alternative to fossil fuels for cars and buses.

The EcoPark can organise visits for groups of students with the possibility of touring the site and meeting engineers.

www.londonwaste.co.uk/community/tours

EXPLORE

POSSIBLE SITES

London Transport Museum

120 Gunnersbury Lane, W3 9BQ

020 7565 7298
bookings@ltmuseum.co.uk

The Crystal is a sustainable cities initiative by Siemens. It is home to the world's largest exhibition on the future of cities and is one of the world's most sustainable buildings. Inspire your students to consider STEM (Science, Technology, Engineering and Maths) careers through access to practising engineers and London Transport Museum's historic collection.

The key stage 3 Inspire Engineering Day includes:

- Interviews with inspiring engineers
- Participation in our exciting hands-on 'Braking Eggsperiment'
- Exploration of the engineering wonders at the London Transport Museum Depot

This session is CREST accredited by the British Science Association. All participating students receive a CREST Discovery Award at the end of the day.

ltmuseum.co.uk/learning/schools/key-stage-3

Vestry House Museum

Vestry Road, E17 9NH

020 8496 4391
vhm.enquiries@walthamforest.gov.uk

Home of first British internal combustion engine car, which is exhibited at the museum alongside a historical account of the development of this technology.

walthamforest.gov.uk/vestry-house

Local transport museums

There are various local transport museums with historic collections of transport through the ages which could allow students to explore the differences and the efficiencies of fuel use e.g. miles per gallon.

Hayes
londonmotormuseum.co.uk

Weybridge
londonbusmuseum.com/school-parties/

Enfield
whitewebbsmuseum.co.uk

Walthamstow
www.e17pumphouse.org.uk

EXPLORE

POSSIBLE SITES

The Crystal

1 Siemens Brothers Way, E16 1GB

020 7055 6400
education@thecrystal.org

The Crystal is a sustainable cities initiative by Siemens. It is home to the world's largest exhibition on the future of cities and is one of the world's most sustainable buildings.

Zone 8 Keep moving

This zone explores the increased need for transport infrastructure as people move to cities. It discusses the significance of road and rail electrification and explores green transport choices, integrated traffic solutions and e-mobility.

siemens.co.uk/education/en/teachers/the-crystal/the-zone-downloads.htm

Also see:

STEM ambassadors and employee volunteers into schools.

This could be used to supplement discover lesson 4 or as an alternative to the visit.

Where possible Siemens employees may be available to visit schools, colleges and academies to help deliver fun and engaging workshop and practical activity sessions and presentations in areas in which they are expert.

If you are a teacher or are representing a school and would like to request a visit, please contact either:

stemnet.org.uk

inspiringthefuture.org

© The Crystal

EXPLORE

POSSIBLE SITES

Very local learning

Outside activities could include:

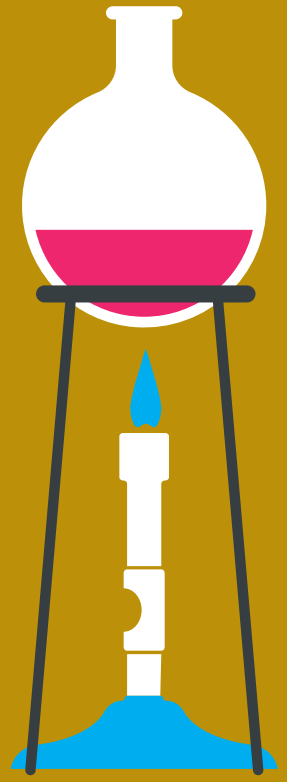
- counting and displaying information about traffic in areas around the school
- devising tests for pollution using sellotape and microscopes to count particulates and comparing different types of roads
- monitoring pollution levels at varying distances from main roads and on different sides of the road
- spotting and photographing five signs of air pollution in the local area, examples might include: a smoking chimney, car or bus exhaust or a plane flying overhead. (Health and safety issues must be considered.) The types of pollution they represent could be researched and presented back in the classroom
- looking for signs of pollution along their street, or by their school. Examples might include: blackened walls, dust or particulates on walls or windows
- conducting a survey of pollution-loving lichens etc.
- conducting a carbon cycle caper (this could be carried out in the locality of the school eg in the playground & linked to one or more of the local suggestions above)
- a game from the Science Museum to summarize much of the content of the unit so far.

www.sciencemuseum.org.uk/educators/classroom-resources/activities/carbon_cycle_caper

Students should write a short paragraph to summarise the carbon cycle from the game and to say how this is related to the issue of transport.

CONNECT

This session will draw together ideas from the unit as students are called upon to plan a presentation to the Mayor tackling some of the key questions facing the future of London's transport.



LESSON 5
TRANSPORT SOLUTIONS FOR THE FUTURE

BIG IDEA

This session will draw together ideas from the unit as students are called upon to plan a presentation to the Mayor tackling some of the key questions facing the future of London's transport.

LEARNING OBJECTIVES

Could evaluate ideas from the topic to produce a balanced argument for the big questions presentation and a rationale for why the solutions chosen are considered the best by the group.

Should be able to provide evidence for and against a given solution to the big questions.

Must participate in the production of a group presentation to answer at least two of the big questions.

RESOURCES

Resource 5.1: Big questions

LESSON 5: TRANSPORT SOLUTIONS FOR THE FUTURE

ACTIVITIES

MAIN

Students will produce a presentation on some or all of the Big questions given. They can be encouraged to use varied formats eg radio chat show, video, power-point or poster presentation. You may decide to limit the modes of presentation so that students can produce the presentation in the lesson time.

The Mayor has decided the use of fuels in London needs to change and needs advice from expert chemists. He wants a top class presentation including good science and evidence collected from visits and from research.

Big questions need to be answered:

- Should London transport give up on the use of fossil fuels?
- How could London Transport be powered without the use of fossil fuels?
- Should London Transport be only via electric cars?
- What is the best fuel to run London buses and taxis?
- Should diesel cars, buses and taxis be banned on London roads?
- Should areas of London eg major shopping areas be pedestrianised?

Students should develop a series of success criteria for the task. Suggestions might include:

- All students must participate in presentation
- Presentation must include how the chemistry of combustion is involved in transport
- Presentation must include how does combustion lead to issues for the environment
- There should be a balanced argument i.e. there should be ideas for and against a given solution?
- Ideas about technological developments should be included and assessed for their contribution to any solutions.

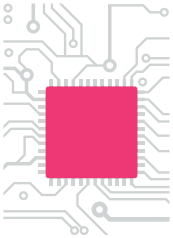
LESSON 5: TRANSPORT SOLUTIONS FOR THE FUTURE

RESOURCE 5.1: BIG QUESTION RECORD SHEET

- Should London transport give up on the use of fossil fuels?
- How could London Transport be powered without the use of fossil fuels?
- Should London Transport be only via electric cars?
- What is the best fuel to run London buses and taxis?
- Should diesel cars, buses and taxis be banned on London roads?
- Should areas of London eg major shopping areas be pedestrianised?

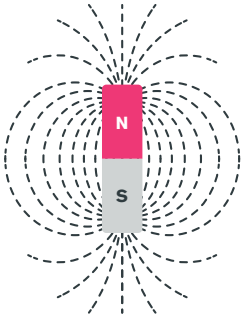
LINKS TO OTHER LONDON CURRICULUM SUBJECTS

London refuelled is part of London on the Move, a set of London Curriculum teaching resources that explore the application of STEM subject in the transport systems of the city.



COMPUTING

The Connected city examines the role computing plays in keeping journeys on the road network in particular reliable and safe.



PHYSICS

London's driving forces illustrates and explores the topics of energy and forces in the context of travel around the city and sets students the challenge of designing a vehicle for London's future.

CREDITS

The GLA would like to thank the following organisations for their contribution:

Our collaborators on the London Curriculum

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www.thirteen.co.uk

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City Hall
The Queen's Walk
London SE1 2AA

www.london.gov.uk
enquiries 020 7983 4100
minicom 020 7983 4458

‘The idea of using London as a teaching resource has never been explored much before, so both students and teachers are excited about it’

Key stage 3 teacher

‘It makes me feel proud to be a Londoner’

Key stage 3 student