

Koroush SHIRVAN

John Clark Hardwick (1986) Career Development Professor
Nuclear Innovation in Fission Technologies
Co-Director of RTC for Utility Executives
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EDUCATION

- Sept. 2012** **Ph.D. Nuclear Science and Engineering**
Massachusetts Institute of Technology, Cambridge, Massachusetts
Major: Reactor Design and Analysis
Minor: Probabilistic Risk Assessment

Ph.D. Dissertation Title: Development of Optimized Core Design and Analysis
Methods for High Power Density BWRs
Ph.D. Supervisor: Professor Mujid Kazimi (late)
- May 2010** **Masters of Science in Nuclear Science and Engineering**
Massachusetts Institute of Technology, Cambridge, Massachusetts

MS Thesis Title: Optimization of Small Integral Light Water Reactors
MS Supervisor: Professor Mujid Kazimi (late)
- May 2008** **Bachelor of Science in Nuclear Engineering**
University of Florida, Gainesville, Florida
Graduated with Summa Cum Laude (Highest Honors)
- February 2011** **Swiss Federal Institute of Technology, Zürich (ETHZ),**
Short Course with certificate: Modeling & Computational Multi Phase Flow

WORK EXPERIENCE

- Sept 2008 – Sept 2012** **Research / Teaching Assistant**
Sept 2012 – Dec 2016 **Research Scientist**
Jan 2017 – July 2017 **Principal Scientist**
July 2017 – present **Assistant Professor**
Center for Advanced Nuclear Energy Systems (CANES)
Department of Nuclear Engineering
Massachusetts Institute of Technology

Research Activities

Research work primarily includes modeling and simulation (M&S) informed experimentation and advanced data analytics and their applications for advanced reactor technology. Specific recent research/education responsibilities include:

- Present: Supervise 5 PhD, 3 Masters, 4 Post-Docs and a visiting PhD student.
- 2019-Present: PI of development of reinforcement learning code package for core design optimization (PWRs and BWRs) funded by Exelon.
- 2019-Present: Co-PI of development of fiber optics sensors for advanced reactors, focusing on implications for fast MSR funded by ARPA-E and led by NETL.
- 2018-Present: PI of optimization of EDF Small Modular Reactor focusing on improving Economics, Safety and deployment.
- 2018-Present: PI of ATF-FLEX NEUP focused on combining ATF and FLEX technologies to improve plant coping time.
- 2018-Present: Co-PI of impact of equipment based seismic isolation on advanced reactor economics funded by ARPA-E and led by University of Buffalo.
- 2015-2019: Executive Director of Accident Tolerant Fuel Integrated Research Project – Responsible for project organization involving multiple universities and industry partners. Technical lead on both experimental and simulation effort at MIT related to coated Zircaloy cladding with Chromium and Moly/FeCrAl and fuel with additives/dopants. Simulation work is focused on development of ATF material models and their validation in TRACE and MOOSE/BISON tools.
- 2015-Present: Principal Investigator of Fuel-in-Fiber Concept (SBIR subcontract) – Responsible for project on use of additive manufacturing technique to produce high purity SiC fibers and allow online fuel deposition to produce more compact TRISO-type fuel. Work involves investigating SiC fibers corrosion performance in autoclave and characterize their mechanical behavior to inform M&S models to design an optimum new fuel concept.
- 2012-Present: Reduced Moderated Boiling Water Reactor Safety Assessment (DOE NEUP, HITACHI-GE Nuclear) – Responsible for code development capability for system level safety and stability assessment and fuel performance of MOX fuel.
- 2012-Present: SiC clad for LWRs (CTP, Lockheed Martin, Westinghouse, General Atomics, Plasma Pros) – Responsible for the R&D of the ceramic matrix composite SiC cladding and coated composite cladding.
- 2015-16: PI of Uranium Nitride fuel performance for AP1000 (ExxonMobil)
- 2015-16: PI of Thorium-Plutonium fuel performance (Lockheed-Martin).
- 2013-2020: Chair of MIT CASL (simulation hub) Education activities – Responsible for development of fuel performance education material with MOOSE/BISON and co-organizer of a two week CASL school covering multi-physics simulation topics.
- Co-instructor of design, nuclear safety and nuclear systems class.
- Development of reactor system and perform safety analysis for nuclear reactors including BWRs, PWRs, Small Modular Reactors, Sodium and Lead Bismuth Fast Reactors and Light Water Breeders.
- Performing both Validation through experimentation and Verification through high fidelity simulation in areas of thermal hydraulics and fuel performance.
- Development of methodology for design of Light Water Reactor (LWR) cores using coupled multi-physics analysis.
- Power cycle optimization including Rankine and Supercritical CO₂ cycles
- Development of single and two-phase CFD and empirical models for performance analysis of nuclear fuels and safety systems.
- Development of methods for BWR two-phase stability in both frequency/ time domains.
- Technology selection of nuclear reactor concepts for different energy applications.

May 2007 – August 2008

Core Design Intern
Southern Nuclear Company
Birmingham, Alabama

PWR Core Analysis, Summer 2008

- Worked extensively on PWR Pellet Clad Interaction risk assessment and created new methodologies to analyze fuel performance during power changes.

Plant Vogtle Core Analysis, Summer 2007

- Created a new core design methodology used by industry to reduce CRUD deposition on fuel rods through utilization of neutronics, thermal hydraulics and plant chemistry assessment tools.

Teaching Experience

Teaching Instructor

Fall 14/Spring 18-20 MIT Nuclear Engineering 22.06: Engineering of Nuclear Systems

Fall 15/17 MIT Nuclear Engineering 22.033: Undergraduate Design (co-Instructor)

Spring 2016 MIT Mechanical Engineering 2.006: Fluids/Heat transfer (Recitation Ins.)

Fall 2017/19 MIT Nuclear Engineering 22.39: Nuclear Reactor Design and Safety

Instructor of several professional courses on nuclear technology for executives

SKILLS/EXPERIENCE

- **Computer and Computational**

- CANES Manager of Computer Software Repository and Cluster Systems
- Proficient in Fortran language and familiar with Python, C++, C#, Xml, JAVA, Visual Basic, Maple, Matlab, MOOSE, Goldsim, GNU, CMake, HDF5, git
- Expert User of major Nuclear Engineering modeling, analysis and licensing codes including:
 - **Radiation Transport:** ANC, CASMO, SIMULATE, S3K, MCNP5/X, SERPENT, SCALE, PARTISN, DRAGON, ROSA, MPACT, PARCS
 - **Thermal Hydraulics/CFD:** RETRAN, RELAP, TRACE, VIPRE, COBRA, MAAP, MELCOR, TRANSAT, FLUENT, CFX, STARCCM+, ASPEN
 - **Structural Materials and Nuclear Fuel:** ABAQUS, BOA, FRAPCON, FRAPTRAN, MOOSE, BISON, FALCON, SOLID WORKS, ADINA

- **Experimental**

- Design and conduct experiments with high temperature/pressure/voltage
- Materials characterization using Scanning Electron Microscopy (SEM), Focused Ion Beam (FIB) milling, energy-dispersive X-ray spectroscopy (EDX)

PROFESSIONAL ACTIVITIES

Co-Director of Reactor Technology Course (RTC) for Utility Executives	2016-Present
Consultant, Nuclear Technology and Fuels	2013-Present
Technical Thermal Hydraulic Track Leader for ICAPP Conference	2013-Present
Chair of the MIT CASL Education Activity	2013-Present
Technical Program Committee for Nuclear Innovation Bootcamp	2016-2018
Director of Accident Tolerant Fuel (ATF) DOE Integrated Research Project	2015-2018
Assistant Technical Program Chair for ICAPP Conference	2018
Organizer, Identifying Failure Modes of ATF Concepts Workshop	2018
American Society of Mechanical Engineers Member	2018-Present
Completed Multiphysics Model Validation Workshop	2017
Organizer, Modeling and Simulation of Near Term ATF Workshop	2017
Technical Program Member, Int. Conf. on Advanced Ceramics & Composites	2015
Technical Advanced Reactor Track Leader for ICAPP Conference	2015
Member, EPRI Gen-IV Reactor Group	2015
Completed Micro and Nanotechnologies in Medicine Workshop	2014
Tech. Prog. Com. member for Nuclear Fuels and Structural Materials Conf.	2014
Technical Program Committee member and chair for TopFuel Conference	2013
Peer Reviewer, FRAPCON/FRAPTRAN Fuel Performance codes	2013
Referee, major nuclear journals including NED, NT, Progress, Anals, JNM	2012-Present
Member, ANS Small and Medium Sized Reactor Committee	2011-2012
Co-Developers and Administrator of MIT NSE website in response to Fukushima-Daiichi Accident (more than one million hits in the first 5 days)	2011-2013
Delegate and Presenter at the Global Conference on Energy (Ishigaki, Japan)	2010
MIT International Energy Conference Organizer and Presenter	2010-2015
American Nuclear Society Member	2006-Present

HONORS & AWARDS

Elite Nuclear Engineering Fellowship (Univ. of Florida)	2006-08
Alpha Nu Sigma Nuclear Honor Society	2007-Present
TAU BETA PI Honor Society	2007-Present
Reinhold Rudenberg Memorial Award (MIT)	2011
Signature Fission Doctorate Seminar Selectee (MIT)	2012
Outstanding Student Service Award (MIT)	2012
Outstanding Assistant Technical Program Chair – ICAPP	2018
NRC Young Faculty Fellowship Award	2018-2021
Young Professional TH Research Competition – ANS	2018

PUBLICATIONS

Peer-Reviewed Journals/Conference Proceedings

<i>Focus Area</i>	<i># Of Published Peer Reviewed Papers</i>
<i>Design and System Modeling</i>	<i>>20</i>
<i>Reactor Physics Modeling</i>	<i>>20</i>
<i>Thermal Hydraulic Testing/Modeling</i>	<i>>25</i>
<i>Structural Materials/Nuclear Fuel Testing/Modeling</i>	<i>>25</i>

Peer-Reviewed Accepted/Published Journals:

Ma Z., **Shirvan K.**, Wu Y., Su G., “A three-dimensional axial fuel relocation framework with discrete element method to support burnup extension,” *Journal of Nuclear Materials*, Available Online, August 2020.

Jin Y., Wu X., **Shirvan K.**, “System Code Evaluation of Near-term Accident Tolerant Claddings during Pressurized Water Reactor Station Blackout Accidents,” *Nuclear Engineering and Design*, Available Online, August 2020.

Jin Y., Cheung FB., **Shirvan K.**, Bajorek S.M., Tien K., Hoxie C.L., “Development of a New Spacer Grid Pressure Drop Model in Rod Bundle for the Post-Dryout Two-Phase Flow Regime during Reflood Transients,” *Nuclear Engineering and Design*, Available Online, August 2020.

Jin Y., Cheung FB., **Shirvan K.**, Bajorek S.M., Tien K., Hoxie C.L., “Numerical investigation of rod bundle thermal-hydraulic behavior during reflood transients using COBRA-TF,” *Annals of Nuclear Energy*, Vol. 148, 107708, Dec. 2020.

Seshadri A., Forrest E.C., **Shirvan K.**, “Why ionizing radiation enhances surface wettability,” *Applied Surface Science*, Vol. 514, 145935, June 2020. <https://doi.org/10.1016/j.apsusc.2020.145935>

Li W., **Shirvan K.**, Pegna J., Harrison S., “Innovative accident tolerant fuel concept enabled through direct manufacturing technology,” *Applied Energy*, Vol. 264, 114742 April 2020. <https://doi.org/10.1016/j.apenergy.2020.114742>

White P., **Shirvan K.**, “Impact of technology hazards and regulatory methods on commercial fusion development,” *IEEE Transactions on Plasma Science*, Special Issue, Available Online. 10.1109/TPS.2020.2975183

Silva R. B., **Shirvan K.**, Cruz J.J., Marques R.P., Marques A.L.F., Piqueira J.R.C., “Advanced method for neutronics and system code coupling RELAP, PARCS, and MATLAB for instrumentation and control assessment,” *Annals of Nuclear Energy*, October 2019. <https://doi.org/10.1016/j.anucene.2019.107098>

Shirvan K., “Implications of accident tolerant fuels on thermal-hydraulic research” *Nuclear Engineering and Design*, Vol 358, March 2020. <https://doi.org/10.1016/j.nucengdes.2019.110432>

Zhao X., **Shirvan K.**, Salko R., “On the prediction of critical heat flux using a physics-informed machine learning-aided framework” *Applied Thermal Engineering*, Vol 164, 5, Available Online Oct 2019.

Li W., **Shirvan K.**, “Finite Element Analysis of the SiC/SiC Composite Clad Deformation in the Presence of Spacer Grids,” *Annals of Nuclear Energy*, Available Online Oct 2019.

Wu X. **Shirvan K.**, “System code evaluation of near-term accident tolerant claddings during boiling water reactor short-term and long-term station blackout accidents,” *Nuclear Engineering and Design*, Available Online Oct 2019.

He Y., **Shirvan K.**, Wu Y., Su G., “Fuel performance optimization of U3Si2-SiC design during normal, power ramp and RIA conditions,” *Nuclear Engineering and Design*, Vol. 353, P. 110256, 2019.

Jin Y., Cheung FB., **Shirvan K.**, Bajorek S.M., Tien K., Hoxie C.L., “Development of a droplet breakup model for dry spacer grid in the dispersed flow film boiling regime during reflood transients,” *International Journal of Heat and Mass Transfer*, Vol. 143, P. 118544, 2019. <https://doi.org/10.1016/j.ijheatmasstransfer.2019.118544>

Wu X., **Shirvan K.**, Kozlowski T., “Demonstration of the relationship between sensitivity and identifiability for inverse uncertainty quantification,” *Journal of Computational Physics*, Vol. 396, pp. 12-30, 2019. <https://doi.org/10.1016/j.jcp.2019.06.032>

He Y., **Shirvan K.**, Wu Y., Su G., “Integrating a multi-layer deformation model in FRAPTRAN for accident tolerant fuel analysis,” *Annals of Nuclear Energy*, Vol. 133, P. 441-454, 2019.

Li W., **Shirvan K.**, “*U3Si2-SiC fuel performance analysis in BISON during normal operation,*” *Annals of Nuclear Energy*, Vol. 132, P. 34-45, 2019.

Hiscox B., **Shirvan K.**, “*Reactor Physics Analysis of a New Accident Tolerant Fuel Called Fuel-in-Fibers,*” *Annals of Nuclear Energy*, Vol. 130, P. 473-482, 2019.

Sukjai Y., **Shirvan K.**, “*Enhancing FRAPCON fuel performance code for physical phenomena at high temperature and high burnup,*” *Journal of Nuclear Materials*, Vol 517, pp. 113-127, 2019.

Deng, Y., **Shirvan, K.**, Wu, Y., Su, G. “*Utilization of 3D fuel modeling capability of BISON to derive new insights in performance of advanced PWR fuel concepts,*” *Journal of Nuclear Materials*, Vol 516, pp. 271-288, 2019.

Li W., **Shirvan K.**, “*ABAQUS analysis of the SiC cladding fuel rod behavior under PWR normal operation conditions*” *Journal of Nuclear Materials*, Vol 515, pp. 14-27, 2019

Zhao X., Salko R., Wysocki A., **Shirvan K.**, “*Validation and Benchmarking of CTF for Single- and Two-Phase Flow,*” *Nuclear Technology*, Vol 205 pp. 338-351, 2019.

Seshadri A., Philips B., **Shirvan K.**, “*Towards Understanding the Effects of Irradiation on Quenching Heat Transfer,*” *Journal of Heat and Mass Transfer*, Vol 127 pp. 1087-1095, 2018.

Seshadri A., **Shirvan K.**, “*Quenching Heat Transfer Analysis of Accident Tolerant Coated Fuel Cladding,*” *Nuclear Engineering and Design*, Vol. 338 pp. 5-15, 2018.

Wagih, M., Spencer, B., Hales, J., **Shirvan, K.**, “*Fuel performance of chromium-coated zirconium alloy and silicon carbide accident tolerant fuel claddings,*” *Annals of Nuclear Energy*, Vol 120, pp. 304-318, 2018.

Che, Y., Pastore, G., Hales, J., **Shirvan, K.**, “*Modeling of Cr2O3-doped UO2 as a near-term accident tolerant fuel for LWRs using the BISON code,*” *Nuclear Engineering and Design*, Vol 337 pp. 271-278, 2018.

Gurgen, A., **Shirvan, K.**, “*Estimation of coping time in pressurized water reactors for near term accident tolerant fuel claddings*”, *Nuclear Engineering and Design*, Vol 337 pp. 38-50, 2018.

Wu, X., Kozlowski, T., Meidani, H., **Shirvan, K.**, “*Inverse uncertainty quantification using the modular Bayesian approach based on Gaussian process, Part 1: Theory,*” *Nuclear Engineering and Design*, Vol 335, pp. 339-35, 2018.

Wu, X., Kozlowski, T., Meidani, H., **Shirvan, K.**, “*Inverse uncertainty quantification using the modular Bayesian approach based on Gaussian Process, Part 2: Application to TRACE*” *Nuclear Engineering and Design*, Vol 335, pp. 417-431, 2018.

Deng, Y., **Shirvan, K.**, Wu, Y., Su, G. “*Probabilistic view of SiC/SiC composite cladding failure based on full core thermo-mechanical response,*” *Journal of Nuclear Materials*, Vol 507, pp. 24-37, 2018.

Shirvan, K., Forrest, E.C. “*Modeling physical vapor deposition of energetic materials,*” *Journal of Vacuum Science and Technology A: Vacuum, Surfaces and Films* Vol 36 Issue 3, Article 03E103, 2018.

Li W., Wu X., **Shirvan K.**, Su G., “*An Investigation of Numerical Performance Enhancement of RELAP5: Numerical Stability, Higher Resolution and an Alternative Constitutive Relation*”, *Nuclear Engineering and Design*, Vol 328 pp. 309-320, March 2018.

Sevecek M., Gurgen A., Seshadri A., Che Y., Wagih M., Phillips B., Champagne V, **Shirvan K.**, “*Development of Cr Cold-Sprayed Fuel Cladding with Enhanced Accident Tolerance,*” *Nuclear Engineering and Technology Journal*, Vol 50, pp. 229-236, 2018.

Hino T., J. Miwa, T. Mitsuyasu, Y. Ishii, M. Ohtsuka, K. Moriya, K. **Shirvan**, V. Seker, A. Hall, T. Downar, P. M. Gorman, M. Fratoni and E. Greenspan, “*Core Design and Analysis of Axially*

Heterogeneous Boiling Water Reactor for Burning Transuranium Elements,” Vol. 187, Issue 3 Journal of Nuclear Science and Technology, 2017.

Avincola V., Guenoun P., **Shirvan K.**, “*Mechanical Performance of SiC Multi-layer Cladding in PWRs,*” Nuclear Engineering and Design, vol. 310, pp. 280-294, Dec, 2016.

Zhao, X., **Shirvan K.**, Wu Y., Kazimi M., “*Critical Power and Void Fraction Prediction of Tight Bundle Designs*” Nuclear Technology, vol. 196(3), pp. 553-567, Dec 2016.

Shirvan K., Ballinger R., Buongiorno J., Forsberg C., Kazimi M., Todreas N., “*Technology Selection for Offshore Underwater Small Modular Reactors*”, Journal of Nuclear Engineering and Technology , vol. 48(6), Dec, 2016.

Shirvan K., Kazimi M., “*Superheated Water Small Modular Underwater Reactor Concept,*” Journal of Nuclear Engineering and Technology vol. 48(6), Dec, 2016.

Shirvan K., “*Numerical Investigation of the Boiling Crisis for Helical Cruciform-Shaped Rods at High Pressures,*” Journal of Multiphase Flow vol. 83, pp. 51-61, July, 2016.

Shirvan K., Forrest E., “*Design of an Organic Simplified Nuclear Reactor,*” Journal of Nuclear Engineering and Technology, Vol. 48(4), August, 2016.

Andrews N., **Shirvan K.**, Kazimi M., “*Steady State and Accident Transient Analysis Burning Weapons Grade Plutonium in Thorium and Uranium with Silicon Carbide Cladding*”, Nuclear Technology, 15-41, March 2016.

Busquim R. Marques A., Cruz J., **Shirvan K.**, Kazimi, M., “*Reactivity estimation during a reactivity-initiated accident using the extended Kalman filter,*” Annals of Nuclear Energy, vol. 85, pp. 753-762, 2015.

Andrews, N., **Shirvan K.**, Kazimi M., “*Viability of Uranium Nitride Fueled High-Conversion PWR*”, Progress in Nuclear Energy, Vol 82 pp. 28-32, 2014.

Shirvan K., and Kazimi M.S., “*Three Dimensional Considerations in Thermal-Hydraulics of Helical Cruciform Fuel Rods for LWR Power Uprates,*” Nuclear Engineering and Design, vol. 270, pp. 259-272, 2014.

Shirvan K. and M.S. Kazimi, “*BWR-HD: An Optimized BWR for High Power Density,*” Nuclear Technology vol. 184, Number 3, Dec, 2013.

Shirvan K. and Kazimi M. “*Safety Analysis of BWR-HD: An Optimized BWR for High Power Density,*” Nuclear Technology vol. 184, Number 3, Dec, 2013.

Shirvan K. and Kazimi M. “*Stability Analysis of an Optimized BWR for High Power Density (BWR-HD),*” Nuclear Technology vol. 184, Number 3, Dec, 2013.

Shirvan K., Hejzlar P., and Kazimi M.S., “*The Design of A Compact Integral Medium Size PWR,*” Nuclear Engineering and Design vol. 243, pp. 393-403, Feb 2012.

Peer Reviewed Conference Proceedings

Yenatsky M., **Shirvan K.**, Wysocki A., Morrow R., Ayre D., Green M., Cohen C., “*Modifications to the University of Florida Training Reactor,*” Transactions of the American Nuclear Society, Vol 99, New York, pp. 99-100, 2008.

Shirvan K., Hejzlar P. Shatilla Y. and Kazimi M.S., “*Enhancing the Power Density of IRIS by Compact Steam Generators,*” Transactions of the American Nuclear Society, Vol 100, New York, pp. 567-568, 2009.

Shirvan K., Hejzlar P., and Kazimi M.S., M., “*The Design of a Compact Vessel Integrated LWR,*” Proceedings of International Congress on Advances in Nuclear Power Plants (ICAPP '10), San Diego.

Shirvan K. and Kazimi M.S., “*Limitation of Control Rod Modeling with Current BWR Methods,*” Transactions of the American Nuclear Society, Hollywood, FL, 2011.

Shirvan K. And Kazimi M.S., “*Nuclear Design Behaviour of Helical Cruciform Fuel Rods,*” PHYSOR, Knoxville, TN, 2012.

Shirvan K., Andrews A., Kazimi M.S., “*Best Estimate Void Fraction and Critical Power Correlations for Tight Lattice BWR Bundles,*” International Congress on Advanced Power Plants, Korea, 2013.

Hall, A. Xu Y., Ward A., Downar T., **Shirvan K.**, Kazimi M., “*Advanced Neutronics Methods for Analysis of the RBWR-AC,*” American Nuclear Society Transactions, San Diego, 2013.

Andrews M., **Shirvan K.**, Kazimi M., “*Viability of Uranium Nitride Fueled High-Conversion PWR,*” Proceedings of Innovative Nuclear Energy Systems 4, Japan, 2013.

Shirvan K. Baglietto E., Kazimi M. “*Assessment of a baseline Two Phase CFD closure for PWR applications,*” Transactions of the American Nuclear Society, Washington D.C, 2013.

Shirvan K. Kazimi M. “*Is a PWR SMR or a BWR SMR the Better Choice for the Future?,*” Transactions of the American Nuclear Society, Washington D.C, 2013.

Hall, A., Downar T., Ward A., Jarret M., Wysocki A., Xu Y., **Shirvan K.**, “*Advanced Methods Development for Equilibrium Cycle Calculations of the RBWR,*” ICAPP, Charlotte, NC, 2014.

Shirvan K., Kazimi M.S., Cheng L., Todosow M., Hall A., Jarrett M., Ward A.M., Downar T.J., “*Stability and Safety Analysis of Tight Lattice Breeding LWR,*” ICAPP Charlotte, NC, 2014.

Sukjai Y., **Shirvan K.**, Pilat E., Kazimi M., “*The Effects of SiC Cladding Thickness on Advanced PWR Fuel Rod Performance,*” ICAPP, Charlotte, NC, 2014.

Andrews N., **Shirvan K.**, Pilat E., Kazimi M., “*Impact of SiC Cladding on Plutonium Burning in a Thorium Fueled PWR,*” ICAPP, Charlotte, NC, 2014.

Shirvan K., “*Assessment of BISON Fuel Performance Code and Its Application to Advanced Fuels,*” ICAPP, Charlotte, NC, 2014.

Avincola V., **Shirvan K.**, Kazimi, M., “*Stress Analysis Study of Silicon Carbide Cladding Under Accident Conditions,*” Nuclear Fuels and Structural Materials, ANS annual meeting, Reno, NV, 2014.

Shirvan K., Kazimi M.S., “*Neutronic Challenges of Advanced Boiling Water Reactor Designs,*” PHYSOR, Kyoto, Japan, 2014

Shirvan K., Kazimi M., “*Technical and Economic Viability of Ceramic Multi-Layer Composite SiC Cladding for LWRs,*” IAEA, Oakridge National Lab, 2014.

Andrews N., **Shirvan K.**, Pilat E., Kazimi M., “*Burning Weapons Grade Plutonium in Thorium and Uranium with Silicone-Carbide Cladding,*” American Nuclear Society, Anaheim, CA, 2014.

Bloore D. **Shirvan K.**, Pilat E., Kazimi M., “*Reactor Physics Implications of Advanced SiC-clad Fuel in PWRs,*” American Nuclear Society, Anaheim, CA, 2014.

Shirvan K., Haratyk G., Ballinger R., Buongiorno J., Forsberg C., Kazimi M., Todreas N., “*Advanced Offshore Seabed Reactors*,” ICAPP, France, 2015.

Shirvan K., “*AOA/CRUD Mitigation Techniques Through Core Redesign*,” ICAPP, France, 2015.

Andrews, N., **Shirvan K.**, Pilat E., Kazimi M., “*Economic Assessment of Accident Tolerant Fuel Claddings*,” Advanced Nuclear Fuel Management, Hilton Head 2015.

Mieloszyk A., **Shirvan K.**, Kazimi M., “*A Full Core Integral Fuel Performance Assessment of SiC Cladding Failure Risk*,” Advanced Nuclear Fuel Management, Hilton Head 2015.

Zhao, X. **Shirvan K.**, Wu Y., Kazimi M., “*An Updated Approach to the Prediction of Dryout and Void Fraction for RBWR Bundles*” NURETH, Chicago, 2015.

Haratyk G., **Shirvan K.**, Kazimi M., “*Compact Steam Generator for Nuclear Application*,” NURETH, Chicago, 2015.

Shirvan K., Azizian R., “*Simulation of Orientation Effects on Critical Heat Flux in Downward-Facing Channel for IVR*,” NURETH, Chicago, 2015.

Shirvan K., “*Advanced LWR Fuel Designs with Significant Potential for Power Uprate*,” IAEA Technical Meeting on Greater than 5% fuel, Vienna, 2015.

Guillaume G., **Shirvan K.**, “*Nitride Fuel Potential for Power-Uprates*,” ANS Annual Meeting, New Orleans, 2016

Shirvan K., “*High Power Density Boiling Water Reactor Assembly Design for 500 and 5000 MWh Designs*,” ICAPP, San Francisco, 2016.

Hiscox, B. and **Shirvan, K.** (2016) "Neutronics Analysis of Fuel-in-fiber Concept." Trans. Am. Nucl. Soc., 115 (2016) 1351-1354.

Sukjai Y., **Shirvan K.**, Ballinger R., “*Fuel Performance Modeling of Transuranic Burning Boiling Water Reactor*,” *International Congress on Advances in Nuclear Power Plants (ICAPP)*, Kyoto, 2017.

Wagih M., Che Y., **Shirvan K.**, “*Fuel Performance of Multi-Layered Zirconium Based Accident Tolerant Fuel Cladding*” *ICAPP*, Kyoto 2017.

Genzman G., **Shirvan K.**, Buongiorno J., Golay M., Todreas N., “*Ship Collision Security for an Offshore Nuclear Platform*” *ICAPP*, Kyoto 2017.

Shirvan K., Ballinger R., Kim JH, Hwang, I., “*System Level Thermal-Hydraulic Assessment of a Natural Circulating LFR*” *ICAPP*, Kyoto 2017.

Gurgen A., **Shirvan K.**, “*Estimation of Core Recovery Time with TRACE*,” Proc. Transaction of ANS Annual Meeting, San Francisco, 2017.

Sevecek M., Gurgen A., Seshadri A., Che Y., Wagih M., Phillips B., Champagne V, **Shirvan K.**, “*Development of Cr Cold-Sprayed Fuel Cladding with Enhanced Accident Tolerance*,” *WRFM Meeting*, Jeju Island, Sept 2017.

Shirvan K., Grantom C.R., “*Risk Implications of Using Accident Tolerant Fuels in LWRs*,” Probability Safety Assessment Conference (PSA), Pittsburg, Sept. 2017

X. Zhao, R. Salko, A. Wysocki, K. **Shirvan**, “*Validation and Benchmarking of CTF for Single- and Two-Phase Flow*”, Proceedings of NURETH-17, Xi'an, China Sept. 2017.

Seshadri A., **Shirvan K.**, “*Wettability and Quench Characteristics of Zircaloy and FeCrAl Coating*,” ANS Winter Meeting, Washington DC, Nov 2017.

Shirvan K., Che Y., Sevecek M., Gurgen A., Seshadri A., Wagih M., Phillips B. “*Chromium-Based Accident-tolerant Fuel Concept*,” TMS Annual Meeting & Exhibition, Tuscan, 2018.

Borrel L., **Shirvan K.**, Couet A., “*Implementation and Validation of a physically based fuel cladding oxidation model in BISON for LOCA application*,” TMS Annual Meeting & Exhibition, Tuscan, 2018.

Zhao, X., Wysocki, A., Salko, R., **Shirvan, K.** “*Mechanistic modeling of departure from nucleate boiling under transient scenarios*,” ICAPP, Charlotte, 2018.

Wang, J., Gurgen, A., Corradini, M.L., **Shirvan, K.** “*Accident tolerant fuels benchmark calculation by melcor and trace for a simplified generic pressurized water reactor*,” ICAPP, Charlotte, 2018.

Wu X., Kozlowski T., **Shirvan K.**, “*Inverse Uncertainty Quantification using the Modular Bayesian Approach in the Presence of Model Discrepancy*,” BEPU, Italy, 2018.

Wu X., **Shirvan K.**, Kozlowski T., “*On the Connection between Sensitivity and Identifiability for Inverse Uncertainty Quantification*,” ANS Annual Meeting, Philadelphia, June 2018.

Wu X., **Shirvan K.**, Kozlowski T., “*Validating TRACE Void Fraction Predictive Capability Using the Quantitative Area Validation Metric*,” ANS Annual Meeting, Philadelphia, June 2018.

Snead L., **Shirvan K.**, “*Wigner Energy in SiC and Implications to LWR Design*” ANS Annual Meeting, Philadelphia, June 2018.

Che Y., Wu X., Li W., **Shirvan K.**, Pastore G., Hales J., “*Sensitivity and Uncertainty Analysis of Fuel Performance Assessment of Chromia-Doped Fuel During Large-Break LOCA*,” Topfuel, Prague Oct 2018.

Shahin M., Petrik J., Seshadri A., Philips B., **Shirvan K.**, “*Experimental Investigation of Cold-Spray Chromium Cladding*,” Topfuel, Prague Oct 2018.

Sevecek M., Krijci J., Shahin M., Petrik J., Ballinger R., **Shirvan K.**, “*Fatigue Behavior of Cold-Spray Coated Accident Tolerant Cladding*,” Topfuel, Prague Oct 2018.

Borell L., Wen J., Spencer B., **Shirvan K.**, Couet A., “*Modeling high-temperature corrosion of zirconium alloys fuel cladding using XFEM with BISON*,” NuMat Seattle, Oct 2018.

Seshadri A., **Shirvan K.**, “*Accelerating Introduction of Innovative Claddings through Microscale Phenomenological Understanding of Thermal Hydraulics*,” ANS Winter Meeting: Advances in thermal-hydraulics Topical, Orlando Nov 2018.

Zhao X., **Shirvan K.**, Salko R., “*Machine Learning-Based Critical Heat Flux Predictors in Subcooled and Low-Quality Flow Boiling*” ANS Winter Meeting: Advances in thermal-hydraulics Topical, Orlando 2018.

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Wu X., **Shirvan K.**, “*System Code Evaluation of Accident Tolerant Claddings during BWR Station Blackout Accident*” ANS Winter Meeting, Orlando Nov 2018.

Che Y., Wu X., Li W., **Shirvan K.**, Pastore G., Hales J., “*Sensitivity and Uncertainty Analysis of Fuel Performance Assessment of Chromia-Doped Fuel During Large-Break LOCA*,” ANS Winter Meeting, Orlando, Nov 2018.

Seshadri A., **Shirvan K.** Jacobsen G., Deck C., “*Post-Irradiation Examination of SiC/SiC composite Cladding*,” International Conference on Advanced Ceramics & Composites, Daytona, Florida, Jan 2019.

Shirvan K., Li W., “*Multi-Physics Simulation of SiC/SiC Composite Cladding*,” International Conference on Advanced Ceramics & Composites, Daytona, Florida, Jan 2019.

O’Dell J. S., Snead L., **Shirvan K.**, “*Advanced Metallic-SiC Composite Claddings for Improved Damage Tolerance*,” International Conference on Advanced Ceramics & Composites, Daytona, Florida, Jan 2019.

Borrel L., Fournelle J., **Shirvan K.**, Couet A., “*Physically Based Model and Experimental Validation of Zirconium Alloy Corrosion for LOCA Scenario*,” ASTM 19th International Symposium on Zirconium in the Nuclear Industry, Manchester, UK May 2019.

Hino T., J. Miwa, Y. Murakami, T. Mitsuyasu, H. Soneda, B. A. Lindley, B. Tollit, P. N. Smith, K. **Shirvan**, T. Downar, M. Fratoni, E. Greenspan, Y. Nagaya, “*Core Design of RBWR (Resource-renewable Boiling Water Reactor) and Benchmark Calculation of Core Analysis Tools*,” ICAPP, France, 2019.

White P., **Shirvan K.**, “Impact of technology hazards and regulatory methods on commercial fusion development,” IEEE Transactions on Plasma Science, Special Issue – SOFE2019, Ponte Vedra Beach, FL June 2019.

Lal K., Parsi S.S., Scott D., **Shirvan K.**, Cohen M., Kirchman P., Kosbab B., Whittaker A., “*Cost Basis For Utilizing Seismic Isolation In Nuclear Power Plants*,” Transactions, SMIRT 25, Charlotte NC., Aug 2019.

Tankg C., Grosse M., Steinbrueck M., **Shirvan K.**, “*Oxidation and Quench Behavior of Cold Spraying Cr-Coated Zircaloy Fuel Cladding Under Severe Accident Scenarios*,” Proceeding of TopFuel, Seattle Sept 2019.

Zhao X., **Shirvan K.** Salko R., “*A Robust Mechanistic Approach to Prediction of Departure from Nucleate Boiling*,” Proceeding of TopFuel, Seattle Sept 2019.

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He Y., Deng Y., **Shirvan K.**, “*Full-Core Normal and Preliminary Transient Analysis for SiC-Based Rod Designs*,” Proceeding of TopFuel, Seattle Sept 2019.

Harrison S., **Shirvan K.**, “*Comparative Thermostructural Properties of Commercial and Pre-Commercial Silicon Carbide Fibers*,” 10th International Conference on High Temperature Ceramic Matrix Composites – HT-CMC 10, France, Sept 2019.

Jin Y., Wu X., **Shirvan K.**, *TRACE Simulation of a BWR Large Break LOCA with Zircaloy and Cr-Coated Cladding*, Transaction to ANS Winter Conference, Washington D.C. Nov 2019.

Stewart W.B., Buongiorno J., **Shirvan K.**, Baglietto E., Forsberg C., Driscoll M.J., “*Establishing the Requirements for Japan’s Future Nuclear Energy Systems*,” Transaction to ANS Winter Conference, Washington D.C. Nov 2019.

Li W., **Shirvan K.**, “*Modeling of SiC Cladding Bowing Behavior with Consideration of Spacer Grids*,” Transaction to ANS Winter Conference, Washington D.C. Nov 2019.

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COVID-19 Impacted Accepted Publications (available upon request):

Shirvan K., “*Accident Tolerant Fuels: Misconceptions and Opportunities*,” Proceeding of International Congress on Advances in Nuclear Power Plants (ICAPP), Abu Dahbi, March 2020

Velez Lopez E., Kennard J., Buongiorno J., **Shirvan K.**, Einstein H. H., “*Is embedding the reactor building below grade a cost-effective proposition?*” Proceeding of International Congress on Advances in Nuclear Power Plants (ICAPP), Abu Dahbi, March 2020.

Stewart W. R., Buongiorno J., **Shirvan K.**, Velez E., Baglietto E., Forsberg C., Driscoll M., “*Requirements and Technologies for Japan’s Future Energy Systems (JNext)*,” Proceeding of International Congress on Advances in Nuclear Power Plants (ICAPP), Abu Dahbi, March 2020.

Halimi A. A., **Shirvan K.**, “*A Five-Year Soluble Boron Free iPWR Core Design*,” Proceeding of International Congress on Advances in Nuclear Power Plants (ICAPP), Abu Dahbi, March 2020.

Halimi A. A., **Shirvan K.**, “*Impact of Core Power Density on Economics of a Small Integral PWR*,” Proceeding of International Congress on Advances in Nuclear Power Plants (ICAPP), Abu Dahbi, March 2020.

Lal K., Parsi S. S., Charkas H., **Shirvan K.**, Cohen M. Kirchman P., Kosbab B., Whittaker A., “*Impact of Seismic Isolation on the Overnight Capital Cost of Safety-Related Equipment in Nuclear Reactors*,” Proceeding of International Congress on Advances in Nuclear Power Plants (ICAPP), Abu Dahbi, March 2020.

Wang Y.J., **Shirvan K.**, Hu, L.W., Nielson J., “*Improving Safety Margin and Design Evaluation for Fuel Irradiation Experiments with Uncertainty Quantification Approach*,” Proceeding of Best Estimate Plus Uncertainty Conference, Italy, May 2020.

Ma Z., Li W., **Shirvan K.**, “*Modeling Axial Relocation of Fragmented Fuel during Loss of Coolant Conditions by using ABQUS*,” Proceeding of International Conference on Nuclear Engineering (ICONE), ICONE28-POWER2020, Anaheim, Aug 2020.

Jeong Y.S., **Shirvan K.**, “*Dynamic Analysis of Molten Salt Reactor with Coupled Point Kinetics and Thermal-Hydraulics Model*,” ANS Summer Meeting Transactions, Pheonix, June 2020.

Invited Talks

Shirvan K., “*Annular Fuel Design for LWRs*,” University of Reno-Nevada, April, 2013.

Shirvan K., “*Fuel Performance with BISON*,” Consortium for Advanced Nuclear Simulation of LWRs Summer Workshop at ORNL, Knoxville, Tennessee, 2014 & 2015 & 2017 & 2018 & 2019.

Shirvan K., Kazimi M.S., “*Neutronic Challenges of Advanced Boiling Water Reactor Designs*,” Reactor Physics of Non-Traditional LWR Fuel Design Special Session, PHYSOR, Kyoto, Japan, 2014.

Shirvan K., “*Multi-layer Ceramic Matrix Composite Silicon Carbide Cladding for Light Water Reactors*,” Advanced Materials for Sustainable Nuclear Fission and Fusion Energy Special Session, International Conference on Advanced Ceramics & Composites, Daytona, Florida 2016.

Shirvan K., “*Assessment of the V&V Challenges of Accident Tolerant Fuels*” Multiphysics Models Validation Workshop, NC State University, Rayleigh NC, July 2017.

Shirvan K., “*Innovation in Nuclear Technology: Past, Present and Future*,” Nuclear Innovation Bootcamp, UC Berkeley, Berkeley, CA, July 2017

Shirvan K., “*Advanced Fuels R&D: Challenges and Opportunities*” Nuclear Power Institute of China (NPIC) Advanced Methods in Nuclear Reactor Design Workshop, Chengdu, China, October 2017

Shirvan K., “*Acceleration of Fuel Qualification using Modeling and Simulation*” INL EROB & MFC Seminar, Idaho Falls, Idaho, April 2018

Shirvan K., “*Accident Tolerance Fuels R&D: Challenges and Opportunities*”, GE-Hitachi Nuclear, Wilmington, North Carolina, Aug 2018.

Shirvan K., “*Implication of LWR Mechanical Failure Modes, Reactor Environment and Accident Tolerant Fuels on Thermal-Hydraulic Research*,” International Seminar on Nuclear Reactor Core Thermal Hydraulics Analysis (ISReCTHA), Lecco, Italy, Aug 2018.

Shirvan K., “The Safety and Economic Implications of ATFs,” International Uranium Fuel Seminar, Boston, MA, October, 2018.

Shirvan K., “Accident Tolerant Fuel Data Gaps and Failure Modes” Advanced Fuels Campaign Annual Meeting, Gainesville, Florida, Dec 2018.

Shirvan K., “Discussion on role of Modern Experimentation, Simulation and Data Processing to Support Nuclear Fuel R&D” Materials and Fuels Complex, Idaho National Laboratory, Feb 2019.

Shirvan K., “Acceleration of Innovative Nuclear Fuel Development for Sustainability of the Existing Fleet,” Key Note Speaker, Applied Energy A+B Conference, May, 2019.

Shirvan K., “Nuclear Material Study Using a Combined M and E,” MeV Summer School, Oakridge National Laboratory, July, 2019.

Shirvan K., “System Codes Comparison for Time-to-Fuel Failure Analysis,” Enhanced Resilient Plant (ERP) Workshop, Idaho National Laboratory, July 2019.

Shirvan K., “Deep Dive in SMR Cost Drivers,” International Congress on Advances in Nuclear Power Plants (ICAPP), Invited Plenary Chair, March 2020.

Shirvan K., “AI for Nuclear Core Design” Idaho National Laboratory, ML/AI Symposium 2.0, July, 2020.

Shirvan K., “ATF Modelling,” MeV Summer School, Idaho National Laboratory, July, 2020.

Patents

Organically Cooled Nuclear Reactor for Enhanced Economics and Safety, U.S. Patent No. 20,150,348, 654. 3 Dec. 2015. Filed 27 May 2014.

Superhydrophobic Surfaces, U.S. Patent No. 16/842,110, 7 Apr. 2020. Filed June 18, 2019

Major Reports

Kazimi, M.S., Hejzlar P., Shatilla Y., Feng B., Ko Y., Pilat E., **Shirvan K.**, Whitman J., and Hamed A., “A High Efficiency and Environmentally Friendly Nuclear Reactor (HEER) for Electricity and Hydrogen”, MIT-ANP-TR-125, October 2009.

Shirvan K., Smith K., “CRUD Collector Feasibility Study,” CANES FINAL REPORT, October, 2013.

Sukjai Y, Pilat E, **Shirvan K.**, Kazimi MS, “Silicon Carbide Performance as Cladding for Advanced Uranium and Thorium Fuels for Light Water Reactors,” MIT-ANP-TR-1492014

Shirvan, K., Ballinger R., Buongiorno J., Forsberg C., Kazimi M., Todreas N., “Advanced Offshore Seabed Reactors,” MIT-ANP-TR-155, MIT, Cambridge, August 2014.

Shirvan K., Daines G., Sukjai Y, Kang P., Li J., “Silicon Carbide Performance as Cladding for Advanced Uranium and Thorium Fuels for Light Water Reactors,” MIT-ANP-TR-167, 2016

Shaner S., **Shirvan K.**, Pilat E., Ballinger R., “Going Beyond 5 Percent Enrichment,” MIT-NFC-TR-134, CANES Report, 2016.

Shirvan K., Ballinger R. “Lead Bismuth Cooled Fast Reactor System Performance Verification and Validation”, MIT-ANP-TR-171, CANES Report, 2017.

Shirvan K., “Development of Accident Tolerant Fuel Options For Near Term Applications: Final Report,” DOE NEUP Project No. 15-8843, 2018.

Buongiorno J., **Shirvan** K., Baglietto E., Forsberg C., Driscoll M., Einstein H., Macdonald I., W.R. Stewart, Velez-Lopez E., Johnston K., Hashimoto G., “Japan’s Next Nuclear Energy,” MIT-ANP-TR-187 (REV 1), MIT, Cambridge, April 2020.