

Chapter 6 • Basics of Energy Generation

Technical & Professional Knowledge for NICL AO 2026 Risk Engineer

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This independent learning chapter follows the FINAL Chapter 6 plan. It teaches plant arrangements and accounting boundaries; it is not an operating manual. The practice questions are original preparation material, not NICL questions.

Chapter opener

What this chapter covers

Electricity can come from a steam turbine, a gas turbine, an engine, moving water, wind, a photovoltaic array or a fuel-cell system. Their equipment looks different, but a useful first question is the same: **what enters, what is converted, and what leaves?** A heat source is not necessarily the component that supplies shaft work. A generator is not the equipment that produces steam. Some of the output is used inside the plant before the remainder reaches its export connection.

We begin with boilers because their tubes, fittings and heat-recovery equipment form the entrance to a steam station. We then trace Rankine and Brayton arrangements, combine their heat paths, and compare diesel and fuel-cell systems. Hydro and pumped storage introduce water routes and storage accounting. Nuclear, solar, wind and other renewable plants are recognised through their component roles rather than through advanced physics. The final unit brings these routes together using station efficiency, heat rate and three different demand or utilisation factors.

Why this chapter matters. A risk engineer must recognise what a piece of equipment does before interpreting a failure or a plant description. A blocked water route, a missing cooling service and an unavailable reserve unit are different conditions. Here the aim is to read the arrangement accurately, recognise a common misconception and make a short calculation with the correct boundary.

Learning objectives

By the end of the chapter, you should be able to:

1. Distinguish fire-tube and water-tube boilers and explain the functions of their mountings and accessories.
2. Trace a Rankine steam plant and deduct pump work when finding its net cycle output.
3. Trace a Brayton gas plant, recognise exhaust-heat recovery and deduct compressor work.
4. Identify the principal connections and supporting services of diesel and fuel-cell generating plants.
5. Recognise hydro plant parts, interpret head classes and account for a pumped-storage round trip.
6. Explain the nuclear generation chain and distinguish reactor component roles and PWR, BWR and PHWR routes.
7. Explain PV and solar-thermal generation, wind arrangements and the principal other-renewable routes.
8. Find station efficiency and heat rate on compatible fuel and electrical boundaries.
9. Distinguish load, capacity and diversity factors and recognise base duty, peak duty and reserve arrangements.

Topic map and examination use

Read Units 6.1–6.4 as heat or fuel conversion arrangements; Units 6.5–6.9 as water, nuclear, sunlight, wind and other source routes; and Unit 6.10 as the accounting layer that applies to the

whole station. The revision kit collects the relationships after the teaching. Practice Sets A–J contain 90 conceptual questions, followed by Set K's ten short numericals. The explained answer key is at the end, so an answer is not disclosed beside its question.

The supplied NICL examination notice describes a specialist test of 50 questions for 50 marks in 35 minutes and a one-quarter-mark penalty for a wrong answer. The practice here uses five options. For a question scored +1 for a correct answer, –0.25 for an incorrect answer and 0 if left unanswered, the expected mark from answering is $p - 0.25(1 - p)$, where p is the probability of being correct. Break-even is $p = 0.20$. Eliminating one, two or three options leaves expected gains of about 0.063, 0.167 or 0.375 respectively if the remaining options are equally likely. This is a decision aid, not a promise of a particular result. Practise the numericals without a calculator and learn to identify the required plant-specific step first.

Reading and calculation conventions

Core passages support the practice. The single **Optional enrichment** box on the ideal Brayton pressure-ratio expression is not tested. Symbols are defined beside their relationships; η is an efficiency fraction unless a percentage is explicitly requested. P denotes power and E energy. Positive turbine output and positive pump or compressor input are magnitudes, so net work requires a subtraction. Use the same mass, time and measurement boundary before combining quantities. All teaching data are hypothetical, with no national capacity, tariff, regulatory set point or radiation dose to memorise. Sketches are schematic, not construction drawings.

6.1 Boilers: types, mountings and accessories

In a nutshell. A boiler transfers heat to water to produce steam. Tube contents classify the two basic types. Mountings serve essential control or protection; accessories support steam production or recover heat.

6.1.1 Boiler types and fluid paths

A **boiler** is equipment in which water receives heat and becomes steam for a process or a power plant. A fired boiler receives heat from fuel burning in its furnace. The hot combustion products are called **flue gas**. The gas and the water normally occupy separate spaces, with heat crossing the metal between them. Do not read a heat arrow as a pipe that mixes these two fluids.

In a **fire-tube boiler**, the flue gas travels inside tubes and water surrounds their outer surfaces. Follow the gas through a tube to the outlet; then identify the water outside that tube. Steam collects above the water in the shell. The word *fire* tells you which stream occupies the tubes. It does not mean that the water itself is burning.

In a **water-tube boiler**, water or a water/steam mixture travels inside the tubes. The hot gas heats them from outside. A drum can separate and collect steam while water circulates through the heated tubes. The drum is a water/steam component, not a chamber into which the flue gas must flow. Detailed circulation design and pressure ratings are beyond this chapter.

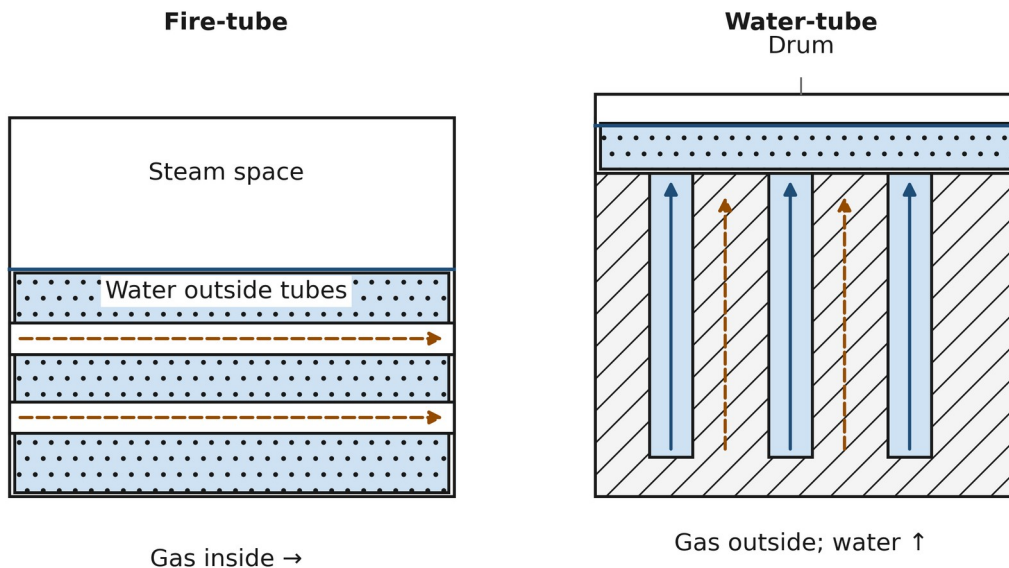
These are distinctions of **fluid placement**, not universal rankings of safety, efficiency or plant capacity. Actual performance depends on the boiler design and operating condition. A question asking which fluid is in a tube can be answered without memorising the dimensions or output of a named boiler.

Key relationship. Fire-tube: gas inside, water outside. Water-tube: water/steam inside, gas outside.

Why this matters. Reversing the two paths reverses the basic identification even if the rest of the equipment labels are correct.

Type	Inside the heated tubes	Outside the heated tubes
Fire-tube	Hot combustion gas	Water in the shell
Water-tube	Water or water/steam mixture	Hot combustion gas

Table 6.1 • Boiler types and fluid paths



Schematic; not to scale. Labels and line styles identify the routes.

Figure 6.1 • Fire-tube and water-tube boilers

6.1.2 Mountings and their protective or operating functions

In the usual textbook grouping, **mountings** are fittings used for essential boiler control or safe operation. They are fitted on the boiler or its immediate connections. An **accessory** has a supporting or performance-improving role. These labels do not mean an accessory can be casually removed from a working plant: a feed pump, for instance, can be essential to a particular installation while remaining in the textbook accessory list.

A **pressure gauge** indicates pressure. A **water-level indicator** communicates with the connected boiler or drum and shows its water level. The instrument must have the relevant connections for the indication to mean anything. Neither reading is itself a release of steam. An operator can observe a gauge without the gauge carrying out the protective action of a valve.

The **safety valve** opens automatically to release steam when pressure becomes excessive. Its automatic pressure-relief role distinguishes it from a manually operated steam outlet valve. This chapter gives no opening pressure, setting procedure or regulatory value. A **steam stop valve** is on the steam outlet; it controls flow or isolates the boiler from that steam line. Closing an outlet is not the safety valve's pressure-relieving action.

A **blowdown connection** discharges some boiler water and its concentrated material. Evaporation removes water as steam while many dissolved or suspended materials remain behind; blowdown provides a discharge route. Earlier chemistry explains deposits and water treatment. Here the target is the fitting's location and discharge function, not chemical causes or treatment reactions.