FUTURE TRAVEL

Practical Project
For Teachers **p2&3**, for Students **p4**

HEALTH AND SAFETY

Students should be encouraged to make their own risk assessment before they carry out any activity, including surveys. In all circumstances this must be checked by a competent person. Students using specialised equipment should be supervised at all times.

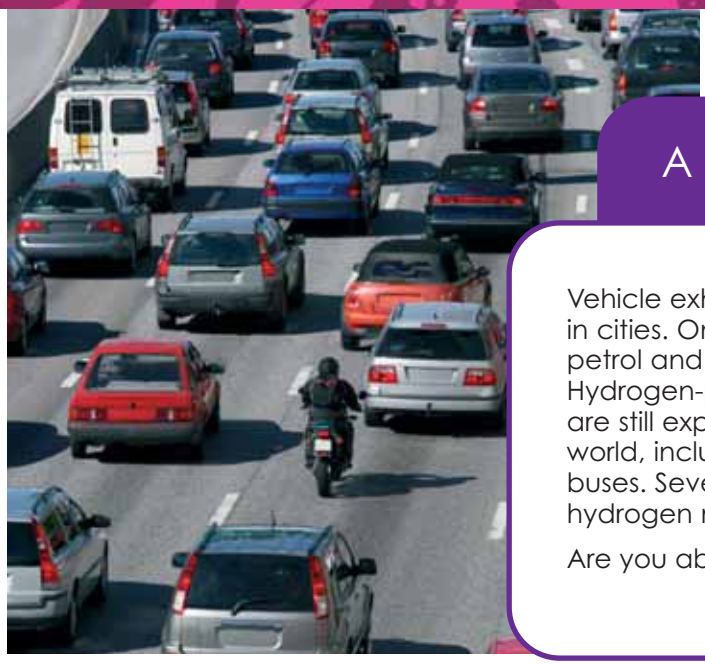
Combustion of fuels requires careful risk assessment and close supervision. Students should plan and carry out their project, but all practical work must be vetted.

The aim of the project is to investigate how CO_2 emissions can be measured. Petrol and other low flash point hydrocarbons must not be used. Alcohols, paraffin, cooking oil and gaseous fuels may be acceptable.

Students may want to set up unorthodox experiments and you may need to seek specialist advice. Organisations such as CLEAPSS and the Royal Society of Chemistry are able to help.

FUTURE TRAVEL:

Silver **Practical** Project - For Teachers



A solution to pollution?

Vehicle exhaust fumes pose serious pollution problems in cities. One suggestion is to use hydrogen instead of petrol and diesel – but that's not as simple as it sounds. Hydrogen-powered vehicles do exist, but so far they are still experimental. At least twelve cities around the world, including in England, are trying out hydrogen buses. Several car manufacturers are developing hydrogen models.

Are you about to witness a 'green transport' revolution?

HAVE YOU EVER WONDERED?

…what makes a good fuel cell for powering cars and buses?

You might like to imagine yourself in a situation such as...

Pollution-free, zero-emission hydrogen fuel cell vehicles sound like a good idea, but so far there aren't many around. You aim to take advantage of this gap in the market by designing a prototype fuel cell, which you will present at a Dragons' Den type forum, to bid for further development funding. Your first step is to **undertake practical experiments** to:

- investigate factors that affect the performance of a hydrogen fuel cell
- evaluate methods of generating hydrogen for use in fuel cells.

POSSIBLE EQUIPMENT, MATERIALS AND RESOURCES

Normal laboratory equipment for:

- measuring heat and electrical energy
- generating hydrogen and oxygen, including by electrolysis

Heat of combustion apparatus

Model kits for hydrogen fuel cells and solar cells (available from laboratory suppliers, usually with instructions for various investigations)

Prompts

The **Student Brief** gives some triggers to start students thinking. They will not have time to investigate all of these and must decide on which aspects to focus.

Each trigger could lead to various lines of investigation. Students should be encouraged to identify possibilities for themselves and to think about which are likely to lead to feasible practical investigations. However, if necessary, prompts such as those below might be given, to point students in suitable directions.

- Why research into fuel cell vehicles tends to focus on using hydrogen as the fuel
  - How does hydrogen compare with, say, methane or methanol cells? What are the advantages and disadvantages?
  - What are the products of cell reactions, and consequent vehicle emissions?
- How a hydrogen fuel cell works
  - What are:
    - the fuel cell components and their functions
    - reactants and products in cell reactions?
  - How and why does hydrogen give electrical energy rather than heat, as in combustion?
- How to measure the performance of a fuel cell
  - What is the energy input and output? How do you calculate efficiency?
  - How do conditions affect output, and thus fuel cell vehicles, in a range of different climates?
  - What characteristics might you change? Ideas can include:
- How altering the design of a fuel cell affects its performance
  - What characteristics might you change? Ideas can include:
    - electrodes – type of material, size, shape, distance apart
    - electrolytes – solute, solvent, concentration, solid electrolyte / membrane
    - physical design – arrangement of components, overall size, shape and mass
- The effectiveness of hydrogen fuel cells compared with other 'green' energy sources, such as biodiesel
  - What does 'effectiveness' mean? How could you assess and compare it?
  - What other 'alternative energy' sources might be used to power vehicles?
- If hydrogen fuel cell vehicles become common, where will all the hydrogen come from?
  - How much hydrogen is required to power one vehicle, say, 10 000 km?
  - What raw materials and reactions could be used to generate hydrogen?
  - Are these methods feasible and economic on a large scale?

NOTE: Mention electrolysis and solar power, if the student has not thought of it within a reasonable time.

Suggestions for supporting students

Though primarily based on laboratory investigations, the Practical project will probably require some initial research into the nature of fuel cells, and also hydrogen generation. One possibility is for two students to undertake their projects – one Practical, the other Research – working independently, but coming together to share mutually useful information and activities.

It is recommended that, wherever possible, Silver Award students should have a scientist or engineer as Mentor for their project. Please contact your CREST Local Coordinator to discuss Mentoring.

A Mentor, with knowledge and/or experience of hydrogen technologies would be ideal. The Mentor might be involved in…

- academic or industrial research into, for instance:
  - fuel cell design and development
  - use of fuel cells for motive power
  - use of photovoltaics (solar cells) for generating hydrogen by electrolysis
- scientific publishing
- measurement and management of energy
- developing or trialling fuel cell cars or buses
- Students should decide their focus, although this may alter in the light of experience as the project progresses.

Internet search

Combine 'hydrogen' with terms such as: fuel cell, vehicle, car, bus, generation or production. Or try:

- Hydrogen vehicles worldwide
  www.netinform.net/H2/H2Mobility/
  (Click 'Hydrogen and Fuel Cell Vehicles Worldwide' for an illustrated timeline of hydrogen vehicle development.)
- How hydrogen fuel cells work
  docbrown.info/page01/ExIndChem/ExtraElectrochem.htm (Click '5 Fuel cells' in index)
  www.schoolscience.co.uk/_db/_documents/tsqg_fuelcells.pdf
  auto.howstuffworks.com/fuel-efficiency/alternative-fuels/fuel-cell.htm
- Making a rudimentary d-i-y hydrogen fuel
  scitoys.com/scitoys/scitoys/echem/fuel_cell/fuel_cell.html
  (Alternatively use carbon electrodes, collecting gases in electrolyte-filled test tubes above them.)
- London Schools Hydrogen Challenge
  lshc.co.uk/secondary/default.asp

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Some things to think about...

- Why research into fuel cell vehicles tends to focus on using hydrogen as the fuel
- How a hydrogen fuel cell works
- How altering the design of a fuel cell affects its performance
- How to measure the performance of a fuel cell
- The effectiveness of hydrogen fuel cells compared with other 'green' energy sources, such as biodiesel
- If hydrogen fuel cell vehicles become common, where will all the hydrogen come from?

Health and Safety

Before you carry out any experiment:

(a) find out if any of the substances, equipment or procedures are hazardous

(b) assess the risks (think about what could go wrong and how serious it might be)

(c) decide what you need to do to reduce any risks (such as wearing personal protective equipment, knowing how to deal with emergencies and so on)

(d) make sure your teacher agrees with your plan and risk assessment

NOTE: Your teacher will check your risk assessment against that of your school. If no risk assessment exists for the activity, your teacher may need to obtain special advice. This may take some time.

(e) if special tools or machines are needed, arrange to use them in a properly supervised D&T workshop.