# From Individual Neutrons to Fleets of Reactors

Software Tools for Analyzing Complex Nuclear Energy Systems

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**Abstract**. There are many axes of complexity in nuclear energy modeling and simulation. Multi-physics, multi-scale feedback gets the most attention in efforts like CASL, MOOSE and NEAMS, with a focus on increasing the fidelity of those simulations to reduce approximations of well-understood fundamental physical phenomena on relatively simple geometric domains.  My work explores alternative axes: in one case the geometry itself introduces the complexity; in the other, poorly defined interactions among facilities can lead to complex behavior. With CAD-based Monte Carlo radiation transport at its core, the Svalinn software suite supports workflows that couple the neutronics results in these complex geometries to other analyses including deterministic transport, neutron activation, heat transfer, and mechanical analyses.  These tools are being used for support of licensing at ITER, designing radiation protection for astronaut travel to Mars, and experiment design at ATR. Cyclus uses agent-based modeling to track the flow of material among nuclear energy facilities with a specific goal of facilitating the introduction of new facility models, either to improve the physics model, add nuance to the way the facility interacts with others, or both.  This open source platform enables innovation while ensuring nuclear engineering material compatibility as new facilities are introduced and improved.  Recent work has used Cyclus at large scale to study optimization of fuel cycles and hedging scenarios under disruption.

**Biography**. Paul Wilson is the Grainger Professor of Nuclear Engineering in the University of Wisconsin-Madison's Department of Engineering Physics, and Faculty Director of the Advanced Computing Initiative. His research interests focus on developing improved tools for computational modeling of complex nuclear energy systems, with applications in radiation shielding, nuclear waste management, nuclear non-proliferation and energy policy. Paul joined the University of Wisconsin-Madison as an Assistant Professor in August 2001 as part of the Energy Systems and Policy Hiring Initiative. He currently serves on the Program Committee of the Energy Analysis and Policy Graduate Certificate , the Executive Committee of the Wisconsin Energy Institute and the Governance Committee of the Nelson Institute for Environmental Studies.  Paul has served in a number of advisory and consultant roles, including the DOE's Generation IV Technology Roadmap Committee (2001-2003) and the Blue Ribbon Commission on America's Nuclear Energy Future. In 2015, he served on a committee of the National Academies to review the progress towards the elimination of highly enriched uranium from research and test reactors. Paul received a B.A.Sc. (Engineering Science) from the U of Toronto, an M.S. from U. Wisconsin-Madison, a Dr.-Ing. from the Technical University of Karlsruhe, and a Ph.D. from U. Wisconsin-Madison.  Paul was the founding President of the North American Young Generation in Nuclear [NA-YGN] and has been active in the American Nuclear Society for over 20 years. He represented the ANS and NA-YGN at the international climate change negotiations in Buenos Aires, Argentina (1998), and Bonn, Germany (1999).