# Power Stations

## Nuclear power stations

# Introduction

- A **nuclear power plant** is a thermal power station in which the heat source is a nuclear reactor.
- The heat is used to generate steam which drives a steam turbine connected to a generator which produces electricity.
- As of 16 January 2013, the IAEA report there are 439 nuclear power reactors in operation operating in 31 countries.
- Nuclear power plants are usually considered to be base load stations, since fuel is a small part of the cost of production.

# History

- Electricity was generated by a nuclear reactor for the first time ever 1951, EBR-I experimental station near Arco, Idaho in the United States.
- 1954, the world's first nuclear power plant to generate electricity for a power grid started operations at Obninsk, USSR.
- The world's first full scale power station, Calder Hall in England opened 1956.

# Systems

- The conversion to electrical energy takes place indirectly, as in conventional thermal power plants.
- The heat is produced by fission in a nuclear reactor (a light water reactor). Directly or indirectly, water vapor (steam) is produced.
- The pressurized steam is then fed to a multi-stage steam turbine.
- After the steam turbine has expanded and partially condensed the steam, the remaining vapor is condensed in a condenser.
- The condenser is a heat exchanger which is connected to a secondary side such as a river or a cooling tower.
- The water is then pumped back into the nuclear reactor and the cycle begins again. The water-steam cycle corresponds to the Rankine cycle.

# Nuclear reactors

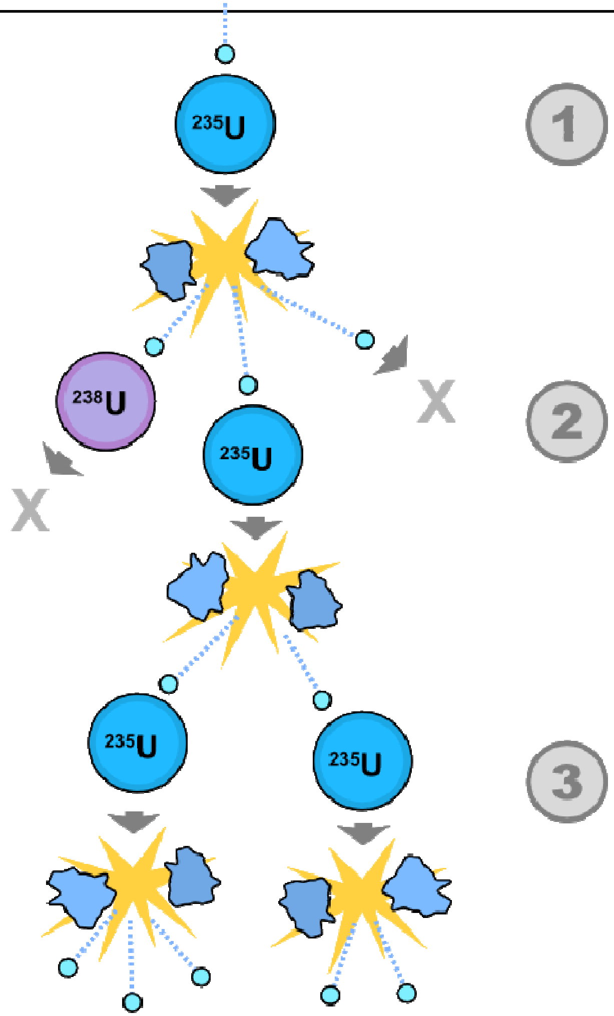
- A device to initiate and control a sustained nuclear chain reaction.
- It is the heart of the plant. In its central part, the reactor core's heat is generated by controlled nuclear fission.
- With this heat, a coolant is heated as it is pumped through the reactor and thereby removes the energy from the reactor.
- Heat from nuclear fission is used to raise steam, which runs through turbines, which in turn powers electrical generators.
- Since nuclear fission creates radioactivity, the reactor core is surrounded by a protective shield. This containment absorbs radiation and prevents radioactive material from being released into the environment.
- Reactors are equipped with a dome of concrete to protect the reactor against both internal casualties and external impacts.
- In nuclear power plants, different types of reactors, nuclear fuels, and cooling circuits and moderators are used.

# Nuclear chain reaction

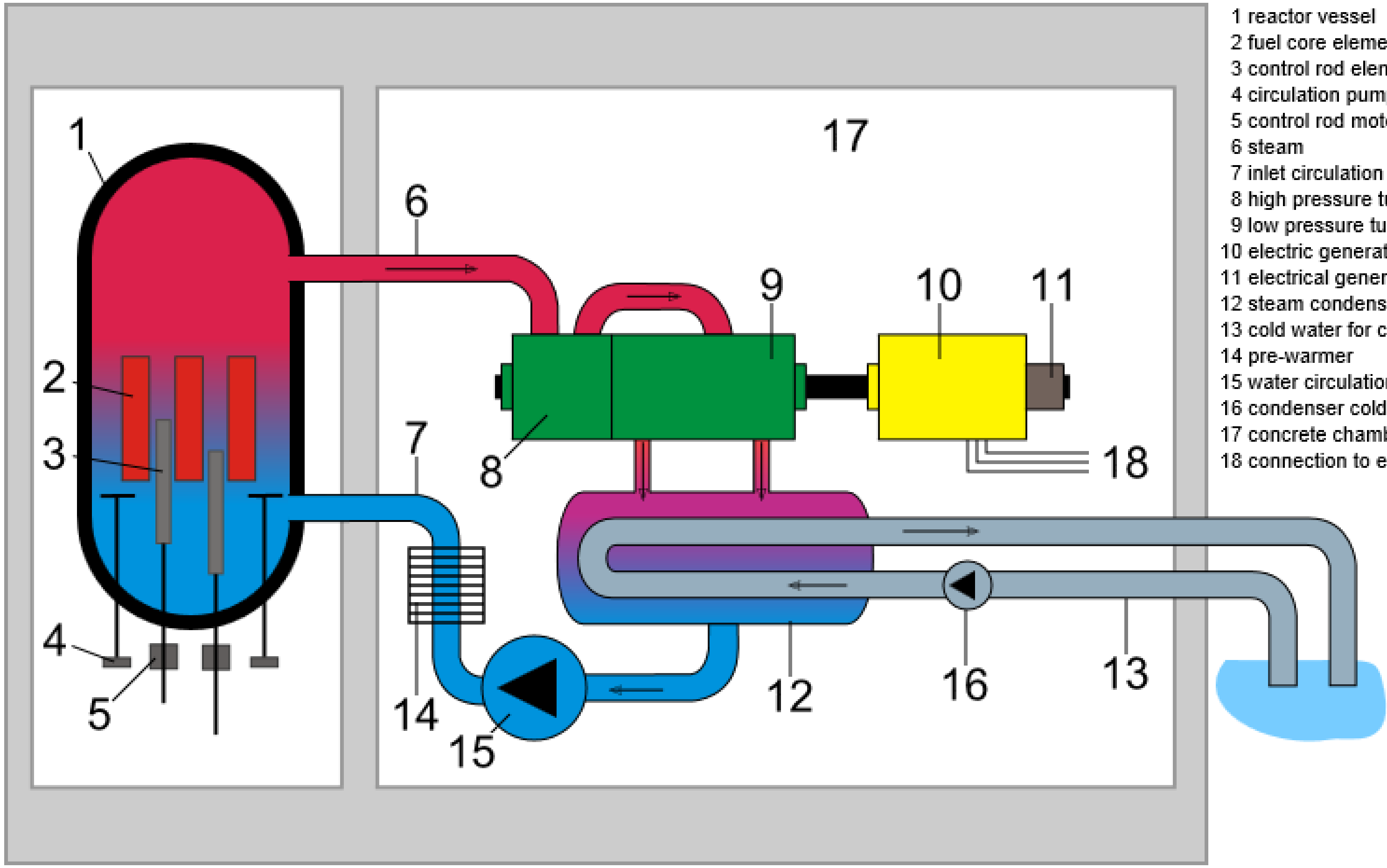
- A **nuclear chain reaction** occurs when one nuclear reaction causes an average of one or more nuclear reactions, thus leading to a self-propagating series of these reactions. The specific nuclear reaction may be the fission of heavy isotopes (e.g. $^{235}U$). The nuclear chain reaction releases several million times more energy per reaction than any chemical reaction.
- Fission chain reactions occur because of interactions between neutrons and fissile isotopes (such as $^{235}U$).
- It requires both the release of neutrons from fissile isotopes undergoing nuclear fission and the subsequent absorption of some of these neutrons in fissile isotopes.
- When an atom undergoes nuclear fission, a few neutrons (the exact number depends on several factors) are ejected from the reaction.
- These free neutrons will then interact with the surrounding medium, and if more fissile fuel is present, some may be absorbed and cause more fissions. Thus, the cycle repeats to give a reaction that is self-sustaining.
- Nuclear power plants operate by precisely controlling the rate at which nuclear reactions occur, and that control is maintained through the use of several redundant layers of safety measures. Moreover, the materials in a nuclear reactor core and the uranium enrichment level make a nuclear explosion impossible, even if all safety measures failed.

# A possible nuclear fission

- 1. A uranium-235 atom absorbs a neutron, and fissions into two new atoms (fission fragments), releasing three new neutrons and a large amount of binding energy.
- 2. One of those neutrons is absorbed by an atom of uranium-238, and does not continue the reaction. Another neutron leaves the system without being absorbed. However, one neutron does collide with an atom of uranium-235, which then fissions and releases two neutrons and more binding energy.
- 3. Both of those neutrons collide with uranium-235 atoms, each of which fissions and releases a few neutrons, which can then continue the reaction.



# Boiling water reactor




1 reactor vessel
2 fuel core element
3 control rod element
4 circulation pumps
5 control rod motors
6 steam
7 inlet circulation water
8 high pressure turbine
9 low pressure turbine
10 electric generator
11 electrical generator exciter
12 steam condenser
13 cold water for condenser
14 pre-warmer
15 water circulation pump
16 condenser cold water pump
17 concrete chamber
18 connection to electricity grid

# Pressurized Water Reactor