

# Aluminium production and recycling

## Aluminium production and recycling: Teacher notes

This resource is aimed at **key stage 4** students in **science** and **applied / vocational science**.

It allows students to look at:

- Aluminium production from raw materials and recycled waste;
- Compare the two production routes for energy-efficiency and waste production;
- The processes inside the aluminium recycling facility and science-based jobs within the recycling plant.

The activities can be delivered in a variety of ways to fit into a 60 minute lesson, or be extended as required.

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# Aluminium production and recycling

**Activity summary** Detailed teacher notes are provided with each activity.

**Introduction / starter presentation** (5 minutes)

The PowerPoint™ presentation describes some of the properties and uses of aluminium.

It involves a short period for students to suggest the uses of aluminium that they are familiar with. This can be achieved with a whole class question and answer or extended by spending more time working in small groups.

The presentation concludes by looking at the production of aluminium from the raw material, bauxite.

**Recycling loop video** (6 minutes)

Introduce the video as showing another way of producing aluminium, by recycling used drinks cans (also called used beverage cans or abbreviated to UBC).

The video shows the processes involved in the collection of used aluminium cans and its recycling to produce aluminium ingots used in the manufacture of more drinks cans.

**Making aluminium: comparison of recycling aluminium cans and their production from raw materials** (20 minutes)

Students use the worksheets provided to compare aluminium production from the raw materials bauxite and from recycled cans. They identify where energy is required and wastes are produced.

This activity is used later to compare with the recycling of aluminium.

**Optional extension activities**

(10 minutes) Students write a summary of both processes.

(10 minutes) Students use the data cards provided to total the waste and energy for the production of aluminium from bauxite. This can then be represented graphically.

**Roles in the recycling plant** (25 minutes)

This activity shows how science works in a real-life context.

Short audio interviews (2 – 3 minutes) with personnel working in the Novelis recycling plant at Warrington, UK describe the role of the following:

# Aluminium production and recycling

Health and safety officer  
 Production manager  
 Foundry team leader  
 Quality control metallurgist  
 Health, safety and training manager

Directed questions help the students to understand the key points of each interview. A variety of methods of using these interviews is suggested in the detailed activity notes.

## Plenary discussion (5 minutes)

Students compare and discuss the use of energy and the production of waste for the two processes. Summarise why recycling aluminium is better option in terms of energy, cost and waste.

Link discussion with issues on sustainable development such as:

- economically a very viable option;
- does not require the use of precious natural resources;
- creates less waste in the production of the recycled aluminium and reduces the amount of waste going to landfill sites;
- can involve communities in recycling and helps to raise an awareness of the issues.

## Science curriculum links

How science works

Applications of science.

Materials and their properties

Useful products from metal ores and rocks.

Range of industrial and environmental contexts.

Health and safety.

Applied science

Science in the workplace

Making useful products

Working safely

# Aluminium production and recycling

## Resources

The following resources are supplied in this pack or can be downloaded from the Think Cans web site ([www.thinkcans.com](http://www.thinkcans.com))

Introduction (PowerPoint™ presentation).

Recycling loop video.

Activity cards and worksheet for the comparisons of aluminium production from raw materials and recycled waste.

Audio interviews with recycling plant personnel.

Video, interviews and presentations are found on the accompanying media or at the web site: [www.thinkcans.com](http://www.thinkcans.com)

The resource also requires access to:

Computer with Microsoft PowerPoint™, connected to data projector to show introduction presentation

Computer with loudspeakers, connected to a data projector to show the video and listen to audio commentaries.

# Aluminium production and recycling

## Making aluminium - Starter presentation notes

The brief presentation looks at aluminium, its uses, how it is obtained from bauxite and how it can be recycled.

The PowerPoint™ presentation is available in the multimedia files that accompany this pack. It may also be downloaded from [www.thinkcans.com](http://www.thinkcans.com)

Also see [www.thinkcans.com](http://www.thinkcans.com) and [www.novelisrecycling.co.uk](http://www.novelisrecycling.co.uk) for more information.

### Slide

### Notes

#### Making aluminium

Presentation will look quickly at some of the properties of aluminium, its uses, how it is obtained from bauxite and how it can be recycled.

#### Aluminium

Third most common element (7.9% of earth). Occurs in places such as rocks, soils, vegetation. Generally in the form of aluminium silicates, oxides or hydroxides.

Bauxite – rock with high levels of aluminium silicate.

Once extracted from bauxite and processed into aluminium metal it can be recycled without the loss of quality.

#### Properties of aluminium

In 1807, the British scientist Sir Humphrey Davey established the existence of the element aluminium. By 1886, French scientist Henri Sainte-Claire had developed processes for aluminium production.

Very light metal but still strong. Strength is increased further when alloys are made with other metals such as magnesium, manganese and copper.

Aluminium (and alloys) can be cast in moulds to produce a variety of products such as light weight petrol engine blocks. Sheets of aluminium can be rolled to different thicknesses for stamping or forming into many shapes. Drink cans are an example of pressed aluminium.

*Pause the presentation and ask students to think of as many uses of aluminium as they can before proceeding to the next slide.*

# Aluminium production and recycling

## Slide

### Uses of aluminium

## Notes

Aluminium is very versatile. Just some uses are listed on the slide. Basically anything where saving weight has an advantage.

Transport

Wheelchairs and walking frames

Ladders

Building materials (window frames, protective cladding, electrical wiring and lighting)

Food containers and foils

Medicines packaging

Antacid medicines and anti-perspirants and many more.....

### Where does aluminium come from?

More details on this process are available in the class activity.

The mineral bauxite contains large amounts of aluminium silicate. It is mined and converted into alumina (aluminium oxide).

Alumina is smelted to produce aluminium metal that is cast into ingots.

Aluminium ingots can be rolled and formed into cans.

### Recycled aluminium

Image shows the stages in recycling aluminium cans.

Some information about recycling:

- Recycling saves 95% of the energy that would be needed to make aluminium from raw materials.
- It reduces the need for valuable natural resources.
- It reduces waste from mining, processing and the disposal of cans to land fill.

### Recycle or raw materials?

Slide moves activity on to comparing both routes of production.

# Aluminium production and recycling

## Aluminium cans: From raw materials and recycling

### Summary

Students compare the production of aluminium cans from the raw material bauxite and from recycling.

Two templates are provided so that students can identify where energy is used and wastes are produced in both processes.

Plenary discussion to focus on the energy and waste saving for producing aluminium by recycling. Recycling aluminium uses just 5% of the energy when compared to producing aluminium from bauxite.

An extension activity can look quantitatively at the energy and waste in the aluminium from bauxite route.

Homework to produce flow diagrams showing both processes.

### Timing

20 minutes in class with optional extension / homework.

### Activities

Students work in small groups to complete the activities.

1. Using the templates provided, students identify where energy is used and wastes produced during the two processes.

**Resources:** Drinks can production templates.

2. Students summarise the energy and waste for aluminium cans from bauxite or recycled cans.
3. Optional extension activity: use the data cards to calculate the total amounts of carbon dioxide, electricity and waste for 1 tonne of aluminium cans. Oil / petrol / fuel depends on the distances travelled so cannot be calculated. This data may be represented graphically if desired.

Answers are shown in the teacher notes below.

**Resources:** Aluminium from bauxite: data cards 1 and 2.

4. Plenary discussion on the implications of the production of aluminium from raw materials (see teacher notes below).
5. Homework / plenary activity

Produce two flow-diagrams to record both routes of aluminium can production.

More information at the [www.thinkcans.com](http://www.thinkcans.com)

# Aluminium production and recycling

## Teacher info

### Quantities of waste and energy

Total amounts per tonne of drink cans from bauxite:

- Wastes: 3 tonnes from bauxite plus 1 tonne of aluminium to land fill. May also mention red mud slurry waste but no data given as to amount.
- Carbon dioxide: smelting, 9.6tonnes equivalent and alumina 991 kg to give total of 10.59 tonnes CO2 equivalent.
- Electricity used: 15.7 kWh

Note, no data is given for the rolling and pressing process to make the cans from aluminium ingots but this is the same for both routes.

### Plenary discussion

Following the activity, or at the conclusion of the lesson, discuss the implications of the production of aluminium from raw materials.

Look for points including:

- Energy is required to process the mineral ore and alumina. This results in the production of greenhouse gases.
- Recycling aluminium saves 95% of the energy that is needed if source is bauxite.
- Recycling aluminium reduces the use of mineral resources.
- Bauxite processing generates waste (e.g. 'red mud' mineral residues in the production of alumina from bauxite).
- Recycling leads to less waste (from mining process and also less domestic waste to land fill).
- Mines cover large areas of land, use large amounts of natural resources and create wastes.
- Mining employs people. It plays a significant role in the economies of areas such as West Africa, Australia, South America and India.
- Transport of the bauxite, alumina and aluminium around the world generates greenhouse gas emissions.





# Aluminium production and recycling

## Aluminium can from bauxite (1)

You are looking at how aluminium is made from the raw material, bauxite. This is a rock that the aluminium is extracted from.

Follow the stages shown on sheets 1, 2 and 3.





In the columns, put a tick where you think resources are being used or where wastes are being produced.

				
<b>Start</b>	Bauxite is mined from the ground	Ore transported for processing	Bauxite processed into Alumina	Alumina transported to smelting plant
<b>Oil or petrol is used</b>				
<b>Electricity is used</b>				
<b>Carbon dioxide is produced</b>				
<b>Waste is produced</b>				

# Aluminium production and recycling

## Aluminium can from bauxite (2)




Tick the boxes to show where energy is used and waste produced.

				
	Alumina is converted into Aluminium ingots	Ingots transported	Drink cans produced and filled	Canned drinks transported to shops
<b>Oil or petrol is used</b>				
<b>Electricity is used</b>				
<b>Carbon dioxide is produced</b>				
<b>Waste is produced</b>				

# Aluminium production and recycling

## Aluminium can from bauxite (3)

Use the final column to summarise whether you think the process uses a lot of the resource or produces a lot of the waste.

				
	Drinks sold in shops	Drinks consumed and can thrown away	Waste goes to landfill rubbish tip	<b>Summary</b>
<b>Oil or petrol is used</b>				
<b>Electricity is used</b>				
<b>Carbon dioxide is produced</b>				
<b>Waste is produced</b>				





# Aluminium production and recycling

## Aluminium cans from recycled cans (1)

You are looking at how new drinks cans are made from recycled aluminium.

Follow the stages shown on sheets 1, 2 and 3.


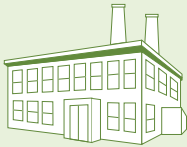

In the columns, put a tick where you think resources are being used or where wastes are being produced.

				
<b>Start</b>	Drinks sold in shops	Empty can is recycled	Cans transported to recycling plant	Aluminium ingots produced
<b>Oil or petrol is used</b>				
<b>Electricity is used</b>				
<b>Carbon dioxide is produced</b>				
<b>Waste is produced</b>				

# Aluminium production and recycling

## Aluminium cans from recycled cans (2)

Use the final column to summarise whether you think the process uses a lot of the resource or produces a lot of the waste.

				<b>Back to start</b>
<b>Start</b>	Ingots transported	Drinks cans produced and filled	Cans transported to be re-sold again	<b>Summary</b>
<b>Oil or petrol is used</b>				
<b>Electricity is used</b>				
<b>Carbon dioxide is produced</b>				
<b>Waste is produced</b>				

# Aluminium production and recycling

## Bauxite mine

Aluminium is the third most common element in the world.

It is found as aluminium hydroxide in deposits of the rock bauxite.

Bauxite mines are found in areas including Australia, West Africa and India



Depending on the quality of the bauxite, it takes an average of 4 tonnes of rock to produce 1 tonne of aluminium metal.

## Alumina production

Bauxite rock is crushed and mixed with sodium hydroxide solution and lime.

A 'red mud' residue is filtered off as a waste.

Alumina (aluminium oxide) precipitates out from the filtered solution.



Making 1 tonne of alumina takes:

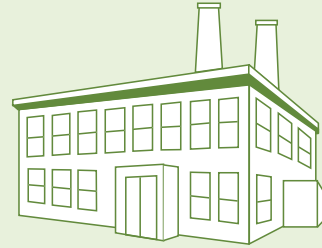
- 75 kg of sodium hydroxide
- 48 kg lime
- Produces the equivalent of 991 kg CO<sub>2</sub>

# Aluminium production and recycling

## Aluminium smelting

Alumina is dissolved in molten sodium aluminium fluoride at 980°C.

A large electric current is passed through the solution. Electrolysis produces aluminium metal which is collected from the bottom of the electrolysis cell.



Making 1 tonne of aluminium takes:

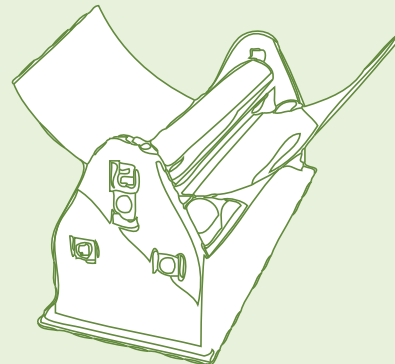
- 15.7 kWh of electricity
- Produces the equivalent of 9.6tonnes CO<sub>2</sub>

## Aluminium rolling and pressing

Ingots of aluminium metal are squeezed between rollers starting at 500°C.

A series of rollers produce a sheet of aluminium that can be less than 1mm thick.

Drinks cans are pressed out of this sheet.



1 tonne of aluminium metal can make over 60,000 drinks cans.

# Aluminium production and recycling

## Audio interviews: Working in a recycling plant

### Summary

Students listen to short interviews with personnel who work in the Novelis aluminium recycling plant.

Each interview lasts 2.5 – 3 minutes and may be re-played.

Accompanying questions are provided to ensure that students pick up on the main points for each job.

The personnel interviewed are:

1. Production manager (plant processes)
2. Shift team leader (foundry activities and safety)
3. Health and safety manager
4. Metallurgist (quality control)
5. Environmental systems manager (environmental responsibilities and regulation)

Activities can be run in several ways:

Whole class listen to interviews together and answer questions on each job. Use the sequence of interviews shown above.

or

Working in groups, each group listens to one interview and then makes a short presentation to the class to describe the role of that person.

or

Independent study, were students access the interviews through the school network, save them to disk or mp3 player and access out of class.

### Timing

25 minutes in class if interviews are listened to as a whole class and notes taken.

20 minutes if presentations are made.

# Aluminium production and recycling

## Resources

There are two versions of the interviews available in the folder on the accompanying media:

An audio commentary and a visual slide show. They will play on a computer / interactive whiteboard connected to loud-speakers. These have the file name xxx\_vid.

Audio-only versions are also given. They may be played on a computer with loud speakers connected or downloaded to students' mp3 players. These have the file name xxx\_mp3.

## Activities

Question cards are supplied at the end of these notes to direct the students whilst listening to each interview.

### Whole class

If only one computer with speakers is available, then the activity can be run with the whole class listening to each interview.

### Separate groups

If students have access to individual computers or mp3 players, divide into groups and each group listens to one interview. Groups then make short presentation to class to describe the role they have just listened to.

### Independent study

The interview files can be saved to a disk, USB pen drive or onto an mp3 player (audio only) so that students can access the interviews whilst out of the classroom.

## Teacher info

Question cards following these teacher notes ask students for information related to each specific interview. Answers are shown listed below.

### Production manager

1. **What responsibilities does the plant manager have?**  
Safety and deliver on commitments to customers – amounts, times and quality.
2. **What types of aluminium waste does the plant recycle?**  
Used drinks cans and general aluminium wastes.

## Aluminium production and recycling

### 3. **What happens to this waste?**

Processes the cans to remove any paints (lacquers), re-melts them and casts into rolling ingots / slabs (25 tonnes).

Other waste is melted down and cast into slabs (10 tonnes).

### 4. **Is there any difference in the quality of the aluminium from recycled waste, compared to from the raw material bauxite?**

No difference in quality from aluminium cans.

Closed loop recycling system

### 5. **What needs to be done so that the processes run smoothly?**

Good maintenance, process control (burners and casting systems working optimally), quality control to test alloys and metal cleanliness. Organisation and planning. Motivate workforce and meet targets.

### **Production shift team leader**

#### 1. **What responsibilities does the shift team leader have?**

Day to day running of the shift.

Health and safety, disciplinary, production, meeting targets.

Meeting with production manager and technical engineers to sort out any problems for the day.

#### 2. **What are the hazards in the foundry? What protective equipment is needed?**

Molten metal is the main hazard.

Fire-proof woollen coats and overalls, boots, visors, gauntlets, glasses, ear plugs (and hard hats). Must be worn at all times.

#### 3. **What type of aluminium is recycled? How is this done?**

General aluminium waste.

Could be ladders, engine blocks etc. Goes into furnace to melt down.

Elements like silicon, manganese, magnesium can be added to meet customer specification.

Impurities are skimmed off, sent out and recycled.

# Aluminium production and recycling

## Health, safety and training manager

1. **What responsibilities do the health, safety and training manager have?**

Day-to-day health and safety on the site.

Vocational training and safety training.

Carry out risk assessments

2. **What is involved in making a risk assessment?**

Look at the hazards associated with a particular task.

Devise a procedure to minimise or eliminate the associated with those hazards.

Monitor that the procedure is being followed.

3. **What are the things done in the foundry to make it as safe as possible?**

Specific legislation for working in a foundry.

Safety clothing.

Woollen clothing treated so that it is fire resistant and so that splashes of molten metal will run off it ('Zirpro wool').

Leather gauntlets.

Footwear made for foundry. High leg boots that are also quick release so that they can be removed quickly if a splash of metal enters the boot.

Hard hat and visor / eye protection.

Hearing protection.

## Metallurgist: quality control

1. **What does the metallurgist do?**

Quality checks for composition and cleanliness checks.

Microscopic examinations.

2. **What is an 'inclusion'?**

Some kind of impurity.

Something that should not be in the metal.

Could have fallen in or been produced during the smelting process.

## Aluminium production and recycling

3. **What damage can be caused if there are too many inclusions in the recycled aluminium?**

Damage to rollers when aluminium is rolled.

4. **How are samples taken to examine the aluminium?**

Samples mounted in acrylic block and polished.

Assessed under the microscope.

5. **What tests does the metallurgist make on the aluminium?**

Optical examination under the microscope to look for inclusions.

Test the chemistry of the alloy using emission spectroscopy. 'Zap' it with electricity and analyse the light given off.

6. **What is one of the most important skills to have as a quality control technician?**

Diligence – being careful. Need to get results right as incorrect quality can cause very expensive damage to customers' machinery (rollers) or need to scrap metal.

### **Environmental systems manager**

1. **What are the responsibilities of an environmental systems manager?**

Monitoring and minimising emissions from the plant. E.g. waste, effluent and emissions to the air.

Try and minimise the amount of waste that is generated and make sure as much as possible of their waste is recycled.

Look to minimise the road traffic in and out of the plant.

2. **What regulations cover the site? Who monitors Novelis?**

Regulation is Integrated Pollution Prevention and Control (IPCC).

This is monitored by the Environment Agency.

3. **What energy does the plant use?**

Natural gas is used in heating processes.

Electricity used in things like conveyors and compressors.

## Aluminium production and recycling

4. **How much energy is used in the recycling of aluminium, when compared to the 'primary industry'? That is aluminium made from the raw material bauxite.**

Recycling uses only about 5% of the energy to make the same amount of aluminium.

# Aluminium production and recycling

## Interview question cards

### Production manager

Listen carefully to the interview.

Answer these questions or cover them in your presentation.

1. What responsibilities does the plant manager have?
2. What types of aluminium waste does the plant recycle?
3. What happens to this waste?
4. Is there any difference in the quality of the aluminium from recycled waste, compared to from the raw material bauxite?
5. What needs to be done so that the processes run smoothly?

### Production shift team leader

Listen carefully to the interview.

Answer these questions or cover them in your presentation.

1. What responsibilities does the shift team leader have?
2. What are the hazards in the foundry? What protective equipment is needed?
3. What type of aluminium is recycled? How is this done?

### Health and safety manager

Listen carefully to the interview.

Answer these questions or cover them in your presentation.

1. What responsibilities do the health, safety and training manager have?
2. What is involved in making a risk assessment?
3. What are the things done in the foundry to make it as safe as possible?

### Metallurgist: quality control

Listen carefully to the interview.

Answer these questions or cover them in your presentation.

1. What does the metallurgist do?
2. What is an 'inclusion'?

## Aluminium production and recycling

3. What damage can be caused if there are too many inclusions in the recycled aluminium?
4. How are samples taken to examine the aluminium?
5. What tests does the metallurgist make on the aluminium?
6. What is one of the most important skills to have as a quality control technician?

### Environmental systems manager

Listen carefully to the interview.

Answer these questions or cover them in your presentation.

1. What are the responsibilities of an environmental systems manager?
2. What regulations cover the site? Who monitors Novelis?
3. What energy does the plant use?
4. How much energy is used in the recycling of aluminium, when compared to the 'primary industry'? That is aluminium made from the raw material bauxite.

# Aluminium production and recycling

## Recycling loop video

Watch the recycling loop video and answer these questions

1. How many drinks cans do we use in the UK each day?
2. How are aluminium cans transported from recycling centres to the recycling plant?
3. How is any steel removed from the shredded aluminium cans in the recycling plant?
4. How hot is the furnace to melt the aluminium?
5. How are impurities removed from the aluminium?
6. What safety clothing do operators in the foundry wear?
7. How heavy are the aluminium ingots made from the molten aluminium? How many are made each day?
8. How much energy does recycling aluminium cans use (when compared to using aluminium from raw materials)?
9. How long could you run a TV for on the energy saved by recycling just one aluminium can?
10. Why is aluminium can recycling called a 'closed loop' system?

## Aluminium production and recycling

### Questions on the recycling loop video

A question sheet is attached below. The questions can be used while the students watch the recycling loop video. Answers are given here for reference.

**1. How many drinks cans do we use in the UK each day?**

13 million.

**2. How are aluminium cans transported from recycling centres to the recycling plant?**

Squashed into bales (approx 300kg per bale) and then transported by road to the recycling plant.

**3. How is any steel removed from the shredded aluminium cans in the recycling plant?**

Removed using an electromagnet. Steel is attracted to the magnet and the aluminium is not.

**4. How hot is the furnace to melt the aluminium?**

Over 7000C.

**5. How are impurities removed from the aluminium?**

Impurities float onto the surface of the molten aluminium and these are then scooped off.

**6. What safety clothing do operators in the foundry wear?**

Safety hats, visors, fire proof clothing – safety suits, gloves and boots.

**7. How heavy are the aluminium ingots made from the molten aluminium? How many are made each day?**

27 tonnes. 12 are made in a day.

**8. How much energy does recycling aluminium cans use (when compared to using aluminium from raw materials)?**

5% of the energy is used. i.e. it saves 95% of the energy that would be needed if the aluminium was obtained from the raw material bauxite.

**9. How long could you run a TV for on the energy saved by recycling just one aluminium can?**

3 hours.

## Aluminium production and recycling

**10. Why is aluminium can recycling called a 'closed loop' system?**

Aluminium is used to make cans which are then recycled to make aluminium, then back into cans and so-on in a loop.