A review of generation IV reactors technology

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Abstract

This paper provides a historical overview of the development of advanced reactors, with a focus on Generation IV reactors and the unique international cooperative research and development framework that was put in place within the Generation IV International Forum. The GIF has marked significant progress in developing a next generation of reactor technologies that break out of the limitations of currently deployed nuclear energy systems. Accompanying papers describe the related research and development activities for the six advanced reactor systems.

Keywords: Generation IV reactors, molten salt reactor, gas-cooled fast reactor, lead-cooled fast reactor, sodium-cooled fast reactor

1. INTRODUCTION

Formed in 2001, the GIF brings together 13 countries including Argentina, Australia, Brazil, Canada, China, France, Japan, the Republic of Korea, the Republic of South Africa, the Russian Federation, Switzerland, the United Kingdom and the United States, as well as Euratom, itself representing the 28 EU member countries. The main objective of the forum is precisely to coordinate research and development (R&D) into advanced nuclear energy systems that offer improved sustainability, economics, safety and reliability, proliferation resistance and physical protection. By pooling and leveraging research efforts, and drawing on skills and facilities of participating countries, the GIF aims at accelerating the development of Generation IV systems up to their commercial deployment [1].

One of the first tasks carried out by the GIF was to select advanced reactor concepts for which there was consensus to move R&D forward. More than a hundred concepts, received from developers from around the world, were screened down to a final set of six systems. This required consensus among experts on a number of criteria which Generation IV systems should meet. In the end, six conceptual nuclear energy systems were selected in July 2002 for collaborative R&D, comprising the sodium-cooled fast reactor (SFR), the very high temperature reactor (VHTR), the supercritical water-cooled reactor (SCWR), the gas-cooled fast reactor (GFR), the lead-cooled fast reactor (LFR), and the molten salt reactor (MSR) [2].

A year later, a technology roadmap for the GIF was published. The 2002 Technology Roadmap of the GIF [3] was updated with the publication in January 2014 of the GIF's "Technology Roadmap Update" [4], which provides a clear picture of how the GIF members will focus their R&D efforts in the coming decade, with several systems having already entered (VHTR, SFR or LFR) or are entering (SCWR) their so-called 'performance phase' (testing of processes and materials at engineering scale under prototypic conditions) in the period to 2023 [5]. It should however also be recognised that reduced R&D budgets in the participating countries have slowed down the rate of progress in advancing these technologies towards their demonstration phase.

For more than a decade, GIF has led international collaborative efforts to develop next generation nuclear energy systems that can help meet the world's future energy needs. Generation IV designs will use fuel more efficiently, reduce waste production, be economically competitive, and meet stringent standards of safety and proliferation resistance.