The meal deal

Teacher's notes

Unit plan

Context

This unit for KS3 (age 11-14) pupils is about something that happens in every home across the planet - cooking. Why do we need to cook given the cost of the energy and the time involved? It engages students with the issue by showing them the difference a stove can make to the lives of people across the planet illustrated by a woman, Sarah, in Kenya. They then explore the wide range of devices used across the world to solve the common problem of making food more palatable and digestible looking at how they reflect local conditions and needs.

Students explore the science of combustion in the context of fuel-burning stoves from around the world. They investigate the energy output from a variety of fuels covering energy values, simple combustion chemistry, stove efficiency, chimney design and the needs of local people.

The unit ends with a design task requiring students to use their scientific and technical knowledge to produce a wood-burning stove suitable for a family in Kenya. They also look at how they might respond to what they have learnt in this unit.

Structure

The unit is divided into three pairs of lessons as given below. The first lesson of each pair is the core and tends to cover the simpler material while the second extends this into more demanding areas. The lessons can be used in isolation, in pairs or as a complete sequence of six lessons. The project works particularly well as an off-timetable event or a STEM club but can also be fitted into normal curriculum time as it covers material required by the National Curriculum.

1: Food and cooking

What's for dinner?
Exploring foods from across the world and investigating the changes in food caused by cooking.

Cook's tour
Looking at the design of cooking stoves from across the planet and their advantages and disadvantages for the local users.

2: Fuels

Fuels for cooking
Looking at the range of possible fuels for cooking and their link to the element carbon.

Energy output
Determining the accurate energy value of fuels and assessing the accuracy of the result.

3: Smokin!

Smoke kills!
Investigating the efficiency of chimneys - do they take away the smoke or just siphon off the heat?

A stove for Isaac
Designing a stove for a family in rural Kenya and reviewing ideas for possible further action.

Lessons

Each pair of lessons includes a variety of activities from whole class discussions to individual work - both practical and theoretical. The tables below give an overview of the various tasks. Each pair of lessons also includes a suggestion for a homework or out-of-school learning activity.

1: Food and cooking

Lesson	Activities	Time / mins	Group size	Format
What's for dinner? Exploring foods from across the world and investigating the changes in food caused by cooking.	Why cook food?	10	Whole class	Discussion
	Cooking rice	25	Pairs	Laboratory practical
	Reviewing the data	10	Whole class	Discussion following practical
Cook's tour Looking at the design of cooking stoves from across the planet and their advantages and disadvantages for the local users.	Sarah's stove	15	Whole class	Discussion following video clip
	Stove sort	10	Small groups	Card-sorting activity
	Stove catalogue	20	Small groups	Internet research
Homework / out-of-school activity	Sarah's story	20	Individual	Creative writing task

2: Fuels

Lesson	Activities	Time / mins	Group size	Format
Fuels for cooking Investigating possible fuels for cooking leading to the formulation of a simple fire triangle and an appreciation of the role of carbon in fuels.	Fuel facts	10	Whole class	Class brainstorm
	Investigating fuels	25	Pairs	Laboratory practical
	Reviewing the data	10	Whole class	Discussion following practical work.
Energy output Determining the energy values of a variety of fuels.	Measuring the output	10	Small groups	Discussion
	Investigating energy output	25	Small groups	Laboratory practical
	And the winner is…	10	Whole class	Discussion and vote following practical investigation
Homework / out-of-school activity	Fuels for Uganda	20	Individual	Data response activity

3: Smokin!

Lesson	Activities	Time / mins	Group size	Format
Smoke kills! Investigating the efficiency of chimneys - do they take away the smoke or just siphon off the heat?	Not just heat	10	Whole class	Discussion following video clip
	The perfect chimney	25	Pairs	Laboratory practical
	Reviewing the data	10	Whole class	Discussion following video clip
A stove for Isaac Designing a stove for a family in rural Kenya and reviewing ideas for possible further action.	Design brief	5	Whole class	Class discussion
	Designing the stove	20	Small groups	Discussion
	Planning for action	20	Whole class	Discussion and vote
Homework / out-of-school activity	Press release	20	Individual	Creative writing activity

Key vocabulary

Biofuels, biomass, calorie, calorimeter, carbon, combustion, energy, fuel, heat, joule, oxygen, starch, stove, sugar, temperature.

National Curriculum links

The links to the English National Curriculum below are typical of the content that students could cover as they work through this project. Details of specific coverage will depend on individual classes and teachers.

Working scientifically

Through the content across all three disciplines, pupils should be taught to:

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.

Sc2: Biology

Nutrition and digestion

- content of a healthy human diet: carbohydrates, lipids (fats and oils), proteins, vitamins, minerals, dietary fibre and water, and why each is needed
- plants making carbohydrates in their leaves by photosynthesis and gaining mineral nutrients and water from the soil via their roots.

Sc3: Chemistry

Chemical reactions

- chemical reactions as the rearrangement of atoms
- representing chemical reactions using formulae and using equations
- combustion, thermal decomposition, oxidation and displacement reactions

Energetics

- energy changes on changes of state (qualitative)
- exothermic and endothermic chemical reactions (qualitative).

Sc4: Physics

Energy and fuel

- comparing energy values of different foods (from labels) (kJ)
- comparing power ratings of appliances in watts (W, kW)
- comparing amounts of energy transferred (J, kJ, kW hour)
- fuels and energy resources.

Energy changes and transfers

- heating and thermal equilibrium: temperature difference between two objects leading to energy transfer from the hotter to the cooler one, through contact (conduction) or radiation; such transfers tending to reduce the temperature difference: use of insulators
- other processes that involve energy transfer: changing motion, dropping an object, completing an electrical circuit, stretching a spring, metabolism of food, burning fuels.

Lesson 1: What's for dinner?

Learning objectives

- Understand why most foods need to be cooked before they are eaten.
- Explore the effect of cooking on rice.
- Recognise the issues relating to the use of wood fires for cooking.

Lesson sequence

Why cook food? 10 mins

Show the presentation *Home cooking* that shows a variety of foods and ask students to sort them into two groups: foods that can be eaten raw and those which are usually cooked before they are eaten. Some foods will fit into both groups so you will end up with three groups: raw, cooked and both. This activity is best done in groups of about four or five. Stress that students can add more foods to their groups from their own ideas (the presentation just shows a small selection of the possible foods) but keep the activity tight - do not let it encroach on time needed for the practical work.

Cooking rice 25 mins

Review the groups as a class and lead students into the idea that almost all food is eaten *after* cooking. Ask them to suggest why cooking seems to be so important to us. It requires effort and uses up valuable fuel that could be used for heating homes but few people would seriously consider living in a world where all food was eaten raw. Why?

Likely suggestions include making the food taste and look better, easier to digest or for safety (some poisons are destroyed by boiling, pathogenic bacteria are killed by cooking). But what happens to the chemicals in food when it is cooked? Brainstorm any visible changes, e.g. eggs become solid when boiled, vegetables soften when boiled, cake mixture goes solid in an oven, meats are charred on a barbecue etc. These are all examples of chemical changes - a possible extension for more able groups.

Explain that they are now going to look at one particular food - rice. They will look at the effect of cooking on rice. If appropriate, demonstrate the food tests for starch and reducing sugars so that students can see the technique. A further support for some students is available in the worksheet *Food tests*.

In groups they should now design an investigation into how cooking affects the availability of starch and sugar in rice grains. Some students will opt for a simple raw/cooked comparison whereas other might go for a more complicated investigation with rice being cooked for different lengths of time. Encourage this more complex approach but allow students to create their own investigation wherever possible. The amount of rice is not crucial - watch out for a misunderstanding of accuracy here and make sure students are not tempted to use rice that has been already tested when they cook it.

This is a deceptively simple investigation but can be extended by asking students how they might agree the colour of the final solution. Does everyone mean the same thing by 'yellow' or 'brick red' for the results of the Benedict's test? How could they agree the colour definitions to make results from different groups more comparable? A suitable suggestion is a shared 'colour chart'. Groups that make more progress or who have more scientific insight might also look at how the time and the cooking water temperature affects the rice.

Reviewing data — 10 mins

Collect the results from the whole class and discuss. Start with simple descriptions of what happened to the nutrients in the rice and then extend to the significance of this data to people who depend on rice as a staple food. This provides a good link to ideas about digestion, food value and healthy diets. Finally, explore the quality of their data - how sure are the students that their results are reliable enough to support strong conclusions?

Suitable questions include:

- Which foods (raw or cooked) contained the most sugar? Or starch?
- What do you think caused this change?
- What does this mean to people who eat rice everyday?
- How can you be sure your results are reliable - are you really sure that your test was 'fair'?
- Were there any unexpected results or surprises? How did you deal with these?

Differentiation

All students will:

- collect data from a practical activity

Most students will also:

- handle equipment safely and carefully to produce accurate data
- analyse raw data and relate this to their original ideas

A few students will make more progress and:

- use insights from the investigation to explain the advantages of cooking and the need for controllable heat from stoves

Resources

Worksheets

- Food tests

Presentation

- Home cooking

Equipment

- Iodine solution in reagent bottles
- Benedict's solution in reagent bottles
- Dropping pipettes and spotting tiles
- Supply of dry rice
- Water bath for heating Benedict's solution

Lesson 2: Cook's tour

Learning objectives

- Research stoves from around the world.
- Understand the advantages and disadvantages of each stove for their users.

Lesson sequence

Sarah's stove — 15 mins

Since students will now see that almost all foods need to be cooked before they are eaten the notion that the world must be fed also involves the understanding that cooking foods in central to people's lives. It is estimated that 80% of the food we eat globally is cooked. Where you live in the world and your economic wealth will have a big impact on how easily you have access to energy for cooking.

Almost half the world's population currently live without modern energy, therefore without access to mains electricity. It is estimated that by 2030, 900 million people will not have access to electricity. As a result, billions of people live without the power to they need to carry out tasks such as cooking and lighting their homes. To find out more about how access to energy can reduce poverty and support the achievement of the Millennium Development Goals go to Energy and the MDGs practicalaction.org/energyandthemdgs.

You might want to ask students whether all people in the UK have access to mains electricity and what might be some of the barriers to everyone accessing electricity in the UK.

Show Sarah's story http://bit.ly/Sarahs-story-kenya . The questions below would reveal some interesting insights.

- Does Sarah need more food?
- What are the problems with Sarah's original stove?
- What are the advantages of her new stove?
- How has it changed her life?

Explain that in this lesson they will be looking at the stoves that are available for people all over the world. The homework sheet *Sarah's story* could be mentioned at this point to forewarn students as appropriate.

Stove sort — 10 mins

Sort the students into groups of four or five and hand out the store cards. Ask students to sort the cards into groups. They can choose their own criteria for sorting but will need to agree on these within their groups. There are eight cards on the worksheet but students should add to these by collecting data from the internet. The key issue to stress is that they are looking for insights from around the world about ways of cooking food.

The comments on the cards are indicative and inevitably a somewhat cursory summary of complex issues. The table below shows the main areas of focus.

Factor	Notes
Name	The stove's name.
Fuel	This is the typical energy source for the stove.
Fumes	Information about the level of smoke produced when the stove is in use.
Country	The source of the image for the stove. Each stove could be used in more than one country.
Environmental impact	A rough measure of the impact of the stove when it use. This ignores cost of manufacture, transport to site of use or disposal after its lifetime although these issues could all be discussed.

Review the grouping of the stoves with the class by asking each team to show how they have created their groups and explain the reasoning for their choices. Note that there is no single 'correct' classification - this exercise is really to help students to engage with the stoves an think about some of their key features ready for the next activity.

Stove catalogue — 20 mins

1: Researching the stoves

Drawing on the insights from the card sorting activity students should now start to research the stoves available across the world. They can create cards like the ones used in the card sort above to show the key features of the stoves they find. This is best tackled in groups with the output being developed as a shared display for the group.

2: Picking winners

Ask students to suggest the stoves that might be suitable for the people listed on the worksheet *Stove supply*. The key issue here is to encourage students to identify the key features of the various stove designs and explain their choices in terms of a good match between these and the potential user. You can either ask all groups to suggest stoves for all users or ask each group to concentrate on a particular user.

Draw the class together to review the suggestions for each user. Which stove best matches which user and why?

Encourage students to appreciate that the technology required (e.g. suitable stoves) in different circumstances for different people might be very different but that access to these necessary technologies can be seen as a global right. This idea is known as **technology justice**.

3: Sarah's story

If appropriate, hand out the worksheet *Sarah's story.* Students could complete this for homework as they convert their understanding of the science and technology behind our need to cook food into an insight into the impact of this simple technology on an individual.

Differentiation

All students will:

- sort a selection of stoves from around the world into groups

Most students will also:

- research stoves from around the world on the internet
- contribute to a discussion about the advantages and disadvantages of different stoves

A few students will make more progress and:

- justify their decisions about the stove choices in terms of underlying scientific or technological ideas and needs of the user

Resources

Worksheets

- Cook's tour
- Stove supply
- Sarah's story

Presentation

- Cook's tour

Equipment

Access to the internet or other information sources would be useful for the stoves research.

Useful websites

practicalaction.org/improved-cook-stoves

A review of some improved cooking stoves.

cleancookstoves.org

A campaigning body which promotes clean-burning stoves.

practicalaction.org/solar-cooking-and-health-1

A variety of solar cookers from around the world.

Fuels

Lesson 1: Fuel for cooking

Learning objectives

- Explore the advantages and disadvantages of a variety of possible fuels.
- Understand the significance of carbon in fuels.

Lesson sequence

Fuel facts — 10 mins

Write ‘fuels for cooking’ in the centre of the board. Ask students to list all the things they know about fuels for cooking on a scrap of paper individually for one minute (time them with a stopwatch or similar) and then ask them to share in groups of four for two minutes (time them again - you want this part of the lesson to zip along at quite a pace!). Finally go round the class and ask each group to suggest one thing from their shared lists and add it to the board. Keep going until all ideas have been collected.

Many of your students may have thought of electricity and gas as fuels for cooking. You might want to ask them which fuels they think most people use who do not have access to modern energy supplies use. It is estimated that 3 billion people in the world use traditional fuels such as wood to cook their foods and three-quarters of these cook and heat water using a three-stone fire. This use of wood as fuel means that many people, women in particular spend up to eight hours per day collecting firewood often in areas where fuel wood is increasingly scarce. They also suffer from the indoor pollution caused by burning fuels. The next step of the lesson focuses on investigating fuels and their properties.

Investigating fuels — 25 mins

Review the suggestions on the board and draw out the idea that all fuels have to burn cleanly, be easy to handle, cheap, readily available and give out a good amount of heat. Ask students to suggest some possible fuels for a cooking stove. They are likely to suggest wood, paper, charcoal, gas etc. Explain that they are going to investigate some possible fuels and rank them from best to worst.

Hand out the worksheet *Investigating fuels* and provide safety warnings. In this experiment students will be burning a variety of possible fuels and this can lead to more excitement than is always wise! Emphasise that they should ONLY burn the fuels provided and in the quantities suggested - this is not an opportunity to burn plastic pens or the assorted contents of their backpacks! Plastic particularly should be avoided as it can produce carcinogenic smoke. If some students want to try a fuel that is not on the list they MUST check with you before they start. With some classes, and for some possible fuels, a teacher demonstration might be more appropriate.

Students should then carry out their investigation. The worksheet provides some guidance but students can develop their investigations as they wish within the safety rules given.

Reviewing the data — 10 mins

Review the data from the investigations. Suitable questions to ask include:

- Which fuel seemed to work best? How did you define 'best'?
- Why do you think this fuel burnt so well? Or so badly?
- Did some fuels burn brightly and quickly but others smouldered? How might you explain these differences?
- What is needed for a fuel to burn?

Construct the fire triangle. Introduce the idea of carbon in the fuels, replace 'air' with 'oxygen' and construct a word equation for combustion including the energy outputs.

Differentiation

All students will:

- collect data from a practical activity

Most students will also:

- handle equipment safely and carefully to produce accurate data
- analyse raw data and relate this to their original ideas

A few students will make more progress and:

- use insights from the investigation to see the importance of carbon in fuels

Resources

Worksheets

- Investigating fuels
- Fuels in Uganda

Equipment

- A fuel selection e.g. wooden spills, lumps of wood, paper, cardboard, charcoal, hexamine, fire lighter blocks (cut into smaller stockcube-sized lumps), straw, fat blocks.
- A safety mat is crucial for burning the fuels on. A tin tray is also useful to contain the fuels when they are being burnt.
- An electric balance

SAFETY WARNING

Students should not burn anything that has not been approved by the teacher and should burn only small amounts of material. Suitable ventilation is necessary.

Useful websites

practicalaction.org/briquetting

This looks at how materials can be made into briquettes which makes them easier to burn.

practicalaction.org/biomass-as-a-solid-fuel

Looks at biomass as a fuel.

Lesson 2: Energy output

Learning objectives

- Carry out an experiment to find the energy value of common fuels.
- Design a device to maximise useful heat output from a combustion reaction.

A note about units

The correct SI unit for energy is the joule. However, the old unit, the calorie, is still in very common use as is the term 'calorific value' which many students may be familiar with from diets. Similarly most people will still use the term 'calorimeter'. Opt for joules rather than calories but be aware that confusion caused by this strategy may occur and respond accordingly. The units are easily interconverted using this formula: 4.2J = 1 cal

Lesson sequence

Measuring the output — 10 mins

Show the students the presentation *Processing fuels* comparing fuelwood with charcoal, biogas and biodiesel. What are the advantages and disadvantages of each type of fuel? They all burn - but which makes the 'best' fuel? Draw out the students' understanding that a key issue with any fuel is the energy output when it burns. This is not the same as how brightly it burns.

Ask the students if they think all fuels give out the same amount of heat. They will probably say that different fuels give out different amounts of heat. Ask them how this heat output could be measured. Some will suggest putting a thermometer above (or in) a flame! This will both destroy the thermometer and release toxic vapour (if it is a mercury in glass thermometer) and will only give a measure of the temperature of the flame (if it is a suitable electronic probe) - not how much energy is given out. Energy release depends on *how long* a fuel burns for as well as *how high* a temperature it burns at.

A better way to measure energy output is to absorb the energy given out in a measured time in a body of known mass and measure its temperature rise. Show the outline diagram of the calorimeter or hand out the worksheet *Heat output* and ask students to work on the details before they measure the energy output from some simple fuels. Stress that the diagram acts as a clue - not a complete method.

Investigating energy output — 25 mins

Students should now carry out their investigations of charcoal and wood as fuels. While the worksheet *Heat output* offers support you will probably need to facilitate the investigation with many students. Emphasise issues about quality of the data collected using questions in speech bubbles on the worksheet. Students should engage in this experiment with a higher level of sophistication than the fuels tasks in the previous lesson.

And the winner is... — 10 mins

Collect data on the different fuels from across the class and identify the fuel that gave the greatest energy output. Use this opportunity to identify outliers in the data and quiz these teams about their experimental methods to ensure that all results are reliable and comparable. At the end come up with a league table of fuels with the best at the top.

Differentiation

All students will:

- collect data from a practical activity

Most students will also:

- handle equipment safely and carefully to produce accurate data
- analyse raw data and relate this to their original ideas

A few students will make more progress and:

- use insights from the investigation and discussion to see how a calorimeter produces accurate and reliable results for the energy value of different fuels

Resources

Presentation

- Processing fuels

Worksheets

- Energy output
- The professional calorimeter

Equipment

- An electric balance
- Thermometer -10 to 110^{o}C
- Measuring cylinder 25 cm^{3}
- Stopclocks or stopwatches
- Fuel samples: wooden spills, charcoal sticks

Useful websites

practicalaction.org/videos-energy

A collection of videos that show the importance of energy to people across the world.

Homework suggestions

Use the worksheet *Fuels in Uganda* to explore some of the issues around fuel types.

Smokin!

Lesson 1: Smoke kills!

Learning objectives

- Investigate the smoke output from burning fuels.
- Investigate the efficiency of chimneys.

Lesson sequence

Not just heat — 10 mins

Students will now have an understanding that burning fuels give out heat and an understanding of how this may be measured using a simple calorimeter. Ask them about other outputs from a fire - many will suggest smoke.

Now show the Adam Hart Davis video from 0.00 to 2.40. bit.ly/KdE4xh

Nearly four million people die each year as a result of inhaling the dangerous cocktail of pollutants in smoke from basic kitchen stoves and fires. Most of these deaths are a result of respiratory infections. Each year, close to 4 million people die from diseases caused by smoke from cooking (Lim *et al*, 2012): more than the combined death toll of TB, HIV/AIDS and malaria. It is the fourth largest risk factor to global health, and the second largest for women.

Scientists and technologists can play a key role in helping to develop cleaner cooking fuels, improved cooking stoves and chimneys to divert smoke from homes. All of these improvements can lead to improved life expectancy for people living in fuel poverty.

Ask the groups to list the problems smoke causes in homes and how they think people can avoid these. Write suitable suggestions on the board.

The perfect chimney — 25 mins

Demonstrate a technique for making a simple chimney out of aluminium foil and show how this can be used to model the effect of a chimney flue on a smoking fire. Ask students to explore the design for a chimney to see what factors affect how well it works. They could look at the length or width of the chimney flue, the shape, the distance between the flue opening and the fire etc. Leave the decisions up to the teams of students. Spend some time agreeing how the chimney designs will be scored. There is no easy quantitative measure so the teams' results may not be directly comparable, i.e. if one group looks at flue width and another at flue length the results may not be comparable between the groups. However, each group will be able to distinguish between 'good' and 'bad' designs within their own data set.

This investigation also allows you to encourage students to make observations that are not simply noting numerical results in a table. Ask them to keep notes of how well the different chimneys work and to be careful not to miss any observations because they cannot be easily measured. This is a good opportunity to give students exposure to the usefulness of qualitative and descriptive data.

Reviewing the data — 10 mins

Even given the problems comparing data between teams identified above it should be possible to draw out features of the most successful chimneys. Each team should be able to contribute a feature of a successful design based on their investigations.

Show the rest of the Adam Heart Davis video. bit.ly/KdE4xh Ask students how the introduction of the chimney has affected the people in their homes.

Finally, ask students to suggest why the smoke is 'drawn' up the chimney. Many will suggest it is something to do with convection of heated air but ask them to extend their explanation - why does the chimney cause this drawing whereas open air has less of an effect? Lead them to the notion that as hot air rises up the chimney it creates an area of lower pressure so sucking in fumes and amplifying the effect.

Differentiation

All students will:

- collect data from a practical activity

Most students will also:

- handle equipment safely and carefully to produce accurate data
- analyse raw data and relate this to their original ideas

A few students will make more progress and:

- use insights from the investigation and discussion to identify key features of successful chimney design

Resources

Worksheets

- Smokin!

Equipment

- Aluminium foil
- Metre rules or other way to measure distances
- A smokey fuel (cardboard soaked in paraffin) placed in a metal tray.

Useful websites

practicalaction.org/video-healthy-smoke-hoods-in-nepal

Video clip looking at the benefits of cooker hoods that conduct away smoke.

bit.ly/KdE4xh

The source of the Adam Hart-Davis clip mentioned in the lesson.

Lesson 2: A stove for Isaac

Learning objectives

- Design a stove for Isaac Okello that uses insights from previous lessons.
- Identify good ideas in the designs of others and build on them.
- Identify opportunities for appropriate action for all parties involved.

Lesson sequence

Design brief — 5 mins

Introduce this activity - to use students' growing understanding of the needs of people across the world and their scientific knowledge about heat output from fuels and management of smoke from combustion to produce the next-generation stove design. They will work in teams to do this and can draw on any sources of information they think would be useful including their growing knowledge of existing stoves.You may wish to briefly review your students' learning about stoves so far. Remind them that good stoves:

- Increase the efficiency with which fuels burn. A good ceramic stove can save approximately half the wood used. This reduces the burden of fuel wood collection, especially for women and children.
- Lead to a cleaner cooking environment, reducing the chances of respiratory infections caused by inhaling potentially deadly smoke fumes.
- Reduce environment damage caused by collecting firewood for three-stone fires.

Hand out the worksheet *A stove for Isaac* and explain the rules of the design task.

Designing the stove — 20mins

Students should now designs their stoves in teams. Emphasise that the best designs will use ideas from their investigations and insights gathered from people working across the planet in this area. Encourage teams to add notes to their posters showing their thinking behind their design decisions and warn against concentrating on the look of the stove rather than the way it works. Also, stress that their poster will be the showcase for their design - they should make sure it sells their ideas well.

Planning for action — 20 mins

Give students five minutes to look at the different posters and then five minutes to update their own designs. Then, as a class, review the displays drawing out aspects of each team's work that are generally regarded as useful. Note these on the board.

Now hand out the worksheet *Taking action…* and give students two minutes to identify key actions for each of the listed parties. As a class suggest the most appropriate actions for each group from the suggestions given. Encourage students to generate their own ideas for action rather than agreeing with suggestions made by the teacher or other experts.

Finally, review Sarah's story cleancookstoves.org/resources/multimedia/sarahs-story-kenya.html and ask students to consider whether their responses, as individuals, a team and the whole class, is appropriate. Note that there is no 'correct' response and students may come up with a range of these - but they should all be able to argue that their approach is reasonable and defensible.

Differentiation

All students will:

- produce a poster showcasing the design for a stove

Most students will also:

- identify useful ideas and features of posters from other teams
- offer useful feedback to other teams about their posters

A few students will make more progress and:

- use insights from other teams to improve their stove design

Resources

Worksheets

- A stove for Isaac

Equipment

- Suitable computers and access to the internet.
- Printers may help to output any data collected by students.
- Poster-making kit including large sheets of paper, marker pens, glue or sticky tape.

Useful websites

practicalaction.org/improved-cook-stoves

A review of some improved stove designs form around the world.
cleancookstoves.org/resources/multimedia/sarahs-story-kenya.html

This is the source of Sarah's story.

Homework suggestions

This is the final lesson so no homework suggestions have been created. However, a number of students may have developed an involvement in the topic that could lead to further action. Schools may be able to support this through a range of activities including:

- further study (perhaps in a Science or STEM Club)
- asking visiting speakers from bodies working in this area
- fund-raising - a sale of cookies or food made on a traditional stove can be fun!
- reporting the project through the school website or by contributing to other outlets, e.g. the Young Scientists magazine butrousfoundation.com/ysjournal/