Renewable Energy Research

Renewable Energy Research

Dr. Rama Venkat
Dean, College of Engineering
Phone: (702) 895-1094
Email: Rama.Venkat@unlv.edu

Dr. Mohamed Trabia
Associate Dean, College of Engineering
Phone: (702) 895-0957
Email: Mohamed.Trabia@unlv.edu

For more than a decade, UNLV researchers have engaged in world-class efforts to study various aspects of renewable energy. This research program has received funding by federal and state agencies, as well as many industrial partners. Our researchers have addressed questions related to many topics, including solar and wind energies, fuel cells and "smart grid" technology.

We would like to introduce you to some of our researchers. Please contact us if we can help with future collaboration.

Photo on slide 1: DesertSol, UNLV's entry into the 2013 U.S. DoE Solar Decathlon, won second place, making it the highest-ranked of all U.S. schools.

Renewable Energy
Research Areas of Expertise

- Electric power systems and power quality
- Solar power generation
- Design of grid-tied and standalone photovoltaic (PV) systems
- Power plant dry cooling
- Solar thermal applications: domestic hot water, process heat, cooling
- Thermosiphon-driven solar heaters
- Solar hybrid lighting
- Wind energy assessment
- Aerodynamics of turbine blades
- Solar-powered atmospheric water harvesting
- Vehicle design with fuel cells and alternative fuels
- Hybrid electric vehicles and battery charging systems
- Third generation dye-sensitized solar cells
- Flow studies for solid solar receivers
- Photocatalysts for solar energy conversion
- Molten salt technology as a heat energy storage medium
- Combustion and propulsion modeling
- Molten salt properties and storage vessel design
- Soft polymeric materials for efficient heat and mass transfer

Renewable Energy Research

Why UNLV?

- UNLV is a leader among the state's public entities dedicated to advancing renewable energy in the region and beyond.
- UNLV is located centrally in the southwest, close to many renewable energy resources including solar, wind, and geothermal energies.
- UNLV has been the host site of the *National Clean Energy Summit*, as well as other important international meetings.
- UNLV is now considered a convening center for renewable energy leaders throughout the nation and world.

Renewable Energy Research

Why UNLV?

- UNLV's outstanding achievements in renewable energy research, its success in forging public/private partnerships, and its excellent academic programs place the university at the forefront of the field.
- UNLV has acquired more than $99 million in research funding in the past decade on wide-ranging subjects in the clean energy area, including:
  - Solar and geothermal power;
  - Biofuels;
  - Photonics;
  - Nuclear energy and the reprocessing of nuclear waste; and
  - Hydrogen production, storage, and use.

Faculty Involved in Renewable Energy Research

Dr. Yahia Baghzouz
Professor, Department of Electrical and Computer Engineering
Co-Director, Center for Energy Research

Dr. Shubhra Bansal
Assistant Professor, Department of Mechanical Engineering

Dr. Wolfgang Bein
Professor, Department of Computer Science
Co-Director, Center for Information Technology and Algorithms

Dr. Robert Boehm, P.E.
Distinguished Professor, Department of Mechanical Engineering
Director, Center for Energy Research

Dr. Yi-Tung Chen
Professor, Department of Mechanical Engineering
Co-Director, Center for Energy Research

Dr. Jeremy Cho
Assistant Professor, Department of Mechanical Engineering

Dr. William Culbreth
Associate Professor, Department of Mechanical Engineering

Dr. Samaan Ladkany
Professor, Department of Civil & Environmental Engineering & Construction

Dr. Jaeyun Moon
Associate Professor, Department of Mechanical Engineering

Dr. Samir Moujaes, P.E.
Professor, Department of Mechanical Engineering

Dr. Darrell Pepper
Professor, Department of Mechanical Engineering

Dr. Hui Zhao
Associate Professor, Department of Mechanical Engineering

Renewable Energy Research

Additional Resources
Center for Energy Research
Center for Materials and Structures
Solar Energy Initiative
Team Las Vegas Solar Decathlon 2017

Renewable Energy
Research Highlights

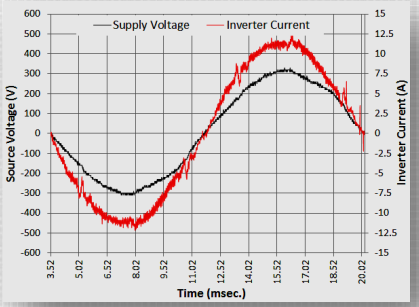
Renewable Energy Research

Dr. Yahia Baghzouz
Professor, Department of Electrical and Computer Engineering
Co-Director, Center for Energy Research

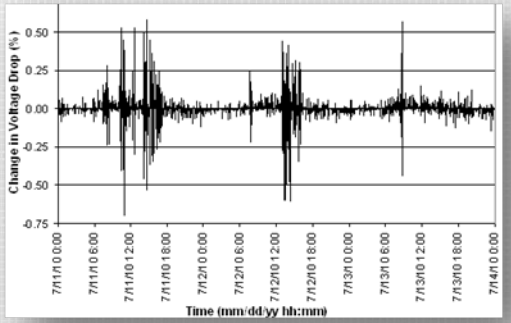
Phone: (702) 895-0887

Email: yahia.baghzouz@unlv.edu

- Expertise
  - Electric power systems, power quality, and static power converters
  - Design of grid-tied and standalone photovoltaic (PV) systems
  - Impact of partial shading on PV array performance
  - Impact of distributed generation in electrical distribution systems
  - Hybrid electric vehicles and battery charging systems
  - Demand-side management
  - Smart Grid concepts



Determining voltage quality through computer simulations.



Searching for the impact of PV power fluctuations.

Testing bifacial PV panel to search for an accurate electrical circuit model.

Renewable Energy Research

Dr. Yahia Baghzouz

Professor, Department of Electrical and Computer Engineering
Co-Director, Center for Energy Research

Relevant Publications

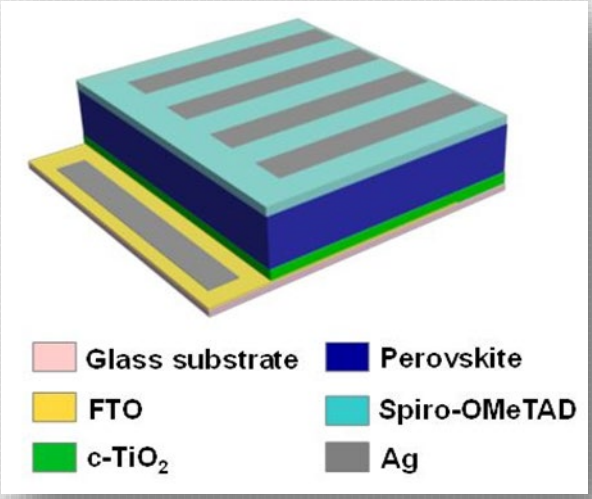
- C. Hicks and Y. Baghzouz, "Experimental Steady-State and Transient Analysis of a Behind-The-Meter Battery Storage for Residential Customers with PV Systems", *IEEE International Conference on Clean Electric Power*, Otranto, Italy, July 2-5, 2019. art. no. 8890193, pp. 438-443.
- Blackstone, B., Hicks, C., Gonzalez, O., Baghzouz, Y. (2018) "Development of an Outdoor Diesel Generator - PV Microgrid for Education and Research" (Conference Paper) IEEE Power and Energy Society General Meeting (2018), 8586424.
- Pinzon, A.M.O., Silveira, P.M.D., Baghzouz, Y. (2018) "Simulation of microgrid hierarchical control" (Conference Paper) Proceedings of International Conference on Harmonics and Quality of Power, ICHQP, pp. 1-6.
- Hicks, C., Baghzouz, Y., Haddad, S., "Power quality of residential PV system under low solar irradiance and off-grid operation" (Conference Paper) Proceedings of International Conference on Harmonics and Quality of Power, ICHQP, pp. 1-5 (2018).
- A. Arabali, M. Ghofrani, M. Etezadi-Amoli, M. Fadali and Y. Baghzouz, "Optimal Genetic Algorithm-Based Optimization Approach for Energy Management", submitted to *IEEE Transactions on Power Delivery*, Issue: 99, Nov. 2012.
- J. Johnson, D. Yoon and Y. Baghzouz, "Modeling and Analysis of a Bifacial Grid-Connected PV System", IEEE/PES General Meeting, July 22-27, 2012.
- B. Blackstone, Y. Baghzouz, and S. Premrudeepreechacharn, "Determining MPPT and Anti-Islanding Techniques in a Grid-Tie PV Inverter", Proc. IEEE/ICHQP, June 28-30, 2012.
- X. Chen, J.P. Caputo and Y. Baghzouz, "Harmonic Analysis of Ferroresonance in Single-Phase Transformers," Proc. IEEE/ICHQP, June 28-30, 2012.
- W. Peng, S. Haddad, Y. Baghzouz, "Improving power quality in distribution feeders with high PV penetration through inverter controls," *CIRED*, May 29-30, 2012.
- W. Peng and Y. Baghzouz, "Accurate circuit model for steady-state and dynamic performance of lead-acid AGM batteries", International Conference and Utility Exhibition on Power and Energy Systems, Pattaya City, Thailand, September 28-30, 2011.

Renewable Energy Research

Dr. Shubhra Bansal
Assistant Professor, Department of Mechanical Engineering

Phone: (702) 895-2720
Email: shubhra.bansal@unlv.edu

- Expertise
  - Performance and reliability of thin film photovoltaic devices
  - PV module and device reliability
  - Physics-based life prediction models for design and materials control
  - Energy conversion and storage



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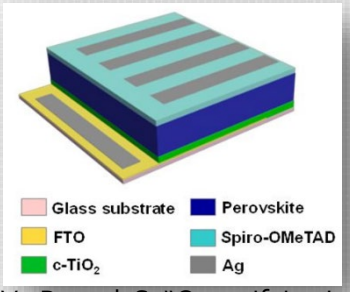


Dr. Shubhra Bansal

Assistant Professor, Department of Mechanical Engineering

Relevant Publications

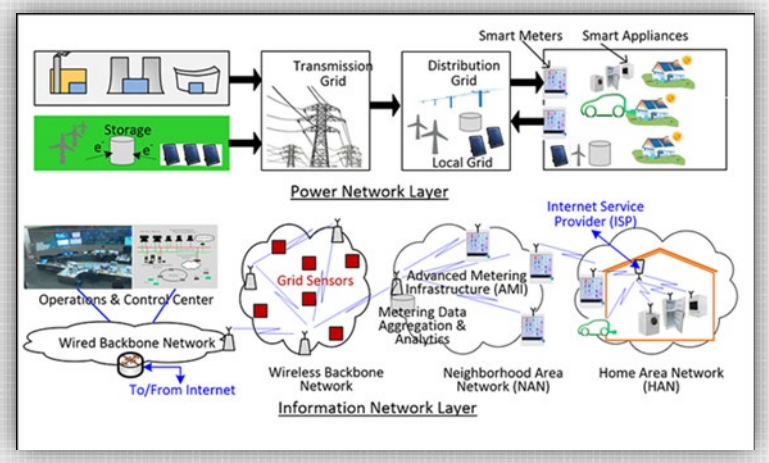
- Nardone, M., Patikirige, Y., Kweon, K.E., Walkons, C., Magorian Friedlmeier, T., Varley, J.B., Lordi, V., Bansal, S. "Quantifying Large Lattice Relaxations in Photovoltaic Devices" (2020) *Physical Review Applied*, 13 (2), art. no. 024025
- Nardone, M., Patikirige, Y., Walkons, C., Bansal, S., Friedlmeier, T.M., Kweon, K.E., Varley, J.B., Lordi, V. "Baseline Models for Three Types of CIGS Cells: Effects of Buffer Layer and Na Content" (2018) IEEE 7th World Conference on Photovoltaic Energy Conversion, WCPEC 2018 - A Joint Conference of 45th IEEE PVSC, 28th PVSEC and 34th EU PVSEC, art. no. 8548167, pp. 3013-3018.
- "Evaluation of new materials for electron and hole transport layers in perovskite-based solar cells through SCAPS-1D simulations" (Conference Paper) Bansal, S., Aryal, P. (2017) IEEE 44th Photovoltaic Specialist Conference, PVSC 2017pp. 1-4.
- Bansal, S., & Chiu, M. (2017). "Atmospherically Processed and Stable Cs-Pb Based Perovskite Solar Cells." *MRS Advances*, *2*(53), 3083-3090. doi:10.1557/adv.2017.449.
- Bansal, S., Aryal, P., "Evaluation of new materials for electron and hole transport layers in perovskite-based solar cells through SCAPS-1D simulations", Conference Record of the IEEE Photovoltaic Specialists Conference Volume November 2016, Article number 7749702, Pages 747-75043rd (2016); Category number CFP16PSC-ART; Code 124913.
- Bansal, S., Aryal, P. "Evaluation of new materials for electron and hole transport layers in perovskite-based solar cells through SCAPS-1D simulations" (2016) Conference Record of the IEEE Photovoltaic Specialists Conference, 2016-November, art. no. 7749702, pp. 747-750.
- Li, J.V., Halverson, A.F., Sulima, O.V., Bansal, S., Burst, J.M., Barnes, T.M., Gessert, T.A., Levi, D.H. "Theoretical analysis of effects of deep level, back contact, and absorber thickness on capacitance-voltage profiling of CdTe thin-film solar cells" (2012) *Solar Energy Materials and Solar Cells*, 100, pp. 126-131.
- Schoeller, H., Bansal, S., Knobloch, A., Shaddock, D., Cho, J. "Effect of alloying elements on the creep behavior of high Pb-based solders" (2011) *Materials Science and Engineering* A, 528 (3), pp. 1063-1070.
- Schoeller, H., Bansal, S., Knobloch, A., Shaddock, D., Cho, J. "Microstructure evolution and the constitutive relations of high-temperature solders" (2009) *Journal of Electronic Materials*, 38 (6), pp. 802-809.
- Bansal, S., Toimil-Molares, E., Saxena, A., Tummala, R.R. "Nanoindentation of single crystal and polycrystalline copper nanowires" (2005) Proceedings - Electronic Components and Technology Conference, 1, pp. 71-76.

Renewable Energy Research

Dr. Wolfgang Bein
Professor, Department of Computer Science
Co-Director, Center for Information Technology and Algorithms (CITA)
Phone: (702) 895-1477
Email: wolfgang.bein@unlv.edu

- Expertise
  - Speed scaling scheduling for CPUs
  - Online energy management: manage variables, distributed and unpredictable supply from renewables
  - Game theoretic approaches for energy networks

Dependable renewable energy distribution.



Algorithm designs for the Smart Grid.

Renewable Energy Research

Dr. Wolfgang Bein

Professor, Department of Computer Science

Co-Director, Center for Information Technology and Algorithms (CITA)

Relevant Publications

- James Andro-Vasko, Wolfgang Bein, Hiro Ito. "Energy Efficiency and Renewable Energy Management with Multi-state Power-down Systems", *Information* (2019).
- Bein W. "Energy Saving in Data Centers". *Electronics* (2018); 7(1):5.
- Andro-Vasko J., Avasarala S.R., Bein W. (2018). "Continuous State Power-Down Systems for Renewable Energy Management." In: Latifi S. (eds) *Information Technology - New Generations. Advances in Intelligent Systems and Computing*, vol 738, Springer Verlag,pp 701-707.
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- Wolfgang Bein, Bharat Madan, Doina Bein, and Dara Nyknahad (2016). "Algorithmic Approaches for a Dependable Smart Grid". *Advances in Intelligent Systems and Computing*, Springer Verlag. 448.
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- Chen J, Han X, Bein W, Ting H. "Black And White Bin Packing Revisited", Proceedings of the 9th Annual International Conference on Combinatorial Optimization and Applications (COCOA 15), LNCS, Springer (2015).
- Andro-Vasko J, Bein W, Ito H, Nyknahad D. "Evaluation of Online Power-Down Algorithms", Proceedings of the 12th International Conference on Information Technology, IEEE, 473-478 (2015).
- Bein W, "Advanced Techniques for Dynamic Programming". In Pardalos P, Du D., Graham R, Editors, *Handbook of Combinatorial Optimization*, 2nd Edition, Springer Verlag, 41 – 91 (2013).
- Bein W, Bein D, "Fault Tolerance and Transmission Reliability in Wireless Networks." In Khan S, Zomaya A, Wang L, Editors, in *Scalable Computing and Communications: Theory and Practice*, John Wiley & Sons, 227 – 256 (2013).

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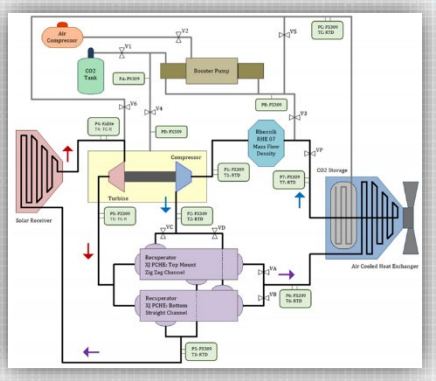
Dr. Robert Boehm, P.E.
Distinguished Professor, Department of Mechanical Engineering
Director, Center for Energy Research

Phone: (702) 895-4160
Email: bob.boehm@unlv.edu
Website for the Center for Energy Research: www.unlv.edu/cer

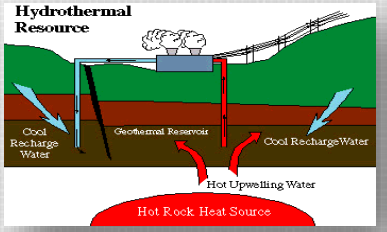


UNLV-designed supercritical CO_2 engine

- Expertise
  - Solar power generation (PV, CPV, CSP)
  - Power plant dry cooling
  - Solar thermal applications: domestic hot water, process heat, cooling
  - Energy conservation and solar applications in buildings
  - Solar hybrid lighting
  - Renewable hydrogen generation
  - Vehicle design with fuel cells and alternative fuels
  - Geothermal power production

Center: At UNLV, a solar powered supercritical CO_2 engine has been developed. It is driven by the dish system shown in the picture.
Bottom: Pictured are some of the roofs in the Villa Trieste project with solar PV panels. 164 project homes were built to minimize peak electrical demand by Pulte Homes with the design assistance of the UNLV CER.

Renewable Energy Research



Geothermal electric power generation

Dr. Robert Boehm, P.E.

Distinguished Professor, Department of Mechanical Engineering

Director, Center for Energy Research

Relevant Publications

- S. Jakhar, M. S. Soni, and R. F. Boehm, "Thermal Modeling of a Rooftop Photovoltaic/Thermal System with Earth Air Heat Exchanger for Combined Power and Space Heating", *Journal Of Solar Energy Engineering*, 140, 2018, 15 pages.
- S. Madala and R. Boehm, "A Review of Nonimaging Solar Concentrators for Stationary and Passive Tracking Applications," *Renewable And Sustainable Energy Reviews*, 71, 2017, pp. 309-322.
- S. Madala and R. Boehm, "Effect of Reflection Losses on Stationary Dielectric-Filled Nonimaging Concentrators", *Journal Of Photonics For Energy*, 6(4), 2016, pp. 047002: 1-14.
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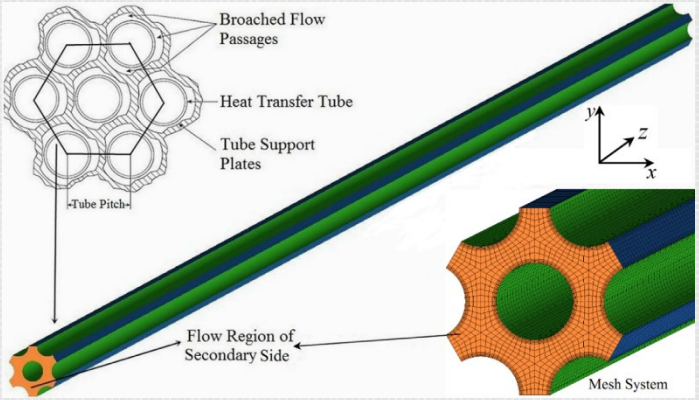
- R. Boehm, "The Nexus between Solar Energy, Water, and the Environment" (Keynote), Proceedings of the 2016 Energy & Water Symposium, Windsor, Ontario, Canada, June 22-23, 2016.
- R. Boehm, H. Yang, J. Yan, Chapter I.1.1. "Introduction: Renewable Energy", in *Handbook Of Clean Energy Systems* (J. Yan, Editor in Chief), Wiley, 2015, pp. 3-8.
- R. Boehm, Chapter I.4.16 "Brief Introduction to Solar Energy Utilization," in *Handbook Of Clean Energy Systems* (J. Yan, Editor in Chief), Wiley, 2015, pp. 265-282.
- R. Boehm, Chapter I.4.21 "Solar Water Heating", in *Handbook Of Clean Energy Systems* (J. Yan, Editor in Chief), Wiley, 2015, pp. 335-354.
- Y. Moumouni, Y. Baghzouz, R. Boehm, "Power Smoothing of a Commercial-size Photovoltaic System by an Energy Storage System," IEEE 16th International Conference on Harmonics and Quality of Power (ICHQP), Bucharest, Romania, May 25-28, 2014.
- Y. Moumouni, R. Boehm, "Utilization of Energy Storage to Buffer PV Output during Cloud Transients," *Applied Mechanics And Materials*, Volume 705, Chapter 5, 2014, pp. 295-304.

Renewable Energy Research

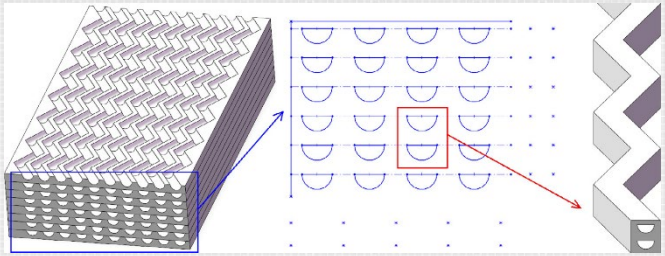
Dr. Yi-Tung Chen
Professor, Department of Mechanical Engineering
Co-Director, Center for Energy Research

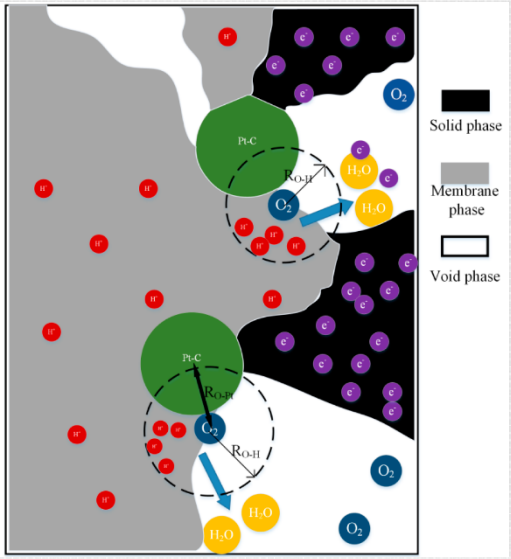
Phone: (702) 895-1202

Email: yitung.chen@unlv.edu



- Expertise
  - Computational fluid dynamics
  - Numerical heat and mass transfer related to thermal system design
  - Renewable energy
  - High temperature heat exchanger and decomposer design
  - Corrosion modeling
  - Fuel cells (PEMFC and SOFC)





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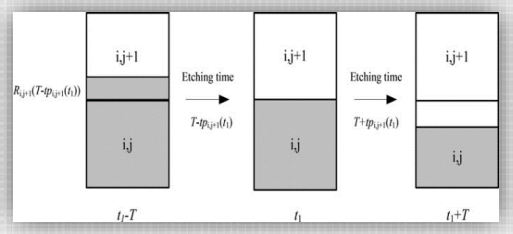
Dr. Yi-Tung Chen

Professor, Department of Mechanical Engineering
Co-Director, Center for Energy Research



Relevant Publications

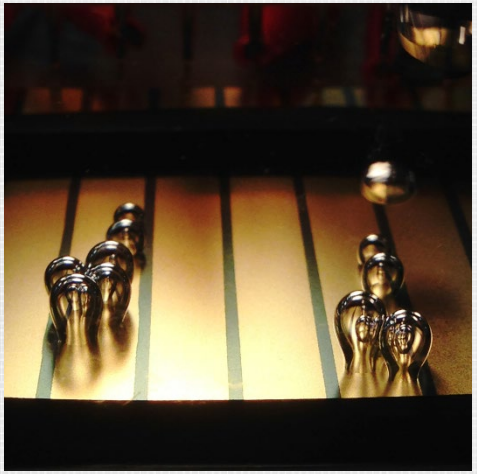
- Wei, H., Chen, Y.-T. "Numerical investigation of the internally heated melt pool natural convection behavior with the consideration of different high internal Rayleigh numbers" (2020) *Annals of Nuclear Energy*, 143, art. no. 107427.
- Bennett, K., Chen, Y.-T. "Thermal-hydraulic correlations for zigzag-channel PCHEs covering a broad range of design parameters for estimating performance prior to modeling" (2020) *Thermal Science and Engineering Progress*, 17, art. no. 100383.
- Li, X., Qi, P., Tan, S., Li, D., Chen, Y., Wang, X. "Experimental study of transient friction characteristics and velocity distribution of pulsatile flow in rod bundles" (2020) Annals of Nuclear Energy, 140, art. no. 107124.
- Zhao, Z., Chen, Y., Sun, B., Shi, J., Yu, X., Wu, W. "Non-uniform thermal-hydraulic behavior in a 61-rod bundle of supercritical water-cooled reactor "(2020) *Applied Thermal Engineering*, 171, art. no. 114688.
- Ma, T., Zhang, P., Shi, H., Chen, Y., Wang, Q. "Prediction of flow maldistribution in printed circuit heat exchanger" (2020) *International Journal of Heat and Mass Transfer*, 152, art. no. 119560.
- Kekaula, K., Chen, Y. "Theoretical analysis of filmwise condensation in inclined tubes with nondivergent and irrotational flow components" (2020) *International Journal of Heat and Mass Transfer*, 151, art. no. 119444.
- Bennett, K., Chen, Y.-T. "One-way coupled three-dimensional fluid-structure interaction analysis of zigzag-channel supercritical CO<inf>2</inf> printed circuit heat exchangers" (2020) *Nuclear Engineering and Design*, 358, art. no. 110434.
- Yang, L., Shao, Y., Chen, Y., Li, Y., Song, F., Hu, Y., Zhang, G., Zhang, X., Xu, R. "Numerical investigation of a burning fuel droplet pair with different spacings and sizes" (2020) *Combustion Theory and Modelling*, 24 (1), pp. 41-71.
- Chu, W., Li, X., Chen, Y., Wang, Q., Ma, T. "Experimental Study on Small Scale Printed Circuit Heat Exchanger with Zigzag Channels" (2020) *Heat Transfer Engineering*.
- Lu, X., Yu, X., Wang, Q., Chen, Y., Ma, T. "Numerical study on nonuniform segmented enhancement method for thermoelectric power generator" (2019) *Numerical Heat Transfer*; Part A: Applications, 76 (8), pp. 605-627

Renewable Energy Research

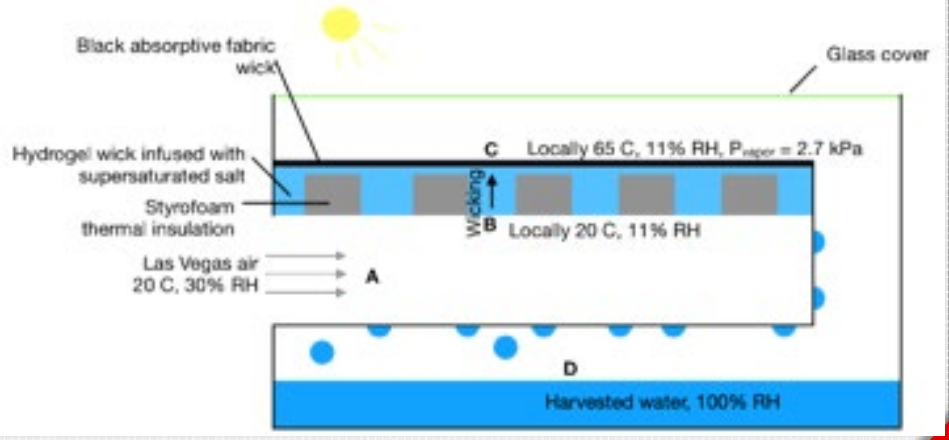
Dr. Jeremy Cho
Assistant Professor, Department of Mechanical Engineering

Phone: (702) 895-4701

Email: jeremy.cho@unlv.edu



- Expertise
  - Liquid-vapor phase-change heat transfer for enhanced thermal management
  - Soft polymeric materials for efficient heat and mass transfer
  - Solar-powered atmospheric water harvesting



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Dr. Jeremy Cho
Assistant Professor, Department of Mechanical Engineering

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- H. J. Cho, D. J. Preston, Y. Zhu, E. N. Wang (2016), "Nanoengineered materials for liquid–vapour phase-change heat transfer," *Nature Reviews Materials*, 2, 16092.
- H. J. Cho, J. P. Mizerak, E. N. Wang (2015), "Turning bubbles on and off during boiling using charged surfactants," *Nature Communications*, 6(1), 1–7.
- H. Kim, H. J. Cho, S. Narayanan, S. Yang, H. Furukawa, S. Schiffres, X. Li, Y. Zhang, J. Jiang, O. M. Yaghi, E. N. Wang (2016), "Characterization of adsorption enthalpy of novel water-stable zeolites and metal-organic frameworks," *Scientific Reports*, 6, 1–7.
- H. J. Cho, E. N. Wang (2019), "Bubble nucleation, growth, and departure: A new dynamic understanding," *International Journal of Heat and Mass Transfer*, 145, 118803.
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- H. J. Cho, S. S. Datta (2019), "Scaling Law for Cracking in Shrinkable Granular Packings," *Physical Review Letters*, 123(15), 158004.
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Renewable Energy Research

Dr. William Culbreth
Associate Professor, Department of Mechanical Engineering

Phone: (702) 895-3426

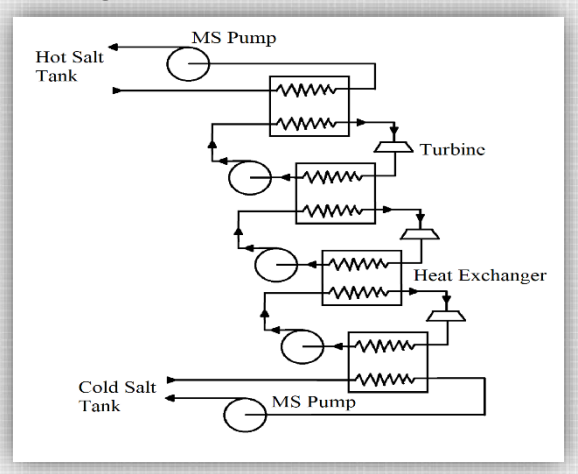
Email: william.culbreth@unlv.edu

Dr. Samaan Ladkany
Professor, Department of Civil & Environmental Engineering & Construction

Phone: (702) 895-3438

Email: samaan.ladkany@unlv.edu

- Expertise
  - Research on molten salts as a heat energy storage medium
  - Molten salt properties and storage vessel design



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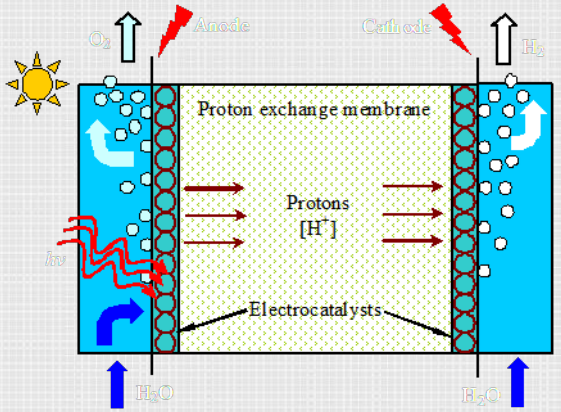
Associate Professor, Department of Mechanical Engineering

Dr. Samaan Ladkany
Professor, Department of Civil & Environmental Engineering & Construction



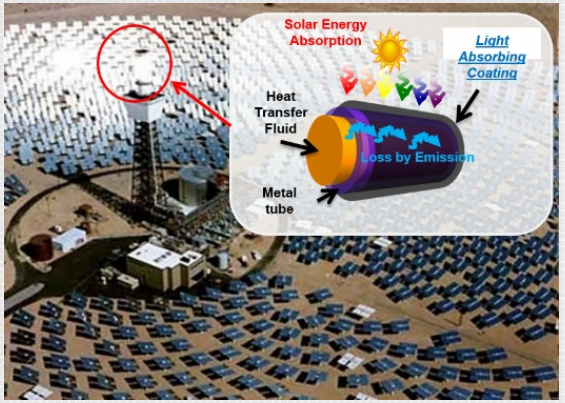
- Samaan Ladkany, William Culbreth, and Nathan Loyd, "Molten Salts and Applications I: Molten Salt History, Types, Thermodynamic and Physical Properties, and Cost," *Journal of Energy and Power Engineering*, 12, 507-516 (2018).
- Samaan Ladkany, William Culbreth, and Nathan Loyd, "Molten Salts and Applications II: 565°C Molten Salt Solar Energy Storage Design, Corrosion, and Insulation," *Journal of Energy and Power Engineering*, 12, 517-532 (2018).
- Samaan Ladkany, William Culbreth, and Nathan Loyd, "Molten Salts and Applications III : Worldwide Molten Salt Technology Developments in Energy Production and Storage," *Journal of Energy and Power Engineering*, 12, 533-544 (2018).
- Kimberly Gonzalez and William Culbreth, "Heat Pump Cycles for Electrical Power Storage using Nitrate and Chloride Salts", accepted for publication and presentation at the International Conference on Renewable Energy (ICREN) 2019, April 24-27, Paris France.
- William Culbreth and Kimberly Gonzalez, "Molten Salt Energy Storage for a Renewable Energy Grid", International Conference on Renewable Energy (ICREN), 2018, April 25 – 27, Barcelona, Spain.

Renewable Energy Research

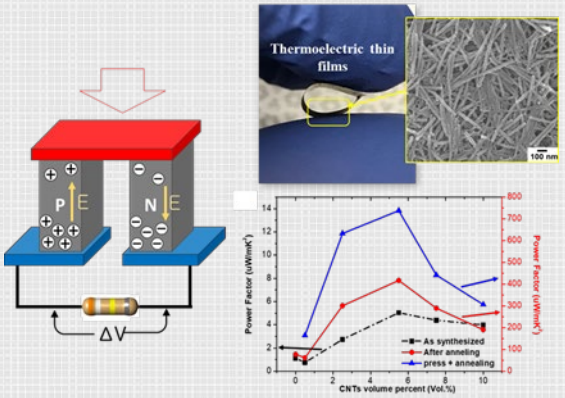
Dr. Jaeyun Moon
Associate Professor, Department of Mechanical Engineering
Phone: (702) 895-5611

Email: jaeyun.moon@unlv.edu
Website: http://jmoon.faculty.unlv.edu/

- Expertise
  - Thermoelectric nanomaterials and device fabrication
  - Nanostructured light-absorbing coatings for advanced Concentrating Solar Power (CSP)
  - Photocatalysts for solar energy conversion
  - Electrical and thermal properties of inorganic and hybrid (inorganic-organic) materials



Ivanpah Solar Electric Generating System and a schematic diagram of solar receivers.



Thermoelectric generators (TEGs) can directly convert heat energy to electricity.

Renewable Energy Research

Dr. Jaeyun Moon

Associate Professor, Department of Mechanical Engineering

Relevant Publications

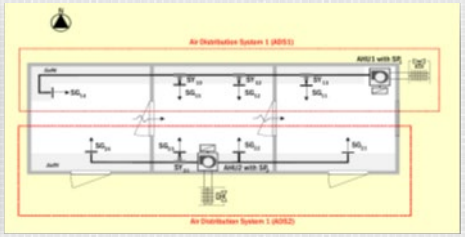
- DeAngelis, F., Muraleedharan, M.G., Moon, J., Seyf, H.R., Minnich, A.J., McGaughey, A.J.H., Henry, A. "Thermal Transport in Disordered Materials" (2019) *Nanoscale and Microscale Thermophysical Engineering*, 23 (2), pp. 81-116.
- H. An, M. Pusko, D. Chun, J. Moon, "In-situ synthesis of flexible hybrid composite films for improved thermoelectric performance", *Chemical Engineering Journal* 357, 547-558 (2019).
- D. E. Karas, J. Byun, C. Jose, S. Tam, J. Moon, "Copper-oxide spinel absorber coatings for high-temperature concentrated solar power systems", *Solar Energy Materials and Solar Cells* 182 321-330 (2018).
- H. An, D. Karas, B. Kim, S. Trabia, J. Moon, "Flexible n-type thermoelectric composite films with enhanced performance through interface engineering and post-treatment", *Nanotechnology* 29 (27) 275403 (2018).
- E. Dechaumphai, J. Moon, M. C. Wingert and R. Chen, "Phononic and Electronic Engineering in Nanowires for Enhanced Thermoelectric Performance" in *Semiconductor Nanowires: From Next-Generation Electronics to Sustainable Energy*, Royal Chemistry of Society, London, UK (2015).
- J. Moon, D. Lu, B. VanSaders, T. K. Kim, S. D. Kong, S. Jin, R. Chen and Z. Liu, "High Performance Multi-scaled Nanostructured Spectrally Selective Coating for Concentrated Solar Power", *Nano Energy*, 8 238-246 (2014).
- T. K. Kim, J. Moon, B. VanSaders, D. W. Chun, J. Y. Jung, G. Wang, R. Chen, Z. Liu, Y. Qiao and S. Jin, "Si-Si Boride Core-Shell Nanoparticles with Improved Oxidation Resistance for High Temperature Applications", *Nano Energy*, 9 32-40 (2014).
- E. Dechaumphai, D. Lu, J. Kan, J. Moon, E. Fullerton, Z. Liu and R. Chen, "Ultralow Thermal Conductivity of Multilayers with Highly Dissimilar Debye Temperatures", *Nano Letters* 14 (5) 2448–2455 (2014).
- E. Dechaumphai, J. L. Barton, J. R. Tesmer, J. Moon, Y. Wang, G. R. Tynan, R. P. Doerner and R. Chen, "Near-Surface Thermal Characterization of Plasma Facing Components Using the 3-omega Method", *Journal of Nuclear Materials* 455(1) 56-60 (2014).
- J. Moon, J. H. Kim, Z. C.Y. Chen, J. Xiang and R. Chen, "Gate-Modulated Thermoelectric Power Factor of Hole Gas in Ge–Si Core–Shell Nanowires", *Nano Letters*, 13 1196–1202 (2013).

Renewable Energy Research

Dr. Samir Moujaes, P.E.
Professor, Department of Mechanical Engineering

Phone: (702) 895-3265
Email: samir.moujaes@unlv.edu

- Expertise
  - Phase studies for alternative fuels derived from coal
  - Flow studies for solid particle solar receivers
  - Computer simulation of thermosiphon-driven solar heaters
  - Two-phase and three-phase flow thermal hydraulics studies
  - Energy conservation and HVAC systems



A schematic of UNLV's Air Duct Leakage Laboratory (ADLL).

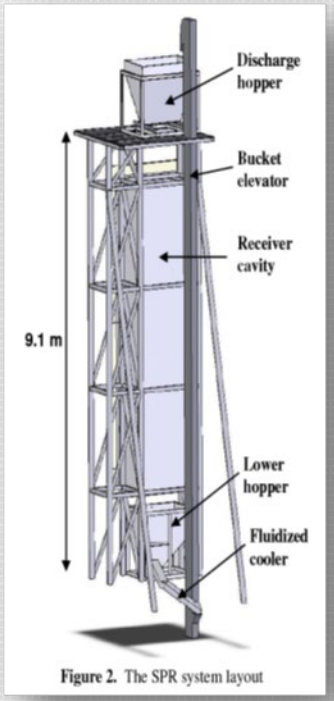


Figure 2. The SPR system layout

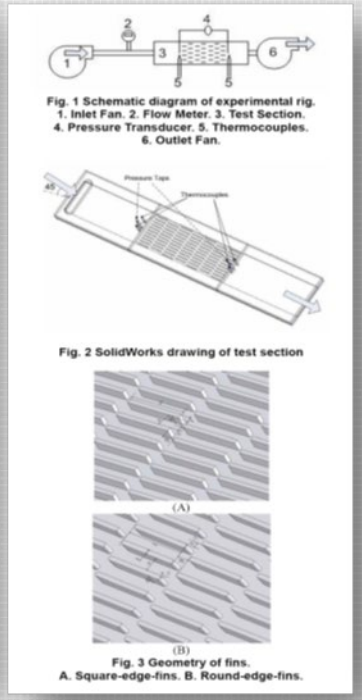


Fig. 1 Schematic diagram of experimental rig. 1. Inlet Fan. 2. Flow Meter. 3. Test Section. 4. Pressure Transducer. 5. Thermocouples. 6. Outlet Fan.

Fig. 2 SolidWorks drawing of test section

Fig. 3 Geometry of fins. A. Square-edge-fins. B. Round-edge-fins.

Above left: A solid-particle receiver (SPR) gravity feed to heat particles for a high-temperature production facility, using concentrated solar energy.
Above right: Testing apparatus used at UNLV to characterize the heat exchanger suggested for high-temperature hydrogen production, using nuclear energy as the heat source.

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Renewable Energy Research

Dr. Samir Moujaes, P.E.

Professor, Department of Mechanical Engineering

Relevant Publications

- S. Mol, S. Moujaes, R. Jazaei, "A Software to Size Rooftop PV Systems" Solar Power International Conference, Anaheim, CA, September 2018, 7 pages.
- A. Saraei, S. Moujaes, "A computer Aided Design for an Air Washer and a Dehumidifier Tested against Two graphical Solutions for Their Applications", ICSEng Conference; Las Vegas, NV; August 20-22, 2017.
- S. Gharehdaghi, S. Moujaes, "Experimental measurement of the Hydrodynamics and Thermal Behavior of Airflow in a Flex Duct Air Distribution System"; ASHRAE Conference paper (LV-17-C060). Las Vegas, NV January 2017.
- S. Pribastami, S. Moujaes, "Effect of Groove Dimension on Thermal Performance of Turbulent Fluid Flow in Internally grooved Tube", IMECE2016-66236. Phoenix, AZ (2016).
- Pirbastami, S., Moujaes, S.F., Mol, S.G. Computational fluid dynamics simulation of heat enhancement in internally helical grooved tubes (2016), *International Communications in Heat and Mass Transfer*, 73, pp. 25-32.
- Moujaes, S., Patil, J. 3D CFD Simulation of the Thermal Performance of an Air Channel Solar Heater (2015) *Advances in Intelligent Systems and Computing*, 1089, pp. 95-100.
- Moujaes, S., Yassin, M. Suggested Simulation of the First Copper-Chlorine Reactor Step for Solar Hydrogen Generation Process (2015) *Advances in Intelligent Systems and Computing*, 1089, pp. 121-126.
- Gharehdaghi, S., Moujaes, S. Numerical characterization of the hydrodynamics and thermal behavior of air flow in flexible air distribution system (2013) AIP Conference Proceedings, 1558, pp. 2095-2098.
- Tan, L., Moujaes, S. Findings of field survey for thermal comfort and ventilation in US office buildings (2012) 10th International Conference on Healthy Buildings 2012, 3, pp. 2619-2625.
- Moujaes, S., Gundavelli, R. CFD simulation of leak in residential HVAC ducts (2012) *Energy and Buildings*, 54, pp. 534-539.
- Nassif, N., Moujaes, S. Improved Delta-Q measurement technique for estimating the total and local leakages in residential buildings (2011) *Journal of Energy Engineering*, 137 (2), pp. 76-87.

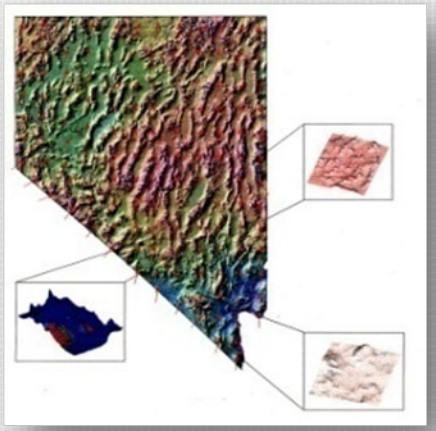
Renewable Energy Research

Dr. Darrell Pepper
Professor, Department of Mechanical Engineering

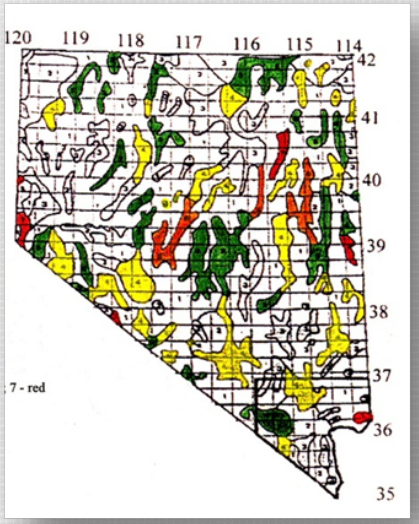
Phone: (702) 895-1056

Email: darrell.pepper@unlv.edu

- Expertise
  - Computational fluid dynamics, heat transfer and species transport
  - Advanced computational techniques
  - Wind energy assessment
  - Groundwater modeling and transport through porous media
  - Aerodynamics of turbine blades
  - Thin-film solar panels
  - Combustion and propulsion modeling



Nevada topography and prevailing wind pattern.



Areas in Nevada with wind energy potential (Class 4-7).

Meteorological tower placed in the Nellis Dunes area.

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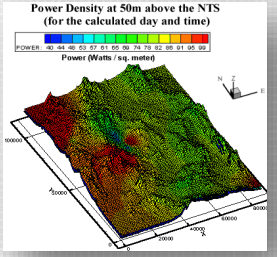
Renewable Energy Research

Dr. Darrell Pepper
Professor, Department of Mechanical Engineering



Power density for a wind turbine with a 50-m hub height within the Nevada Test Site.

Relevant Publications

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- Pepper, D. W. (2012), *Environmental Fluid Mechanics*, McGraw-Hill Yearbook.
- Pepper, D. W. (2010), Meshless Methods, Scholarpedia.
- Pepper, D. W. and D. B. Carrington (2009): *Modeling Indoor Air Pollution*, Imperial College Press, London, UK, 346 p.
- Pepper, D. W. and X. Wang (2009), "An h-adaptive Finite Element Technique for Constructing 3-D Wind Fields," *J. Appl. Meteor. & Climatology.*
- Wang, X. and D. W. Pepper (2009), "An Adaptive Numerical Model for Contaminant Dispersion in Air," *Int. J. Num. Meth. in Fluids.*
- Wang, X. and D. W. Pepper, D. W. (2009), "An hp-Adaptive Procedure for Modeling Indoor Contaminant Dispersion," *Comput. Modeling in. Engr. and Sci.*, Tech Science Press.
- Pepper, D. W. and X. Wang (2009), "An hp-adaptive Finite Element Model for Heat Transfer within Partitioned Enclosures," *Int. J. Num. Meth. Fluid Flow and Heat Transfer*.
- Pepper, D. W. and J. C. Heinrich (2006), *The Finite Element Method: Basic Concepts and Applications*, Taylor and Francis, New York, NY, 2nd Ed., 312 p.
- Pepper, D. W. (2006), "Chapter 7: Meshless Methods," *Handbook of Numerical Heat Transfer, 2nd Ed.*, W. J. Minkowycz et al (Eds.), John Wiley and Sons.

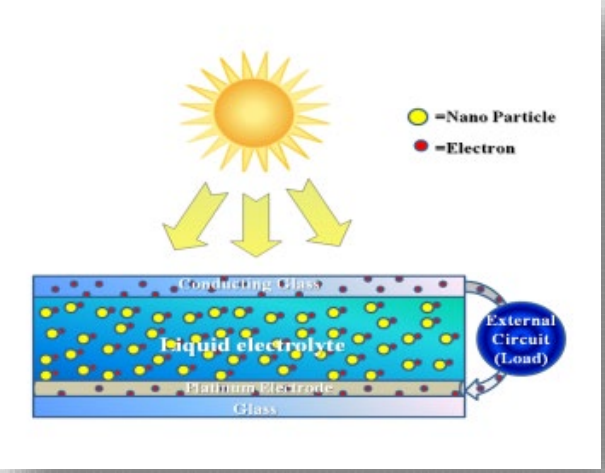
Renewable Energy Research

Dr. Hui Zhao
Associate Professor, Department of Mechanical Engineering

Phone: (702) 895-1463

Email: hui.zhao@unlv.edu

- Expertise
  - Third-generation dye-sensitized solar cell
  - Ionic-liquid-based energy storage technology
  - Lab-on-a-chip technologies toward biomedical diagnostics and analysis



Third-generation nanocrystal-enhanced dye-sensitized solar cell.

Applications of ionic-liquid electrochemical capacitors.

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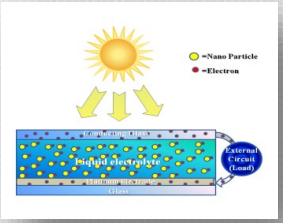

Dr. Hui Zhao
Associate Professor, Department of Mechanical Engineering

Relevant Publications

- H Zhao, S Zhai. (2015), "Energy Conversion over Super-hydrophobic Surfaces". *APS meeting abstracts*.
- Zhao, H. (2012), "The influence of nonelectrostatic ion-ion interactions on double layer capacitance", *Physical Review E*, 86, 051502.
- Uppapalli, S. and Zhao, H. (2012), "The polarization of a diffuse soft particle subjected to an alternating current field," *Langmuir*, 28, 11164-11172.
- Zhao, H. (2011), "Diffuse-charge dynamics of ionic liquids in electrochemical systems", *Physical Review E*, 84, 051504.
- Zhao, H. (2011), "The role of hydrodynamic behavior of DNA molecules in dielectrophoretic polarization under the action of an electric field", *Physical Review E*, 84, 021910.
- Zhao, H. (2011), "Double layer polarization of a non-conducting particle in an alternating current field with applications to dielectrophoresis", *Electrophoresis* 32, 2232-2244.
- Zhao, H. (2011), "Streaming potential generated by a pressure-driven flow over super-hydrophobic stripes", *Physics of Fluids*, 23, 022003. (selected for the Feb. 14, 2011 issue of *Virtual Journal of Nanoscale Science & Technology*) (top 20 most downloaded articles in Feb. 2011).
- Zhao, H. (2010), "Electro-osmotic flow over a charged superhydrophobic surface", *Physical Review E*, 81, 066314.
- Zhao, H. (2010), On the Influence of Ion Excluded Volume (Steric) Effects on the Double Layer Polarization of a Non-Conducting Spherical Particle in an AC Field", *Journal of Physical Chemistry C*, 18, 8389-8397.
- Zhao, H. (2010), "On the Effect of Hydrodynamic Slip on the Polarization of a Nonconducting Spherical Particle in an AC Field, *Physics of Fluids*, 22, 072004.