Westinghouse Global Technology Office

Westinghouse Lead Fast Reactor

Introduction

Westinghouse Electric Company is a world leader in the development and commercialization of nuclear power plants. Westinghouse has established technology innovation programs aimed at supporting operating plants to reduce cost and improve efficiency, and is developing next-generation technologies to address future global market needs. With this latter goal in mind, Westinghouse is developing a next-generation, medium-capacity nuclear power plant based on lead-cooled fast reactor* (LFR) technology. The delivery of commercially competitive, reliable, zero-emission clean and sustainable energy, with unparalleled safety and flexible operations*, are Westinghouse's key goals.

Background

With the objective of commercializing a competitive advanced reactor technology for global markets, Westinghouse has developed a roadmap which paves the way to a commercially viable next-generation nuclear energy technology that uses liquid lead as the primary coolant. LFR technology is being developed as part of our commitment to advance the world's access to reliable, affordable and sustainable electricity while satisfying carbon emission targets.

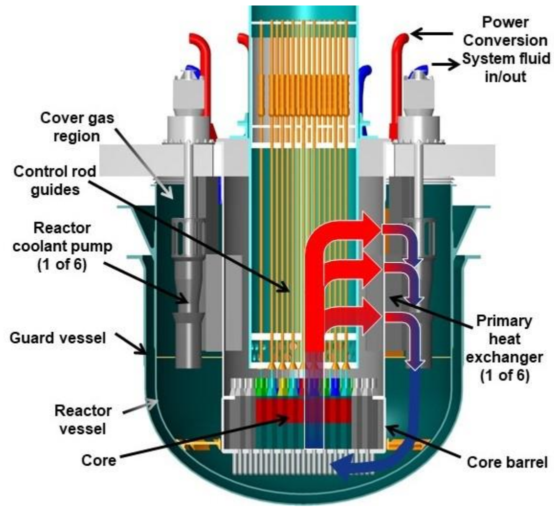
The Westinghouse LFR will achieve the following important objectives for its customers:

- Walk-away safety*
- Reduced capital/overnight costs*
- Competitive Levelized Cost Of Electricity (LCOE*) even in the most challenging global markets
- Variable electricity output to complement renewables
- Capability for non-electricity applications such as cogeneration* and seawater desalination
- Reduced nuclear fuel waste volume per unit of electricity generated

These features will result in a carbon-free technology solution that can compete effectively in the most challenging economic climate. The goal is to develop a reactor that will succeed in a highly competitive, deregulated energy market in the 2030 timeframe.

The Technology

The Westinghouse LFR is a ~450 MWe, highly simplified, passively safe, compact and scalable reactor plant. Scalability of systems and components is used as a key design principle to allow the power output of plant evolutions to fit the needs of future diverse markets, while minimizing re-design efforts.



The compact reactor coolant system together with the lack of appreciable sources of pressurization do not require the large, high-pressure-resistant containment structure typical of conventional plants and, due to its small size, is suitable for underground, secure installation of all systems important to safety. The LFR operates at temperatures leading to much higher efficiencies than conventional nuclear plants which, together with other operational features, allows for a more efficient use of natural resources, namely water and uranium. The result will be enhanced sustainability through a reduction in nuclear waste volume and the possibility of using reprocessed fuel, should local energy policy allow.

By adopting a thermal energy storage system, the LFR is capable of non-baseload flexible operation, which allows complementation of renewable energy generation by providing power

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* Defined in glossary at the end of document

when the grid demands, independent of weather conditions. Moreover, a Supercritical Carbon Dioxide Power Conversion System that uses air as the ultimate heat sink significantly reduces water utilization and eliminates the need for siting the plant near large water bodies.

A comprehensive description of the design and of the associated development program can be found in the literature listed under “Additional Resources”.

Roadmap

The Westinghouse LFR program’s ultimate objective is to support the development of an innovative reactor fleet that is based on lead technology with best-in-class safety, economics and operability performance. The first step toward commercialization is the deployment of a near-term deployment prototype LFR (PLFR) relying on proven materials to accelerate deployment, which will serve as the pilot for follow-on commercial plants. Focused research and development efforts, to be conducted simultaneously with PLFR development, will feed into the design of the commercial fleet, with the goal to enhance economics and operability performance even further. The collaboration between Westinghouse and global organizations with expertise in lead technology and fast reactor design will ensure the program’s success and is a key element of Westinghouse’s strategy.

Benefits

Based upon a thorough and extensive comparison of alternate potential advanced reactor designs, Westinghouse selected LFR as the preferred technology with the best potential for successful commercial deployment. The LFR selection was primarily based on:

- Economics and marketability potential
- Unparalleled safety
- Technology Readiness Level (TRL) sufficient to reduce development risk and facilitate licensing
- Enhanced natural resource utilization and reduced waste generation which, combined with the near-zero carbon emissions typical of any nuclear technology, result in a sustainable, low environmental impact technology

LFR technology is responsive to the growing global mandate to replace carbon-emitting electricity sources and the goal for all future energy solutions to be environmentally friendly throughout their lifespan. The lifespan includes the impact from up-front processing of the initial materials to long-term waste management, plant disassembly and greenfield remediation* of any future power generation site. A key differentiator of LFR technology is its ability to meet these environmental and sustainability goals together with the highest safety standards, while ensuring economic competitiveness.

Additional resources

[1] P. Ferroni et al., “The Westinghouse Lead Fast Reactor Program”. International Nuclear Fuel Cycle Conference (GLOBAL). Seattle, WA, USA, September 22-26, 2019.

[2] T. K. Kim, N. Stauff, C. Stansbury, A. Levinsky, F. Franceschini, “Long core life design options for the Westinghouse LFR”. International Nuclear Fuel Cycle Conference (GLOBAL). Seattle, WA, USA, September 22-26, 2019.

[3] J. Liao, et al., The importance of Phenomena Identification and Raking Table in Lead Fast Reactor Development. 18th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH). Portland, OR (USA). August 18-22, 2019.

[4] G. Grasso, A. Levinsky, F. Franceschini, P. Ferroni, “A MOX-fuel core configuration for the Westinghouse Lead Fast Reactor”. International Congress on Advances in Nuclear Power Plants (ICAPP), Juan-les-pins, France, May 12-15, 2019.

[5] F. Franceschini, G. Grasso and P. Ferroni, “Advanced fuel cost performance assessment for the Westinghouse LFR”. International Congress on Advances in Nuclear Power Plants (ICAPP), Charlotte, NC, USA, April 8-11, 2018.

[6] J. Liao, D. Utley, Study on Reactor Vessel Air Cooling for the Westinghouse Lead Fast Reactor. Nuclear Technology, 2019. DOI: 10.1080/00295450.2019.1599614

[7] C. Stansbury, M. Smith, P. Ferroni, A. Harkness, “Westinghouse Lead Fast Reactor Development: Safety and Economics Can Coexist”. International Congress on Advances in Nuclear Power Plants (ICAPP), Charlotte, NC, USA, April 8-11, 2018.

* Defined in glossary at the end of document

Glossary

Cogeneration: The use of a power station to deliver electricity and heat at the same time, with the latter to be used for applications such as industrial processes and district heating.

Fast Reactor: A category of nuclear reactors in which the fission chain reaction is sustained by fast neutrons, as opposed to thermal, or slow, neutrons like in traditional nuclear plants.

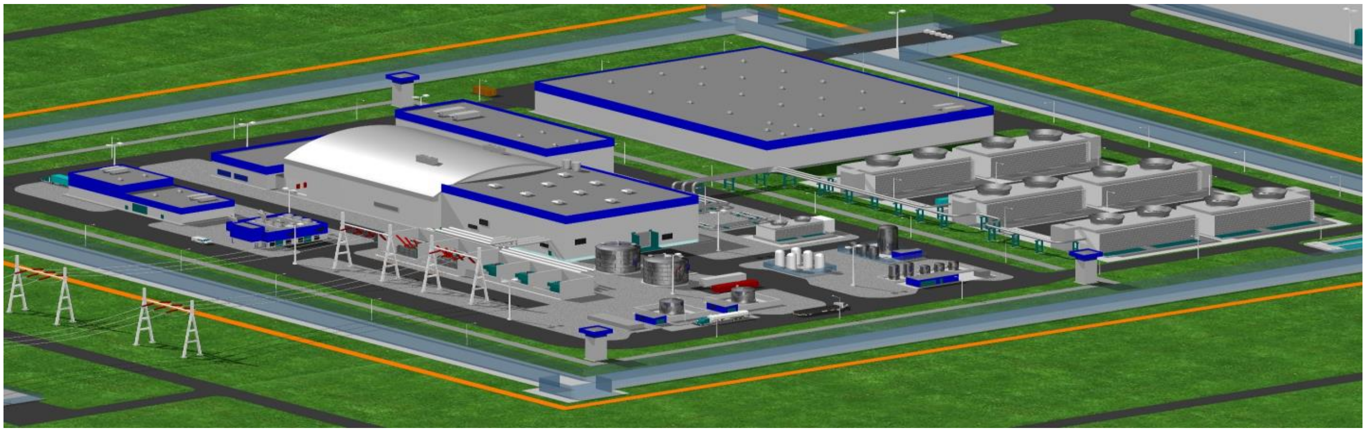
Flexible operation (also known as load following): A power plant that adjusts its power output as demand for electricity fluctuates throughout the day.

Greenfield remediation: The return of an area previously occupied by a human-made installation to its original conditions before any construction had occurred.

Levelized cost of electricity (LCOE): An economic assessment of the total cost to build and operate a power-generating asset over its lifetime, divided by the total energy output of the asset over that lifetime. The LCOE can also be regarded as the minimum cost at which electricity must be sold in order to break-even over the lifetime of the project.

Overnight capital cost: The cost of a construction project if no interest was incurred during construction, as if the project was completed "overnight."

Walk away safety: The capability of a plant to be self-regulating and to prevent radioactivity release in any accident scenario even without operator intervention.



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