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A Systems Methodological Framework for Maintenance and Asset Management of Nuclear Energy Infrastructure

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Climate change is driving carbon neutral solutions for energy generation, resulting in renewed interest in nuclear energy. This has propelled a revived effort in the relevant materials associated with the nuclear fuel cycle, the geochemical stability of nuclear waste forms, and the effects of extension of remaining reactor life on structural concrete components. With the extension of existing reactors, new designs (Gen IV) and high burnup nuclear fuels, strategies of nuclear waste and infrastructure management towards decarbonization efforts in the energy sector become more critical than ever. Radiation damage and the related chemical transformations have accelerated the degradation of characteristics and long-term performance of structural materials such as cement matrixes and minerals in aggregates and structural components such as concrete lining structure being part of nuclear energy asset. A mechanistic multi-scale understanding of the degradation processes is essential to provide scientific support of the safety and infrastructure asset management for deep geological nuclear waste repositories. Using a systems approach, this paper lays out a methodological framework for the maintenance and asset management of nuclear energy infrastructure of nuclear waste that is built on data driven and multi-physics driven performance models.