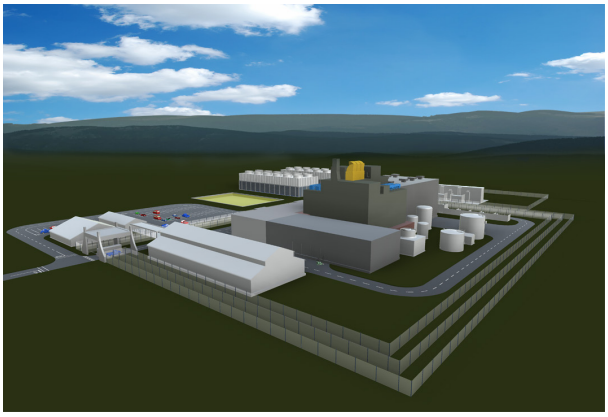
Nuclear Fuel / Fuel Engineering

# Westinghouse Small Modular Reactor Mechanical Shim Operating Strategy and Load Follow Capabilities

## Background

The >225 MWe Westinghouse Small Modular Reactor (SMR) is an ideal size to replace the aging fleet of fossil fuel burning electric power plants in the United States. These older plants are often remotely located and are the sole source of electricity for a small region or community. Utilities are also considering SMRs as a means to augment the electric supply from nonsteady sources such as wind. Therefore, SMRs need to be flexible and responsive to frequent changes in electrical demands.



Small Modular Reactor electric generating station artist rendering

## Description

The Westinghouse SMR is designed to support changing electric market needs by implementing the Westinghouse mechanical shim (MSHIMTM) operating strategy. The MSHIM operating strategy simplifies control of the reactor temperature and power distribution by:

- Using two independent sets of control banks: gray and black M banks dedicated to temperature control and an axial offset (AO) bank dedicated to axial power distribution control.
- Implementing an advanced rod control system to automate the motion of the control banks and maintain tight controls on temperature and power. Operators will not be required to perform manual manipulations of the control rods to maintain reactor control.
- Minimizing operator actions required by reducing the frequency of soluble boron changes required.
- Simplifying both baseload and load follow operations and allowing for easy transition between the two modes of operation.
- Allowing load maneuvering while minimizing boron change because of the degree of allowed insertion of the control banks in conjunction with the independent power distribution control of the AO control bank.

The worth and overlap of the M banks are designed such that the AO control bank insertion will always result in a monotonically decreasing AO.

- Using the M control banks to maintain the programmed coolant average temperature throughout the operating power range. The AO control bank is independently

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modulated by the rod control system to maintain a nearly constant AO throughout the operating power range. The degree of control rod insertion under MSHIM operation allows rapid return to power while minimizing the need to change boron concentration.

The Westinghouse SMR is designed to respond to various load change transients, such as daily and weekend load follow operations, extended reduced power operation and grid frequency response (load regulation).

- Daily load follow can be performed from 100 percent to as low as 20 percent power at a linear power ramp rate of 5 percent per minute.
- During baseload or load follow operations, the plant will also be capable of performing ±10 percent load changes at a rate of ±2 percent per minute to support grid frequency response.

**Load Follow Control**

During load follow maneuvers, power changes are primarily accomplished using only control rod motion, as required.

The power distribution is maintained within acceptable limits through limitations on control rod insertion. Rapid power increases (up to five percent/min) from part power during load follow operation are accomplished with rod motion.

The rod control system is designed to automatically provide power and temperature control for most of the cycle length while minimizing the need to change boron concentration as a result of the load maneuver.

Gray rod cluster assemblies (GRCAs) are used in the M banks in baseload and load follow operations. They provide an MSHIM™ reactivity mechanism to eliminate the need for frequent changes to the concentration of soluble boron (chemical shim). The term gray rod refers to the reduced reactivity worth relative to that of a rod cluster control assembly consisting of 24 silver-indium-cadmium rodlets.

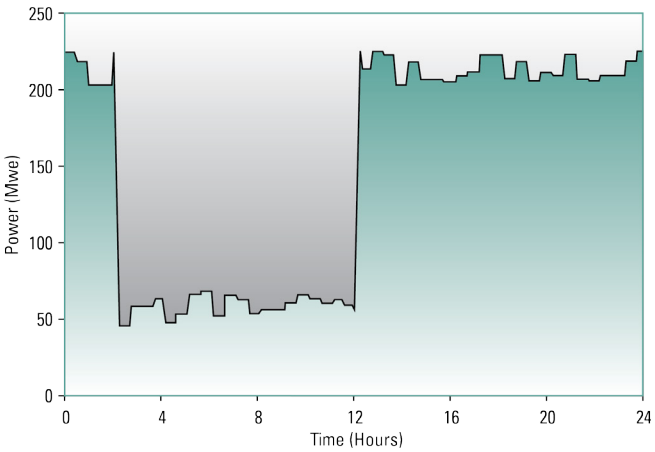
**GRCAs feature:**

- 24 absorber rodlets fastened at the top end to a common hub or spider
- Similarities to a rod cluster control assembly, except that the absorber consists of tungsten within an Inconel®-718 sleeve and clad with stainless steel

## Benefits

The benefits of the MSHIM operating strategy include:

- Allowing the plant to quickly change power in response to changing electrical loads.
- Simplifying operator actions required by reducing frequency of soluble boron changes required during baseload operations, and significantly reducing the number of boron changes required during load follow operations.
- Simplifying operator actions by automating control rod movements required to control reactor temperature and power distribution, significantly reducing required operator intervention




Sample change in power output vs. time during load follow and frequency control

## Experience

Westinghouse has developed and implemented this system for the AP1000® pressurized water reactor..



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