Energy from buried waste:
Landfill gas

Landfill is where we dispose of waste material – by burying it in holes in the ground. These are usually disused stone quarries or clay pits, where clay had been dug for making bricks or pottery. If the waste materials are of organic origin, such as food waste, paper, wood or cloth, then it will gradually break down and generate gases, including methane (CH_4) and carbon dioxide (CO_2). If these are allowed to escape into the atmosphere they will act as greenhouse gases. They can, however, be trapped in the landfill and piped out to burn the methane as a fuel or to be used to generate electricity.

A good example of this is at the former brickworks at Stairfoot, 2 miles from the centre of Barnsley in South Yorkshire.

Stairfoot brickworks. The foreground is landfill in a former clay pit. The dark mound is a vast compost heap and finished bricks are stacked to the left of the picture.

As their clay pits became exhausted, the firm allowed the town council to use the hole to dispose of domestic waste, containing a lot of organic material. This was done carefully, in cells; pipes were laid to collect the gases and the whole mound was covered with impermeable clay.

The clay pit being prepared to receive landfill

As the gases were given off they were piped to the brick kilns and the methane used to bake the clay into bricks. This saved the company about one third of its use of natural gas, which is a fossil fuel.

Bricks emerging from the heat of the kiln

In addition, the brickworks manager invited the local primary school children to plant willow cuttings on top of the landfill mound. Willow grows very quickly and the intention was for the willow trees to be harvested, chipped into small fragments and used to fire the school's boilers.

The clay pit reclaimed after landfill. In the foreground it has been grassed over: in the background willow cuttings have been planted.

Finally, the company asked the local council to bring its garden waste from its parks and flower beds to turn into garden compost on a big scale. Some of the brickyard machinery was not in use all the time and could spend a few minutes each day turning the compost heap as it heated up and destroyed the weed seeds.

The manager explaining the compost making process. He is holding a long temperature probe for testing the heap.

Study the pictures and discuss this project. Then decide which of the activities were releasing

greenhouses gases to the atmosphere. Which were helping to reduce emissions of greenhouse gases in comparison to using fossil fuels? Which were failing to collect the gases from landfill?

Show your suggestions by a tick and a brief comment in the table below:

Activity	Releases carbon	Neutral	Reduces carbon
Bringing waste from the local area to Stairfoot			
Building up the landfill and capping it off			
Decay of organic waste in capped-off landfill			
Trapping of gases and piping them to the kilns			
Burning of landfill methane in the kilns			
Less use of fossil natural gas in the kilns			
Use of willow chips in school boilers			
Making garden compost from organic waste			

……

The back up

Title: Energy from buried waste.

Subtitle: Landfill gas.

Topic: A case study of good practice by an industrial firm to try to reduce its use of fossil fuels and to assist the local community in reducing its carbon footprint.

Age range of pupils: 14 years upwards

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:

- explain how gas generated from landfill can be trapped and used as a source of fuel; explain that methane from landfill is not a fossil fuel, but is a greenhouse gas;
- understand that the use of landfill gas is not entirely carbon-neutral but does cut down on the need for fossil fuels;
- understand that forward-looking industrial firms seek ways of reducing their fuel bills and carbon emissions.

Context:

It is vital that modern technologies are developed not only to manage waste but also to ensure that minimal harmful by-products are allowed to pollute the air or the ground. We must re-cycle as much as possible and mitigate the effects of non-recyclable material.

Suggested answers to the activity table are shown below:

Activity	Releases carbon	Neutral	Reduces carbon
Bringing waste from the local area to Stairfoot	√ *Diesel lorries, although the landfill site is not far from the urban centre*		
Building up the landfill and capping it off	√ *Diesel earthmovers*		
Decay of organic waste in capped-off landfill		√ *Few gases will escape if the landfill is well-managed during construction*	
Trapping of gases and piping them to the kilns		√ *Few gases will escape from the pipework*	
Burning of landfill methane in the kilns	√ *CO_2 is released when methane is burned but is a less potent greenhouse gas than the methane*		
Less use of fossil natural gas in the kilns			√ *Although CO_2 is produced it is less than that from fossil fuels alone*
Use of willow chips in school boilers			√ *Saves on fossil fuel (coal in this case)*
Making garden compost from organic waste			√ *Saves waste going to landfill and thus avoids generation of methane*

Following up the activity: Not all former quarries or brick pits are suitable for landfill. The disused quarry in the photograph below is in attractive moorland in the Peak District near Sheffield. In 1960, Sheffield City Council proposed to use it for landfill, but this was opposed by the Council for the Preservation of Rural England. So a large incinerator was built in the industrial part of the city instead.

Brown Edge Quarry, Ringinglow, near Sheffield.

Suggest the reasons given by the people who were opposed to the plan to use this quarry for landfill (*Possible answers: Heavy traffic bringing in waste, destroying delicate moorland habitat, disturbance to wildlife, smell, noise, water pollution, loss of a geological site for research and education*)
It is just as well that the quarry is still there for geologists to investigate and to educate geology students. Indeed, it features in the Earthlearningidea workshop video, *Any Quarry Guide*! . . . . .
https://www.earthlearningidea.com/Video/V36_Quarry1.html
The full series of 'net zero' Earthlearningideas can be seen on the last page.

Underlying principles:

- Landfill gas typically contains 45% to 60% methane and 40% to 60% carbon dioxide by volume, with small amounts of other compounds.
- Landfill gas reaches peak output about 2 years after completion of the fill and continues to produce gases for about 15 years.
- The gas from one million tonnes of landfill can produce up to 0.78 MW of electricity, or the equivalent in heat.

Thinking skill development:
A pattern develops as pupils work through the process of managing the landfill site. Discussion of the release or reduction of greenhouse gases involves metacognition and will include cognitive conflict as pupils disagree. Applying the process to the real world involves bridging

Resource list:

- these pages on paper or on a screen
- access to the internet

Useful links: 'Energy from burning waste'
https://www.earthlearningidea.com/PDF/376_Net_zero_Energy_waste.pdf

Source: Peter Kennett of the Earthlearningidea team. All photographs by Peter Kennett
This information was as accurate as possible in spring 2021.

The ‘How will the ‘net-zero’ target affect your local area?’ series of Earthlearningideas

Topic			Earthlearningidea title
Introduction			How will the ‘net-zero’ target affect your local area?
Possible mitigation measures	Use alternative energy sources	Solar	Harnessing the power of the Sun
		Wave	Harnessing the power of waves
		Wind	Farming the wind: through onshore and offshore windfarms
		Tidal	Tidal energy
		Nuclear	Nuclear power - harnessing the energy of the atom
		Nuclear waste	Nuclear waste disposal
		Biofuel	Liquid biofuels: keeping our wheels turning into the future
		‘Blue’ hydrogen	Blue hydrogen: the fuel of the future? *Also:* Hydrogen of many colours
		Geothermal – hot rocks	Deep geothermal power from ‘hot dry rocks’: an option in your area?
		Geothermal – flooded mines	A new use for old coal mines
		Hydro – small scale	Small-scale hydroelectric power schemes
		Heat pumps	Heat from the Earth
		Waste – incineration	Energy from burning waste
		Waste – methane	Energy from buried waste
	Stop fuels releasing greenhouse gases	Carbon capture	Capturing carbon?
	Store energy from sources that give irregular energy supplies	Batteries	Nuclear batteries: the future?
		‘Green’ hydrogen	Green hydrogen used to even out renewable energy supplies? *Also* Hydrogen of many colours
		Hydro – storage	Matching supply and demand using stored water
		Compressed gas	Storing gas underground: What can we store? How can we do it? How will it help?
	Provide raw materials for new technologies	Electric vehicles	Electric vehicles: the way to go?
		Insulation	How do I choose the best insulation?
	Remove carbon form the atmosphere	Enhanced weathering	Speeding up nature to trap carbon dioxide
		Tree planting	Let’s plant some trees
Possible adaptation measures		Coastal flooding	How will rising sea level affect our coastlines?
		Inland flooding	Inland flooding: a Sheffield case study
		Landslides	Landslide danger
		Agriculture	The future for global agriculture