RESEARCH REACTORS EXPLAINED

# One reactor, many jobs

REPUBLIC OF KENYA

NuPEA NUCLEAR POWER & ENERGY AGENCY

A research reactor is a source of neutrons: tiny particles that doctors, scientists and industry put to work. It is built for research and services, not for generating electricity.

## Three ways it is used

1

### Teach people

Students, professionals and the public learn here. Any research reactor can do this.

2

### Put materials in

Items placed inside become medical isotopes, get analysed or are improved.

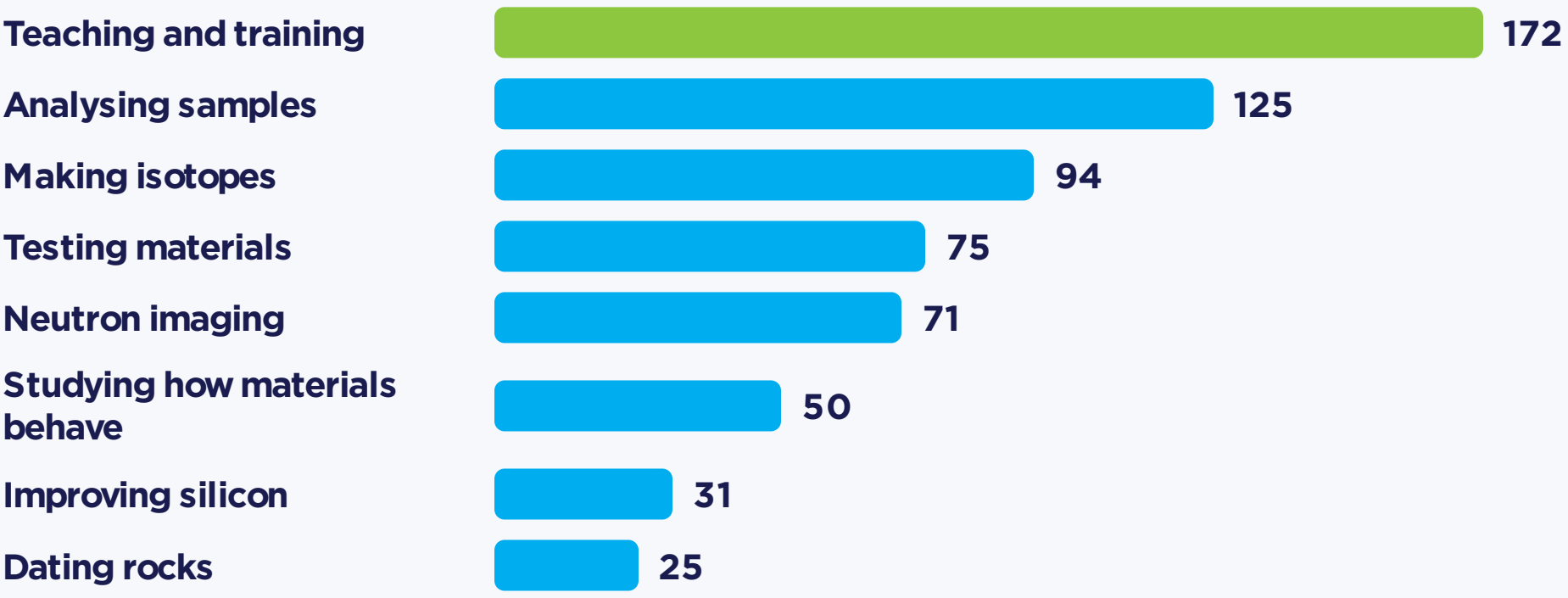
3

### Send beams out

Beams of neutrons leave the reactor to look deep inside objects and materials.

## What the world's research reactors do

Number of reactors offering each use, out of 273 surveyed



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# The reactor behind the hospital scan

Research reactors make radioisotopes: short-lived materials doctors use to see inside the body and to treat diseases such as cancer.

**80%** of nuclear medicine diagnostic scans use **technetium-99m**. Its source, molybdenum-99, is made in research reactors and loses half its strength in under three days, so supply must be steady.

## From reactor to patient

1. **Prepare** — Target material is sealed in a capsule.
2. **Irradiate** — Neutrons in the reactor change some of its atoms.
3. **Process** — The isotope is separated in shielded rooms.
4. **Check** — Purity and strength are tested.
5. **Deliver** — Shielded packages go to hospitals.

## What doctors use them for

| | |
|---|---|
| **Technetium-99m** Scans for cancer and heart disease | **Iodine-131** Treating thyroid cancer |
| **Iridium-192** Radiotherapy placed close to a tumour | **Lutetium-177** Treating solid tumours |
| **Iodine-125** Treating prostate cancer | **Samarium-153** Easing bone pain caused by cancer |

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# A classroom like no other

Every working research reactor, whatever its size, can be used for education and training.

**172** of 273 research reactors surveyed, in **54 countries**, are used for teaching and training. It is the most common use of all.

## Who learns at a research reactor

| | | |
|---|---|---|
| 1 | **The public and schools** | Tours, talks and simple hands-on experiments that spark interest in science. |
| 2 | **Science students** | Biology, chemistry, geology, physics and medicine students run real experiments. |
| 3 | **Radiation safety trainees** | Learn to measure radiation and to work with it safely. |
| 4 | **Nuclear engineers and future operators** | See how a reactor is started, controlled and shut down, with hands-on practice. |

### For countries starting a nuclear programme

Courses of six to eight weeks can cover safety rules, radiation protection, waste management, emergency procedures and public information.

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# Neutrons at work in industry

Research reactors help make better electronics, check that structures are sound and keep instruments accurate.

SILICON DOPING

## Better power electronics

Neutrons change a few silicon atoms into phosphorus, very evenly. Used in hybrid cars, solar and wind power.

NEUTRON IMAGING

## Seeing inside machines

Neutrons pass through metal but show up water, oil and plastic, revealing engines and fuel cells at work.

WELD INSPECTION

## Checking joints are sound

Iridium-192 made in reactors is used to radiograph welds, showing hidden flaws without cutting the metal.

INDUSTRIAL ISOTOPES

## Sterilising and measuring

Cobalt-60 sterilises products. Cobalt-60 and caesium-137 power gauges that measure and control production.

CALIBRATION

## Instruments you can trust

Almost any research reactor can test and calibrate radiation instruments, so their readings are accurate.

MATERIALS TESTING

## Knowing how materials age

Steel, electronics and other materials are exposed to radiation to learn how they will last in service.

**31** research reactors in 20 countries were doping silicon in 2013, a service that can earn a reactor direct income.

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# The detective that reads atoms

Neutron activation analysis reveals exactly which elements are in a sample, even in tiny traces.

## How it works

1. A small sample, such as soil, rock, food or hair, goes into the reactor.
2. Neutrons make its atoms give off their own radiation signals.
3. Each element has a unique signal, so detectors show what is there and how much.

**50 to 60**
elements can be measured in a single sample

**125**
research reactors in 54 countries offer it

**Intact**
samples can be tested without destroying them

## Who uses it

- Mining and geology
- Agriculture
- Forensic science
- Medical centres
- Government agencies
- Universities

### Reading the Earth's clock

Research reactors also help date rocks, from 2,000 years old to 4.6 billion years, the age of the Earth.