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THE OHIO STATE UNIVERSITY

Overview of iPWR – SWR Simulator

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The simulator represents a **150 MW(th) / 45 MW(e) integral PWR** and includes natural/forced circulation plus passive systems such as

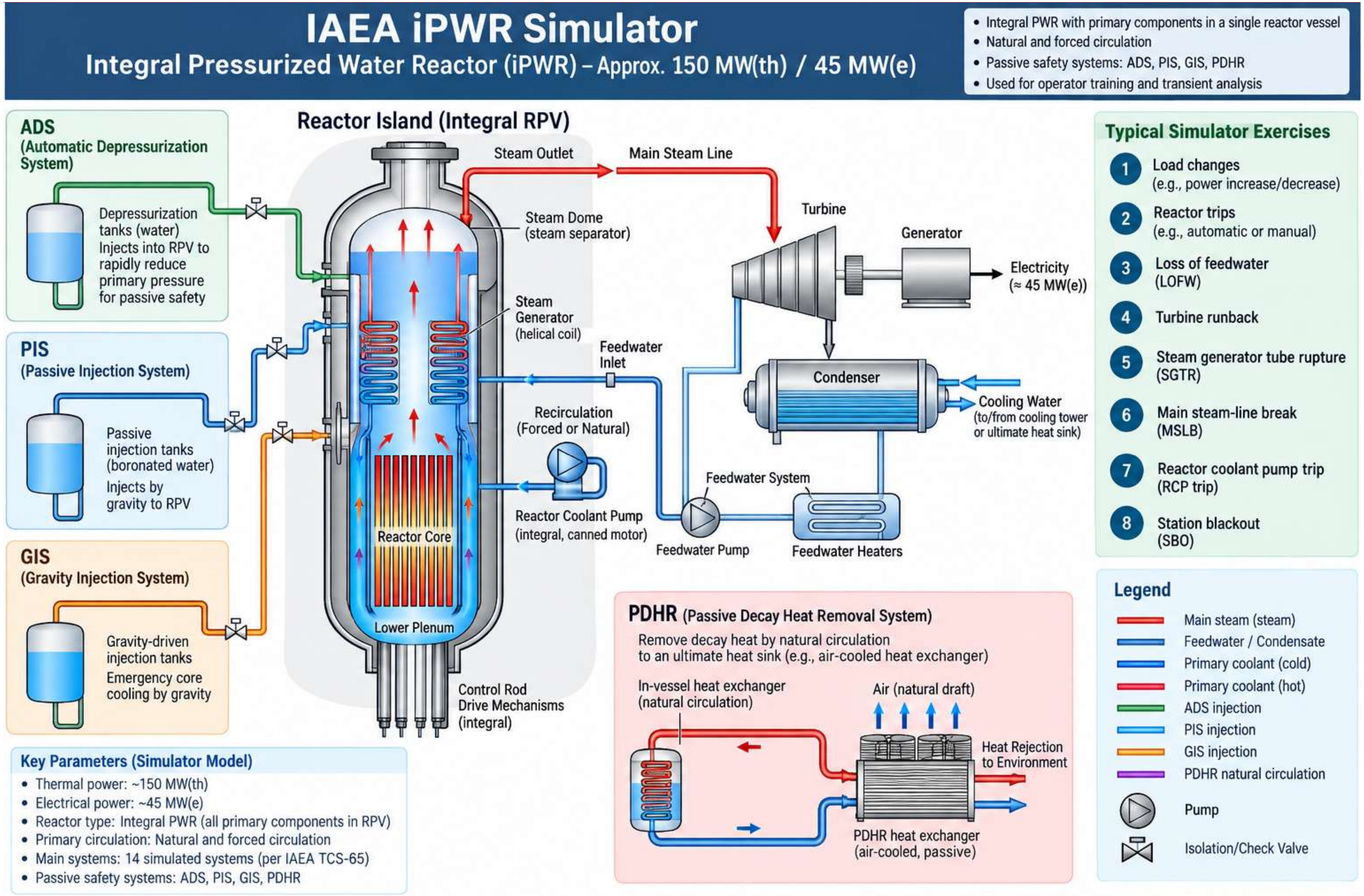
ADS — Automatic Depressurization System
PIS — Passive Injection System
GIS — Gravity Injection System
PDHR — Passive Decay Heat Removal System

It supports exercises including load changes, reactor trips, loss of feedwater, turbine runback, SGTR, main steam-line break, RCP trip, and station blackout.

Load changes:

Load decreases → turbine takes less steam → steam pressure rises → reactor power is reduced → steam generation decreases → plant settles at the new lower power.

1. **Turbine load decreases.** The turbine control valves partially close, so the turbine accepts **less steam**.
2. **Steam accumulates.** The reactor/steam generator is initially still producing approximately the same amount of steam, but less is flowing to the turbine.
3. **Steam pressure rises.** This tells the plant control system, in effect: **"We are producing more steam/heat than the turbine currently needs."**
4. **The reactor control system reduces reactor power.** Depending on the iPWR control logic, this can involve **control-rod insertion** and associated temperature/power feedback.
5. **Less fission heat → less steam generation.** Eventually steam production again matches what the turbine consumes, and steam pressure returns toward its setpoint.



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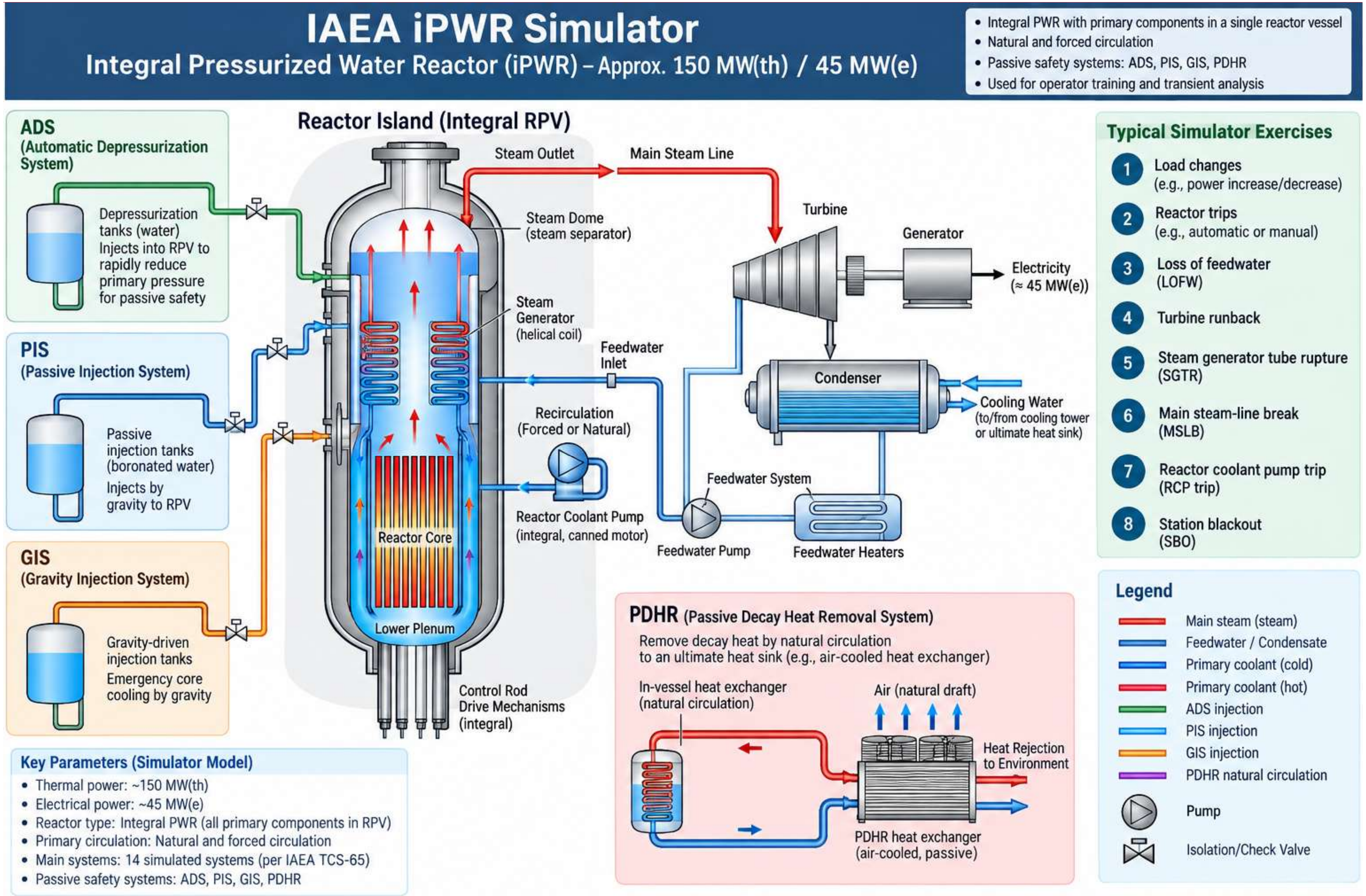
Reactor trips

A **reactor trip** means the reactor is **automatically or manually shut down very rapidly** for safety. It is also commonly called a **reactor scram**.
In a PWR, a trip typically causes the **control rods to rapidly insert into the reactor core**, absorbing neutrons and stopping the self-sustaining fission chain reaction.

The word **“trip”** comes from electrical and mechanical engineering. It means a protective device has been **triggered to quickly stop or disconnect equipment** when an abnormal condition occurs. **circuit breaker tripping** in your house:

So:
- **Reactor trip** = rapid shutdown of the reactor
- **Turbine trip** = rapid shutdown/disconnection of the turbine
- **Generator trip** = generator disconnected from the electrical grid
- **Pump trip** = pump stops, often because of a protective signal

SCRAM is often expanded as **“Safety Control Rod Axe Man.”**



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In a nuclear power plant, **turbine runback** means the turbine's power is **automatically and rapidly reduced to a lower level**, but the turbine is **not completely shut down**.

This is different from a **turbine trip**:
- **Turbine runback:** rapid, controlled **reduction** in turbine load; turbine remains operating.
- **Turbine trip:** turbine is **shut down**, with steam admission rapidly stopped.

Load change → normal, deliberate change in power
Turbine runback → automatic rapid reduction to a lower power
Turbine trip → rapid shutdown of the turbine

Why perform a runback?
A runback is used when some equipment can no longer support full-power operation. For example, loss of a feedwater pump or other balance-of-plant equipment may mean the plant can safely operate at reduced power but not at 100%.

SGTR stands for **Steam Generator Tube Rupture**.
In a PWR, the steam generator normally keeps two water systems physically separated:
Primary side: radioactive reactor coolant
Secondary side: water/steam going to the turbine

The two sides exchange heat through thousands of thin metal tubes:

An **SGTR** occurs when **one or more steam-generator tubes rupture**, creating a direct path between the primary and secondary systems.

Because the **primary system pressure is much higher** than the secondary pressure:
Tube breaks → primary coolant leaks into secondary side → primary inventory decreases + radioactive material can enter the steam system.

This is why SGTR is an important accident scenario.

A key distinction:
LOCA: primary coolant leaks out of the reactor coolant system.
SGTR: primary coolant leaks **into the secondary system through a failed steam-generator tube**.

A **Main Steam-Line Break (MSLB)** is a rupture of one of the **large pipes carrying steam from the steam generator to the turbine**.

For a PWR, think of the normal path as:
Reactor → heats primary coolant → Steam Generator → steam → Main Steam Line → Turbine

An MSLB means:
Steam Generator → ✕ broken main steam pipe → large amount of steam escapes
What happens after the pipe breaks?
Because the secondary side is pressurized, a large amount of steam can escape very rapidly.
1. Secondary pressure drops rapidly
Steam escapes through the break, causing steam-generator pressure to fall.
2. Steam generator removes more heat from the primary system
Lower secondary pressure means a lower steam saturation temperature. The steam generator therefore cools the primary coolant more strongly.
3. Primary coolant temperature decreases
This is particularly important in a PWR.
4. Reactor power may initially tend to increase
Because PWRs normally have a **negative moderator temperature coefficient**:
↓ coolant temperature → ↑ water density → ↑ neutron moderation → ↑ reactivity
So an MSLB is interesting because a **secondary-side pipe rupture can create a reactivity increase in the core**.
5. Reactor protection trips the reactor
The protection system detects abnormal conditions and initiates a **SCRAM/reactor trip**.
6. The plant isolates the broken steam line/steam generator and maintains core cooling and decay-heat removal.

Accident	What breaks?	Main consequence
SGTR	Steam-generator tube	Primary coolant leaks into secondary system
MSLB	Large main steam pipe	Secondary steam escapes rapidly
LOCA	Primary-system piping	Primary coolant escapes