



cavendish
nuclear

MY LIFE

as an AGR fuel element



An AGR is an Advanced Gas cooled Reactor and is the UK's second generation of Gas cooled Reactors following the Magnox reactors which have now all ceased operation and are in decommissioning. The significant difference between the reactors is the increase in operating temperatures from 400 Degrees Centigrade to 600 Degrees Centigrade which increases the reactors efficiency.



Delivered by the **YouthVoice**
NETWORK

CHAPTER 1

I am an element

I have been resting for many years so I have decided to tell you about my exciting journey through a power station; along with the help of some of my fuel friends! We have affected your lives without you even knowing!

For now I'm living in a cooling pond, which is like a deep swimming pool, with all my fuel friends, but this is the end of my journey and I need to start at the beginning, so here goes... my life as a fuel element!

So you need to know how I was made first. My body is made up of a special element called uranium.

Uranium is orange in colour and it can only be found deep under the ground, normally in places like Australia and Africa.

Uranium has to be **mined** from deep under the ground and dug out.

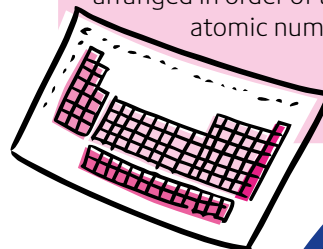


MINED (mining)

This is a process which involves digging up (extracting) materials or minerals of importance to create lots of things.

PERIODIC TABLE

This is the table of elements, it contains chemical elements arranged in order of their atomic number.



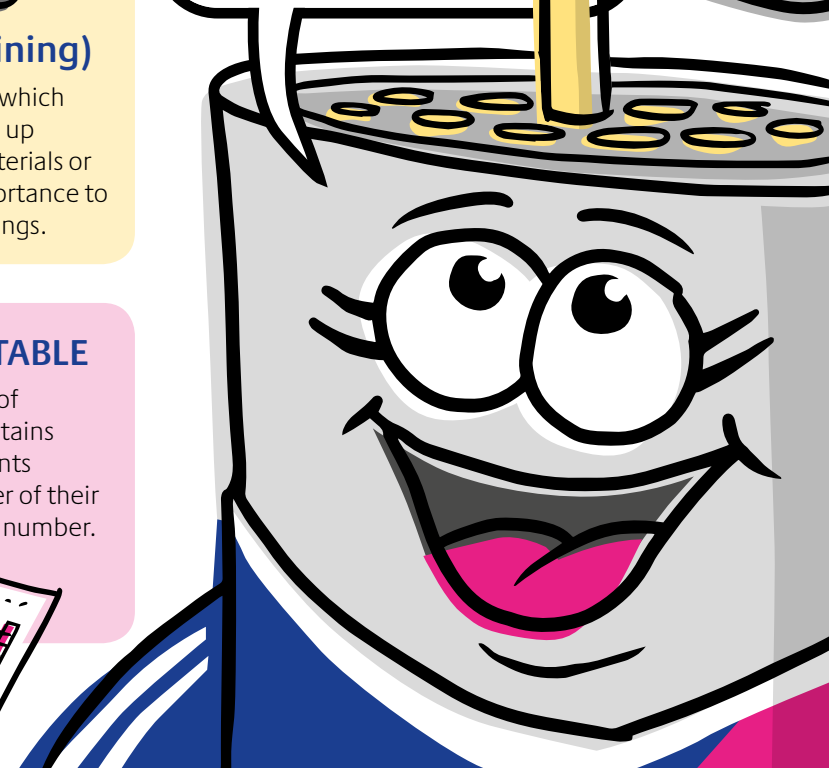
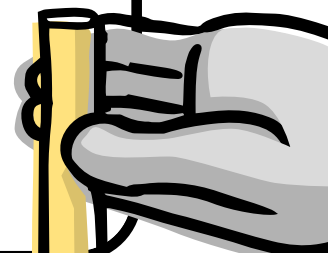
CHAPTER 2

How I am made

But it can't be put straight into my body because it doesn't like to be separated from the other materials it's mixed (lived) with.

So to separate it we have to grind it into a yellow powder called yellow cake.

Uranium is made of 2 isotopes, in the **periodic table** their numbers are 235 and 238, the 235 isotope is the one which is helpful and is put inside me!



CHAPTER 3

What's inside me?

Now that I'm made, I have inside me 36 fuel pins which are filled with uranium 235 **ceramic fuel pellets**. Each one of these fuel pins is clothed with a stainless steel tube; this makes me feel important as it's very shiny. When the **fuel pins** are complete they are connected and I then have an outer graphite sleeve, this is my sports shirt.

Then they write an **identity number** on my shirt, Now I have a name I am a part of the Nuclear Knights, we are a team of fuel rods and are now called a Fuel Assembly made to supply electricity to the world!

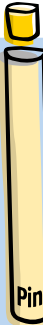
CERAMIC FUEL PELLETS

235

These are the pellets which go in the fuel pins and contain the uranium 235.

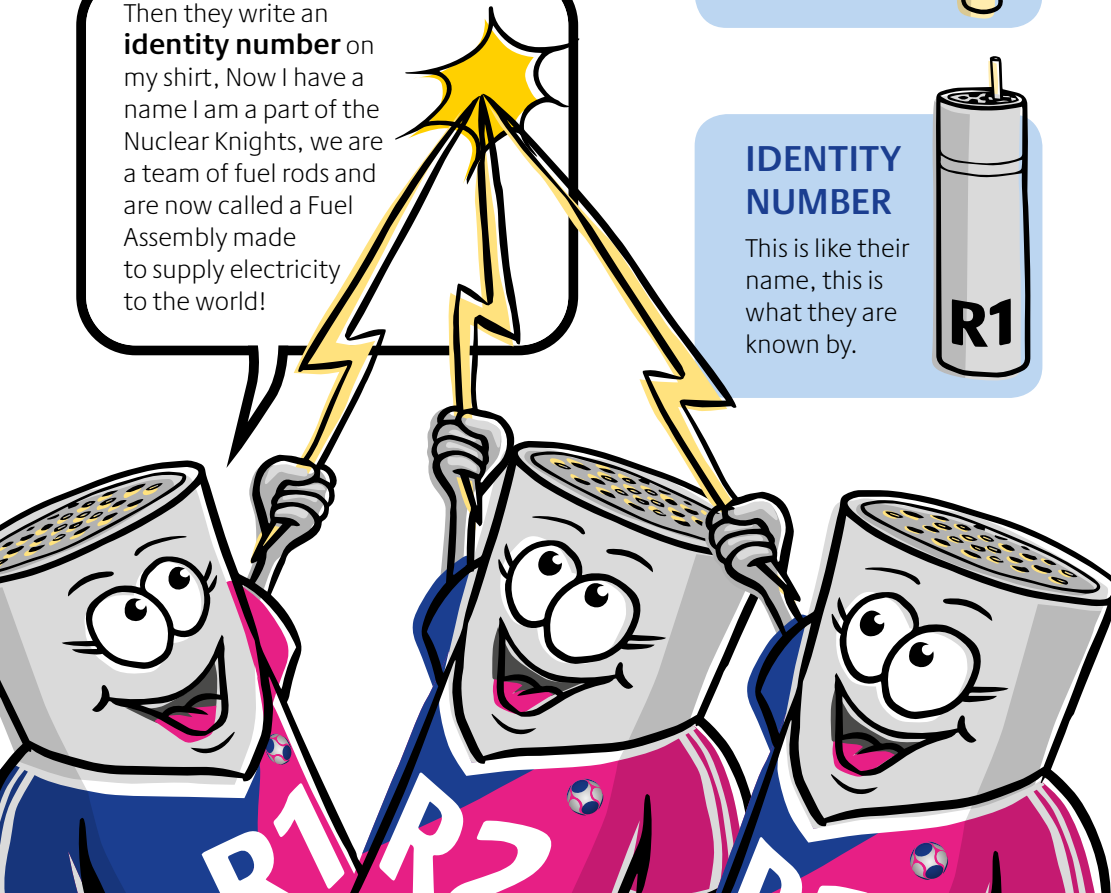
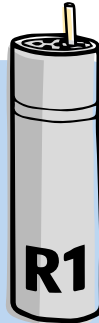
FUEL PINS

These contain the fuel pellets which are used to provide the fuel to the nuclear reactor.



IDENTITY NUMBER

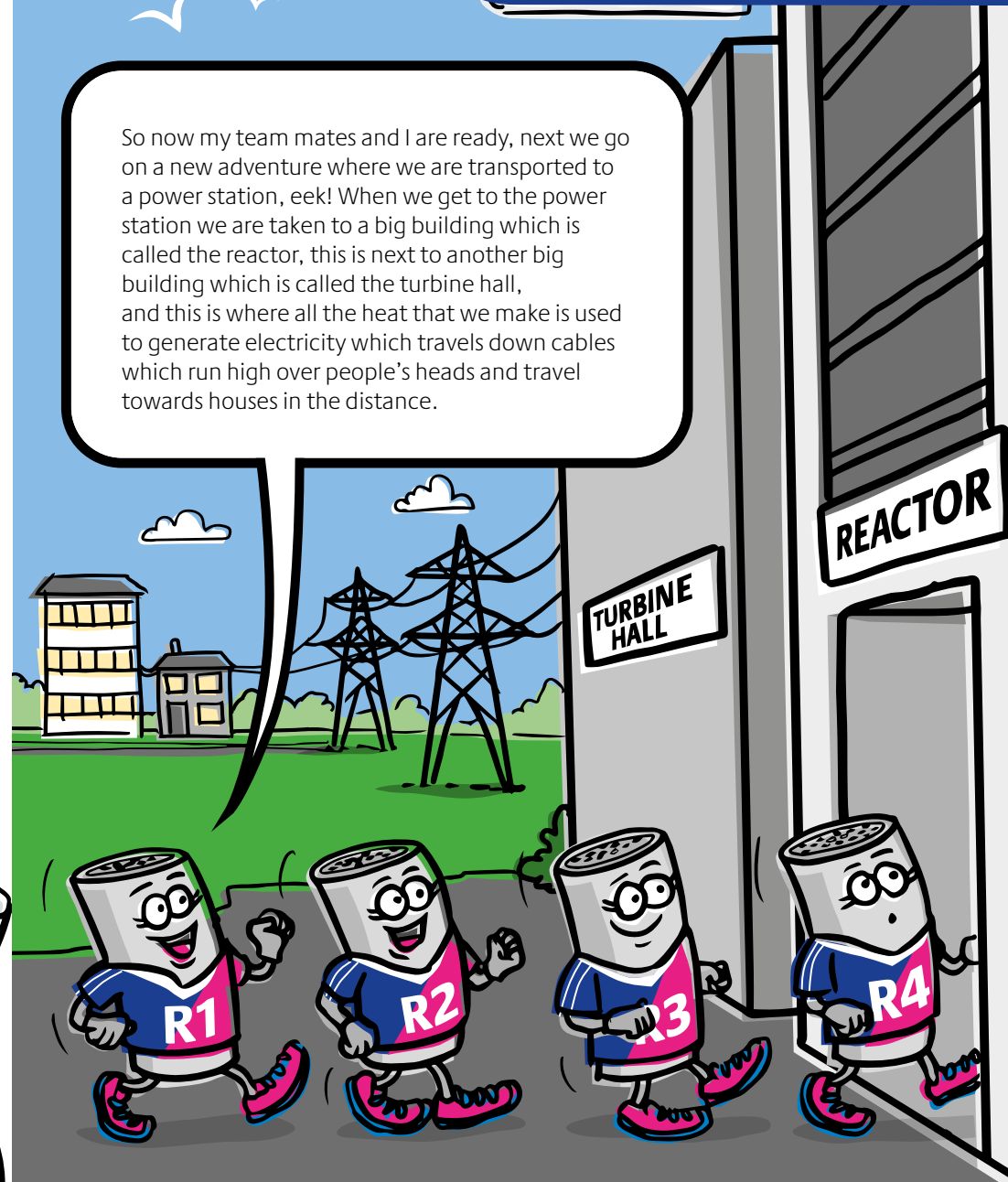
This is like their name, this is what they are known by.



CHAPTER 4

Our journey to a power station

So now my team mates and I are ready, next we go on a new adventure where we are transported to a power station, eek! When we get to the power station we are taken to a big building which is called the reactor, this is next to another big building which is called the turbine hall, and this is where all the heat that we make is used to generate electricity which travels down cables which run high over people's heads and travel towards houses in the distance.



CHAPTER 5

Going inside the reactor

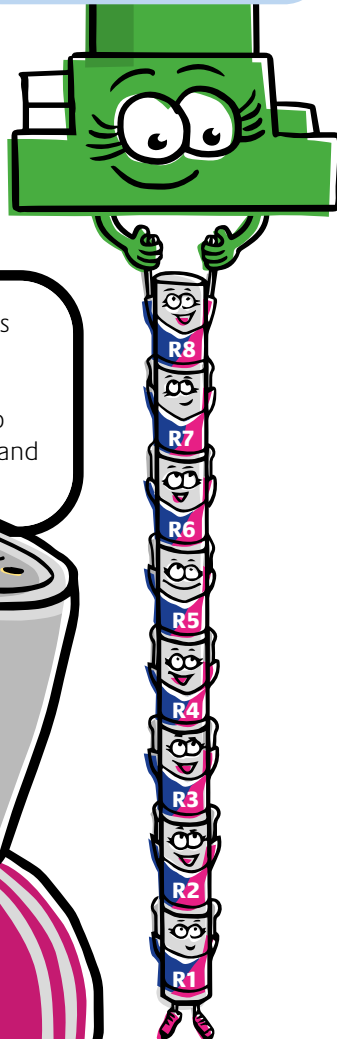
When we are at the power station, my friends and I are checked to make sure we haven't got hurt along the journey. Then I am joined with seven other fuel elements and this is the bigger team I will be playing with to help supply electricity.

We have to then wait for our turn to enter the reactor, the waiting is terrible! We are all eager to start playing the game but we have to wait patiently in the queue because we are going to replace another team who are getting tired.

When it's our time to go, some of my team mates are scared, because they are worried about not being able to produce heat to make electricity. But we meet the **fuelling machine** who has to lower us into the reactor and she is very friendly and she looks after us.

FUELLING MACHINE

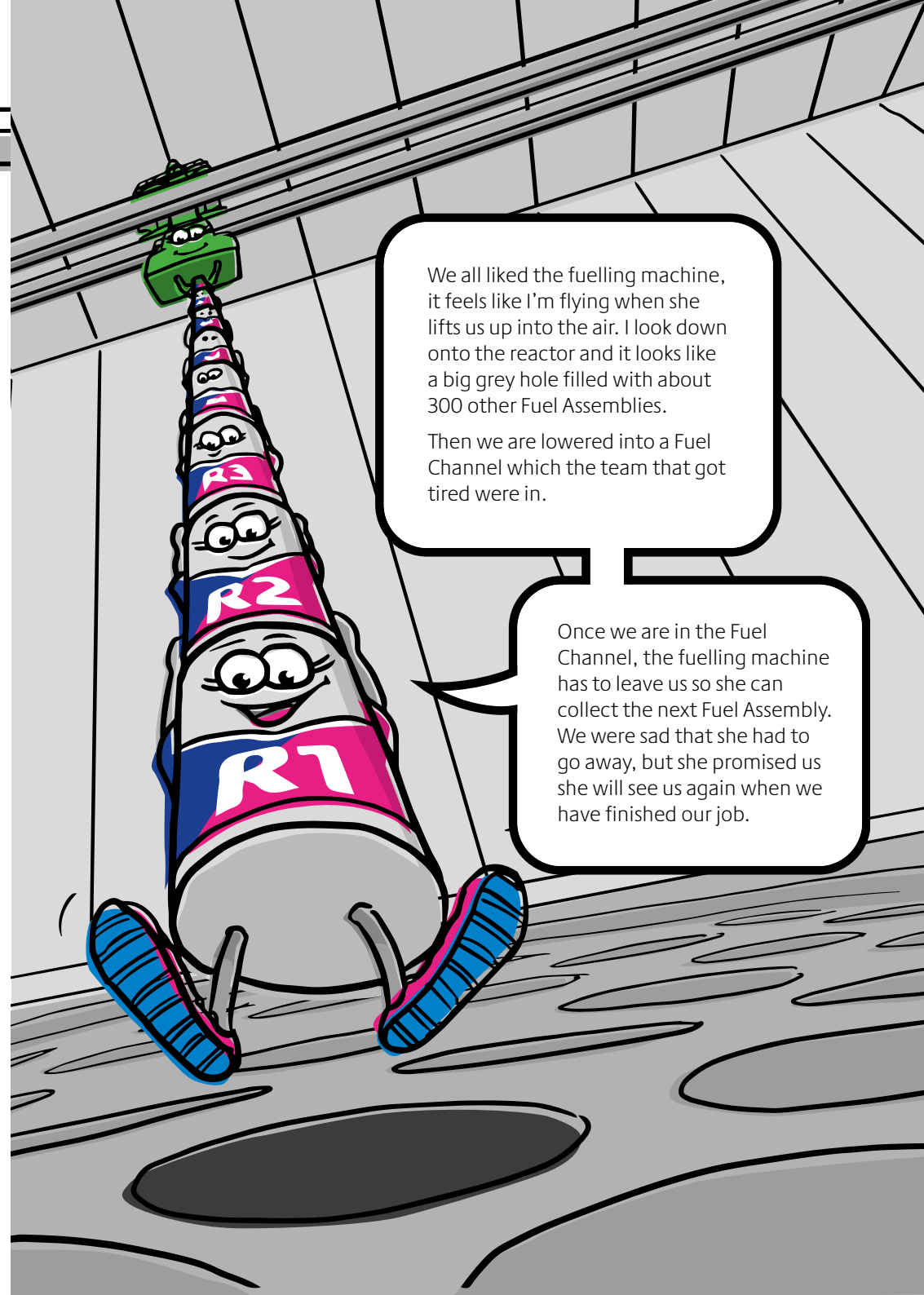
This is an overhead machine which is used to take out the fuel elements and replace them.



We all liked the fuelling machine, it feels like I'm flying when she lifts us up into the air. I look down onto the reactor and it looks like a big grey hole filled with about 300 other Fuel Assemblies.

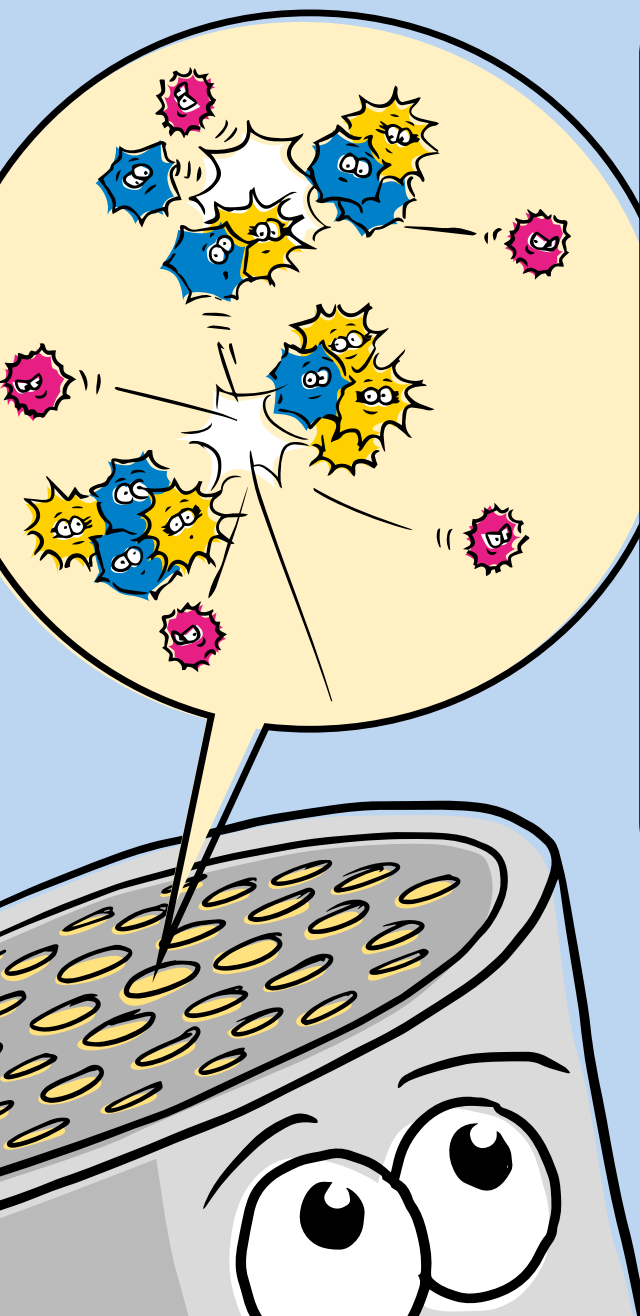
Then we are lowered into a Fuel Channel which the team that got tired were in.

Once we are in the Fuel Channel, the fuelling machine has to leave us so she can collect the next Fuel Assembly. We were sad that she had to go away, but she promised us she will see us again when we have finished our job.



CHAPTER 6

Making energy



Once I get in the reactor my job is half done, I have looked after the uranium inside me so far. Now this is the exciting part of my job.

The uranium 235 which is inside me is made of three things which work together to create energy. These three things are Nippy neutrons, Peggy protons and Eddie electrons.

Inside the uranium they make little groups but some of the nippy neutrons like to whiz around and cause trouble. They try to bump into the groups to break them up, and when the other nippy neutrons see the fun they are having they like to join in and break even more of these groups up!



Nippy neutron



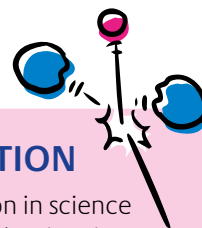
Peggy proton



Eddie electron

REACTION

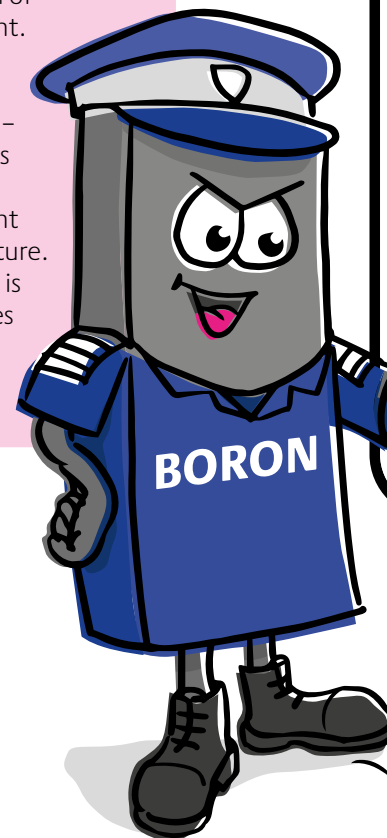
A reaction in science most of the time is chemical. That is where particles collide and this causes chemical changes, however the reaction described here is called fission this is where the particles in the chemicals split.



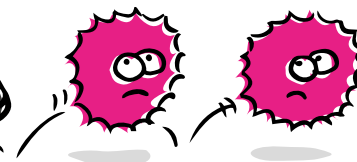
When there are so many nippy neutrons whizzing around causing trouble, it starts to get very hot, it's like I'm on holiday in Spain! This reaction inside of me is helped by large blocks of graphite which slows down the nippy neutrons, it does this so that they collide into each other more as this is the part of the **reaction** where the neutrons collide and join the nucleus of the atoms so they become too heavy and split, this is a reaction. Our job is to keep the temperature in the reactor core at 650 **degrees**.

DEGREES

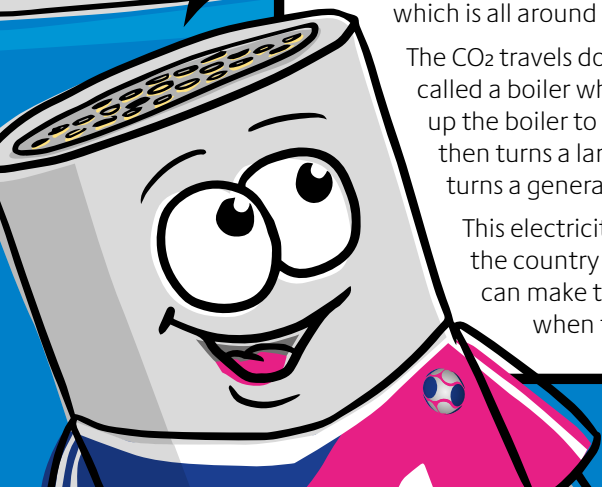
This is a form of measurement. Like on a ruler there is centimetres – well, degrees are the measurement for temperature. 650 degrees is about 3 times the heat of your cooker.



But if the temperature becomes too hot then control rods, which are full of boron, will be lowered into the reactor with us. The naughty neutrons nicknamed him baddie boron because if he has to come into the reactor he tells them off for having too much fun and if some of the neutrons are cheeky they may be taken out to go with baddie boron, normally they behave when he is around so they can stay and have fun!



Electricity for your home



The CO₂ travels down pipes to a large tank of water called a boiler which is like a big kettle; the heat warms up the boiler to produce steam. The steam from this then turns a large wheel called a turbine which then turns a generator which creates electricity.

- 1 Reactor (graphite core)
- 2 Fuel assemblies (approx 300 per reactor)
- 3 Control rods (approx 300 per reactor)
- 4 Gas circulators (CO_2 - 4 per reactor)
- 5 Heat exchangers (boilers - 8 per reactor)
- 6 Steam turbine
- 7 Condensor (returns steam back to water)
- 8 Primary water system pump
- 9 Secondary seawater cooling system
- 10 Seawater pump
- 11 Electricity generator
- 12 Transformer (output 600MW)
- 13 Switchyard (electrical distribution to National Grid)
- 14 Electricity pylon
- 15 Electrical substation
- 16 City
- 17 Inlet
- 18 Sea outlet

This is a gas which is in the periodic table. When we breathe in we are breathing in oxygen which is sent around our body to feed our muscles, when we have finished with the oxygen we breathe out again and the stuff that we breathe out is called carbon dioxide, so there is a lot of it around us but not as much as in a reactor.

The amount of CO₂ in a reactor is 10 Tonnes – this would mean we have to breathe out 10 Million times to get the same amount of CO₂!

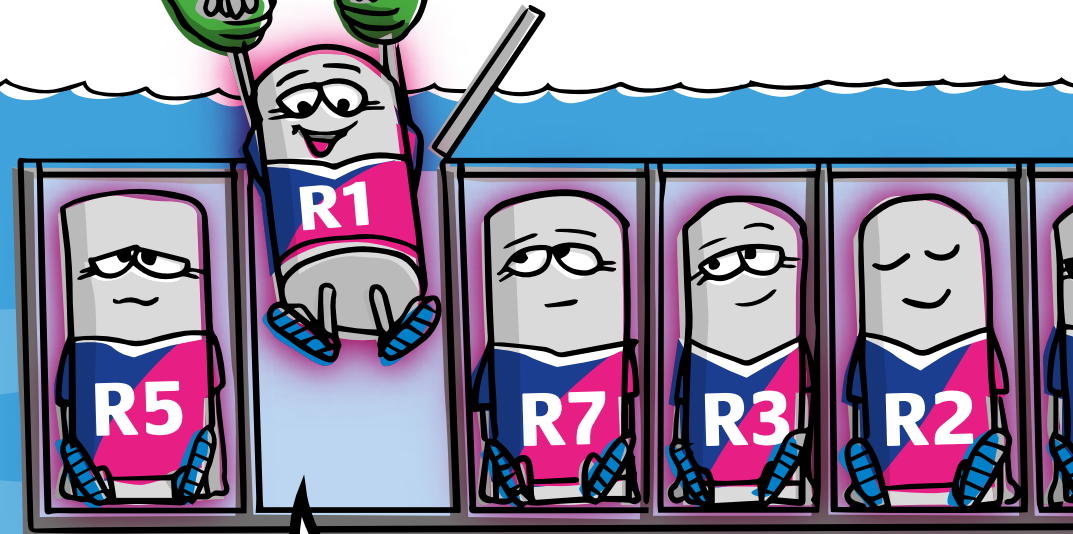
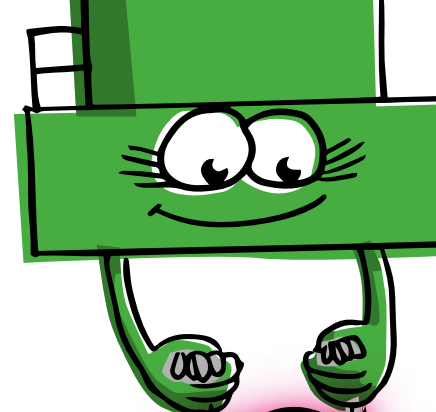
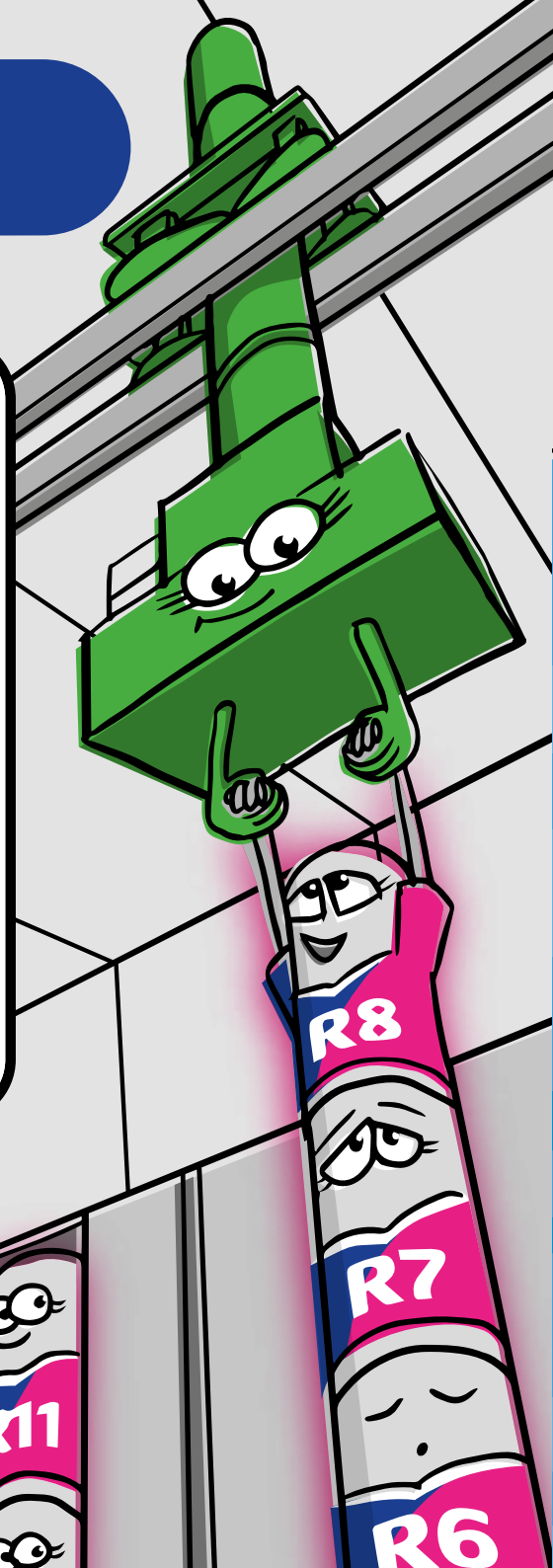
CHAPTER 8

Leaving the reactor

One of the most amazing things about being a fuel rod is that I can provide heat to produce electricity for over 8 years in the reactor!

This takes a lot of my energy though, and eventually, my fuel friends and I feel tired and it is time for us to leave the hot reactor.

It's been a long time since we have seen the fuelling machine and we all shout a welcome to her as she comes to collect us. Excited to tell her about succeeding to produce electricity, she laughs at our boasts as we try to convince her that we must have been the best Fuel Assembly so far.



Because we have been in the reactor and become radioactive, we have to be handled carefully and cannot come into contact with people when we have been removed from the reactor.

The fuelling machine takes us to a large pond where we are left to cool down in the water. After we have cooled down, we leave the pond and the reactor, to be taken to the Long Term Storage Building where my story began.

My fuel friends and I have been here for 50 years now, but it will be many more years for the amount of radiation in our bodies to drop to a safe level and during this time, we still produce large amounts of heat.

CHAPTER 9

Starting all over again?

During my time in the reactor, I provided enough heat to supply electricity to over 500 homes for 8 years, and feel very proud that I have been able to do this without emitting any CO₂ and therefore, have not contributed to global warming or the greenhouse effect.

To pass the time, my fuel friends and I sleep a lot, as we are still very exhausted. After our rest though, we will have the opportunity to be reprocessed, as there is 98% uranium in our bodies that is still useful. Therefore, my fuel friends and I can be recycled and begin our journey again, and again, and again ...

Average House uses: 4,000kWh per year

An AGR with two reactors produces: 1200MW ($1200 \div 2 = 600$)

So each reactor produces 600MW

In a reactor there are 300 Fuel Assemblies with 8 Fuel Elements in each: $300 \times 8 = 2400$

So there are 2400 Elements in each reactor

$600\text{MW} \div 2400 = 0.25\text{MW}$

So each Fuel Element produces 0.25MW per hour

In 1 year there are how many hours?

$365 \text{ (days)} \times 24 \text{ (hours in a day)} = 8760$

If one element produces 0.25MW per hour then:

$0.25\text{MW} \times 8760 = 2190\text{MW}$

Each Element provides 2190MW over 1 year

$2190\text{MW} \div 4000\text{KW} = 547.75$

This means that each Element can provide enough electricity to supply approximately 550 households.

Did you know?

Power stations do not store electricity, so it is constantly being made.

The high voltage electricity (400,000V) is distributed over long distances by pylons and high voltage overhead cables.

The pylons and high voltage lines carry the electricity to a substation.

A substation has transformers that “step down” the high-voltage electricity into medium voltage (12,000V) electricity.

From the substation, distribution lines carry the medium voltage electricity to other transformers on utility poles or on the ground that reduce the electricity to low voltage (240V) so it can be used in homes, offices, stores and factories.

The amount of electricity in the lines must be kept at a constant electrical pressure to provide enough power for the appliances and equipment that will use it.

From the meter box, wires run through the walls in the house to outlets and lights. The electricity is always waiting in the wires to be used.

A cable then carries the electricity from the distribution wires to the house through a meter box. The meter measures how much electricity the people in the house use.

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