

# Hugo Nestor Villegas Pico

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## Education

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Ph.D. in Electrical and Computer Engineering  
Purdue University

*May 2016*  
West Lafayette, IN

*Academic Advisor: Prof. Dionysios Aliprantis*

*Dissertation: Advances to the Dynamic Analysis of Power Converter-based Systems Under Uncertainty: A Reachability Approach*

M.S. in Electrical Engineering

*August 2011*

Iowa State University

Ames, IA

*Academic Advisor: Prof. James McCalley*

*Thesis: Electromechanical Oscillations in Hydro-Dominant Power Systems: An Application to the Colombian Power System*

Ingeniero en Electrónica, Automatización y Control  
Universidad de las Fuerzas Armadas - ESPE

*March 2008*  
Sangolquí, Ecuador

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## Employment

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- Assistant Professor, Department of Electrical & Computer Engineering, Iowa State University, Ames, IA, (Aug. 2019–present)
- Docente Ocasional (Lecturer), Facultad de Ingeniería, Universidad de Cuenca, Cuenca, Ecuador (Apr. 2019–Jul. 2019)
- Postdoctoral Researcher of Power Engineering, National Renewable Energy Laboratory, Golden, CO (Apr. 2017–Mar. 2019)
- Postdoctoral Research Assistant, Purdue University, West Lafayette, IN (May 2016–Apr. 2017)
- Research Assistant, Purdue University - National Science Foundation, West Lafayette, IN (Aug. 2013–Apr. 2016)
- Research Assistant, Iowa State University - Power Systems Engineering Research Center, Ames, IA (Aug. 2011–Aug. 2013)
- Research Assistant, Iowa State University - Electric Power Research Center, Ames, IA (Sep. 2009–Aug. 2011)
- Supervisor of Electrical Maintenance, CELEC EP - Termopichincha, Ecuador (May 2007–Jul. 2009)

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## Awards and Recognitions

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- Harpole-Pentair Assistant Professor, Iowa State University, Aug. 2021–present
- Star Reviewer, IEEE Transactions on Energy Conversion, 2017–2018
- Award of \$2,500 for commitment and outstanding contributions, National Renewable Energy Laboratory, 2018
- Award of \$872 for commitment and outstanding contributions, National Renewable Energy Laboratory, 2017
- Prize paper award, IEEE Power & Energy Society, 2015
- Best paper award, IEEE Transactions on Energy Conversion, 2013–2014
- Fulbright Scholarship, 2009–2011
- Best GPA, Electronics, Automation and Control - ESPE, Nov. 2007–May 2008

## Funding

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### Awarded

- **co-PI**, “Data-driven Control of DERs & Hybrid PV Plants for Enhancing Voltage Stability Over Multiple Timescales,” Power Engineering Research Center. Team Members: Iowa State University (lead) and Washington State University, Aug. 2021–Jul. 2023, Villegas’ Award: **\$70,000**
- **PI**, “Deep Reinforcement Learning Approaches to Resilience of Power Systems,” National Renewable Energy Laboratory. Team Member: Iowa State University, Nov. 2020–Sep. 2021, Award: **\$35,000**
- **PI**, “Orchestrating the Restoration of Wind-Dominant Grids from Blackouts,” U.S. Department of Energy - Office of Science. Team Member: Iowa State University, Sep. 2020–Aug. 2023, Award: **\$729,349**
- **PI**, “Deep Reinforcement Learning for Power System Resilience,” National Renewable Energy Laboratory. Team Member: Iowa State University, Aug. 2020–Sep. 2020, Award: **\$18,000**
- **PI**, “Collaborative Research: Advancing Robust Control and State Estimation of Converter-Based Power Systems,” National Science Foundation - Energy, Power, Control, and Networks Program. Team Members: University of Texas San Antonio (lead) and Iowa State University, Aug. 2020–Jul. 2023, Villegas’ Award: **\$259,998**
- **PI**, “Start-up Package,” Iowa State University. Department of Electrical and Computer Engineering, Aug. 2019–Jul. 2022, Amount: **\$494,991**
- **Co-PI**, “Infinite-Inertia Inverter-Dominant Power Systems,” National Renewable Energy Laboratory. Laboratory Directed Research and Development Program, Oct. 2018–Sep. 2020, Award: **\$329,000**
- **Key Personnel**, “Modular Wide-bandgap String Inverters for Low-cost Medium-voltage Transformerless PV Systems,” U.S. Department of Energy - Solar Energy Technologies Office, Team Members: University of Washington (lead), University of Colorado Boulder, Wolfspeed, National Renewable Energy Laboratory, Oct. 2018–Sep. 2021, Amount: **\$3,550,000**

## Publications

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### Journal Papers

13. L. E. Guillén Montenegro and **H. N. Villegas Pico**, “Ac-heating and fast-charging power requirements of EV battery packs in subzero temperature,” *IEEE Trans. Transport. Electric.*, accepted for publication. [Available on-line] <https://ieeexplore.ieee.org/document/10005127>
12. H. P. Dang and **H. N. Villegas Pico**, “Blackstart and fault-ride through capability of DFIG-based wind turbines,” *IEEE Trans. Smart Grid*, accepted for publication. [Available on-line] <https://ieeexplore.ieee.org/document/9917444>
11. **H. N. Villegas Pico** and Vahan Gevorgian, “Blackstart capability and survivability of wind turbines with fully rated converters,” *IEEE Trans. Energy Convers.*, vol. 37, no. 4, pp. 2482–2497, Dec. 2022.
10. S. Roy and **H. N. Villegas Pico**, “Transient stability and active protection of power systems with grid-forming PV power plants,” *IEEE Trans. Power Syst.*, vol. 38, no. 1, pp. 897–911, Jan. 2023.
9. J. M. Miller, **H. N. Villegas Pico**, I. Dobson, A. Bernstein, and B. Cui, “Feedback control approaches for restoration of power grids from blackouts,” *Electric Power Syst. Research*, vol. 211, no. 108414, Oct. 2022.
8. Y. Lin, J. H. Eto, B. B. Johnson, J. D. Flicker, R. H. Lasseter, **H. N. Villegas Pico**, G.-S. Seo, B. J. Pierre, A. Ellis, J. Miller, and G. Yuan, “Pathways to the next generation power system with inverter-based resources,” *IEEE Electric. Mag.*, vol. 10, no. 1, pp. 10–21, Mar. 2022
7. S. Zhao, Y. Zou, X. Lin, D. Aliprantis, **H. N. Villegas Pico**, M. Chen, and A. Castillo, “Leveraging Generators with Complementary Capabilities for Robust Multi-stage Power Grid Operations,” *IEEE Trans. Control Netw. Syst.*, vol. 7, no. 3, pp. 1441–1452, Sep. 2020
6. **H. N. Villegas Pico** and Brian B. Johnson, “Transient stability assessment of multi-machine multi-converter power systems,” *IEEE Trans. Power Syst.*, vol. 34, no. 5, pp. 3504–3514, Sep. 2019
5. **H. N. Villegas Pico** and D. C. Aliprantis, “Reachability analysis of linear dynamic systems with constant, arbitrary, and Lipschitz continuous inputs,” *Automatica*, vol. 95, pp. 293–305, Sep. 2018
4. **H. N. Villegas Pico** and D. C. Aliprantis, “Voltage ride-through capability verification of DFIG-based wind turbines using reachability analysis,” *IEEE Trans. Energy Convers.*, vol. 31, no. 4, pp. 1387–1398, Dec. 2016
3. **H. N. Villegas Pico**, D. C. Aliprantis, J. McCalley, N. Elia, and N. Castrillon, “Analysis of hydro-coupled power plants and design of robust control to damp oscillatory modes,” *IEEE Trans. Power Syst.*, vol. 30, no. 2, pp. 632–643, Mar. 2015

2. **H. N. Villegas Pico** and D. C. Aliprantis, “Voltage ride-through capability verification of wind turbines with fully-rated converters using reachability analysis,” *IEEE Trans. Energy Convers.*, vol. 29, no. 2, pp. 392–405, Jun. 2014. **Best Paper of the IEEE Transactions on Energy Conversion for 2013–2014. IEEE Power & Energy Society 2015 Prize Paper Award**
1. **H. N. Villegas Pico**, J. McCalley, A. Angel, R. Leon, and N. Castrillon, “Analysis of very low frequency oscillations in hydro-dominant power systems using multi-unit modeling,” *IEEE Trans. Power Syst.*, vol. 27, no. 4, pp. 1906–1915, Oct. 2012

## Conference Papers

10. J. M. Miller, **H. N. Villegas Pico**, I. Dobson, A. Bernstein, and B. Cui, “Feedback control approaches for restoration of power grids from blackouts,” presented at *22nd Power Syst. Computation Conf.*, Porto, Portugal, Jun. 27 – Jul. 01, 2022.
9. **H. N. Villegas Pico** and V. Gevorgian, “Ultra-fast frequency response of converter-dominant grids using PMUs,” presented at *18th Wind Integration Workshop*, Dublin, Ireland, Oct. 16–18, 2019
8. B. J. Pierre, **H. N. Villegas Pico**, R. T. Elliott, J. Flicker, Y. Lin, B. B. Johnson, J. H. Eto, R. H. Lasseter, and A. Ellis, “Bulk power system dynamics with varying levels of synchronous generators and grid-forming power inverters,” presented at *46th IEEE Photovoltaic Specialist Conf.*, Chicago, IL, Jun. 16–21, 2019
7. **H. N. Villegas Pico**, B. Mather, and G.-S. Seo, “Model identification of inverter nonlinear control dynamics,” presented at *3rd IEEE Workshop Electron. Grid*, Charleston, SC, Nov. 12–14, 2018
6. **H. N. Villegas Pico**, V. Gevorgian, P. Koralewicz, and R. Wallen, “Role of motor loads and battery storage for active power controls by wind power,” in *Proc. 17th Int. Workshop Large-Scale Integration of Wind Power into Power Syst. as well as Transmission Networks for Offshore Wind Power Plants*, Stockholm, Sweden, Oct. 17–19, 2018
5. **H. N. Villegas Pico**, D. C. Aliprantis, and X. Lin, “Transient stability assessment of power systems with uncertain renewable generation,” in *Proc. 2017 IREP Symposium–Bulk Power System Dynamics and Control–X*, Espinho, Portugal, Aug. 27–Sep. 1, 2017
4. S. Zhao, X. Lin, D. Aliprantis, **H. N. Villegas Pico**, and M. Chen, “Online multi-stage decisions for robust power-grid operations under high renewable uncertainty,” in *Proc. IEEE Intern. Conf. Comp. Comm.*, San Francisco, CA, Apr. 10–15, 2016
3. **H. N. Villegas Pico**, D. C. Aliprantis, and S. D. Sudhoff, “Reachability analysis of shipboard power systems with uncertain pulsed loads,” in *Proc. IEEE Electric Ship Technologies Symp. (ESTS)*, Alexandria, VA, Jun. 21–24, 2015
2. **H. N. Villegas Pico** and D. C. Aliprantis, “Reachability analysis of power system frequency dynamics with new high-capacity HVAC and HVDC transmission lines,” in *Proc. 2013 IREP Symposium–Bulk Power System Dynamics and Control–IX Optimization, Security and Control of the Emerging Power Grid*, Rethymnon, Crete, Greece, Aug. 25–30, 2013
1. **H. N. Villegas Pico** and J. McCalley, “Modeling and analysis of speed controls in hydro-turbines for frequency performance,” in *Proc. 2011 North American Power Symp.*, Boston, MA, 2011

## Technical Reports

7. V. Gevorgian, P. Koralewicz, S. Shah, E. Mendiola, R. Wallen, and **H. Villegas Pico** “Photovoltaic plant and battery energy storage system integration at NREL’s Flatirons campus” Tech. Rep. NREL/TP-5D00-81104, National Renewable Energy Laboratory, Feb. 2022
6. Y. Lin, B. Johnson, S. Dhople, F. Bullo, P. Chapman, V. Purba, S. Jafarpour, G.-S. Seo, **Hugo Villegas-Pico**, N. Ainsworth, M. Rodriguez, M. Khan, J. Eto, A. Ellis, J. Flicker, B. Pierre, and R. Lasseter, “Final technical report: Stabilizing the power system in 2035 and beyond: evolving from grid-following to grid-forming distributed inverter controllers,” Tech. Rep. NREL/TP-5D00-79761, National Renewable Energy Laboratory, Aug. 2021
5. Y. Lin, J. Eto, B. Johnson, J. Flicker, R. Lasseter, **H. N. Villegas Pico**, Gabsu Seo, Brian Pierre, Abe Ellis, Hariharan Krishnaswami, Jeremiah Miller, and Guohui Yuan. “Research road map on grid-forming inverters,” Tech. Rep. NREL/TP-5D00-73476, National Renewable Energy Laboratory, Nov. 2020 (used by the U.S. DOE’s SETO and WETO for funding opportunities. <https://www.energy.gov/articles/energy-department-announces-45-million-funding-solar-technologies>)
4. V. Gevorgian, P. J. Koralewicz, **H. N. Villegas Pico**, S. D. Shah, R. B. Wallen, D. A. Corbus, J. A. Keller, R. Hovsapiian, M. Mohanpurkar, R. Kadavi, M. Pnawar, J. Leonard, M. Richwine, N. Miller, D. Gao, W. Yan, and W. Gao “Wgrid-49 GMLC project report: Understanding the role of short-term energy storage and large motor loads for active power controls by wind power,” Tech. Rep. NREL/TP-5D00-72888, National Renewable Energy Laboratory, Aug. 2019.
3. C. Brancucci, J. McCall, **H. N. Villegas Pico**, V. Gevorgian, “Iquitos Solar Energy Integration Study,” National Renewable Energy Laboratory, Tech. Rep. NREL/TP-5D00-73675, March 2020
2. **H. N. Villegas Pico**, Y. Lin, B. B. Johnson, “Positive-sequence inverter models with controllers based on: virtual oscillator, speed droop, and phase-locked loop,” National Renewable Energy Laboratory, Tech. Rep., Apr. 2019

1. **H. N. Villegas Pico**, B. Mather, E. Muljadi, and V. Gevorgian, “Review of Government Furnished Information”, National Renewable Energy Laboratory, Tech Rep. (Confidential), Dec. 2017

## Theses and Dissertation

3. **H. N. Villegas Pico**, “Advances to the Dynamic Analysis of Power Converter-based Systems Under Uncertainty: A Reachability Approach,” *Ph.D. dissertation*, Purdue University, West Lafayette, IN, 2016
2. **H. N. Villegas Pico**, “Electromechanical Oscillations in Hydro-dominant Power Systems: An Application to the Colombian Power System,” *Master’s thesis*, Iowa State University, Ames, IA, 2011
1. **H. N. Villegas Pico**, “Design and Implementation of an Automatic Control System for the Lubricating-Oil Separator WSK KRAKOW deLAVAL, Type MPAX 207-24s in the Guangopolo Thermal Station,” *Engineer’s Thesis* (in Spanish), Universidad de las Fuerzas Armadas - Termopichincha, Sangolquí, Ecuador, 2008

## Teaching

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12. EE653 Simulation and control of modern power systems, Iowa State University, Fall 2022
11. EE595X Independent study (Steve Mangette), Iowa State University, Summer 2022
10. EE590F Reliability and resilience of electric power grids with high wind/solar resources (jointly effort of the electric power and energy systems faculty), Iowa State University, Spring 2022
9. EE559/459 Electromechanical wind energy conversion and grid integration, Iowa State University, Fall 2020, Fall 2021
8. EE457 Power system analysis II, Iowa State University, Spring 2020, Spring 2021, Spring 2022
7. EE456 Power system analysis I, Iowa State University, Fall 2019
6. EE490 Independent study (Chad Korby), Iowa State University, Fall 2020
5. EE595X Independent study (Zhenghan Zhang), Iowa State University, Spring 2020
4. EE490 Independent study (Ahmed Salem), Iowa State University, Spring 2020
3. 11029 Advanced control systems (in Spanish), Universidad de Cuenca, Apr. 2019–Jul. 2019
2. 19326 Calculus of several variables (in Spanish), Universidad de Cuenca, Apr. 2019–Jul. 2019
1. 20110 Research methods (in Spanish), Universidad de Cuenca, Apr. 2019–Jul. 2019

## Supervision

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### Postdoctoral Research Associate

- Julio César López Quizhpi, “Restoration of wind-dominant power grids,” Dec. 2020–Nov. 2022

### Ph.D. Program Students

- Hoang P. Dang\*, “Blackstart capability of DFIG-based wind turbines,” May. 2021–present
- Luis E. Guillen Montenegro\*, “Grid integration of electric vehicles in subzero environments,” Jan. 2020–present
- Soumya Roy\*, “Control of power systems with grid-forming PV inverters,” Aug. 2020–present
- Zhenghan Zhang\*, “Machine forecasting of distributed energy resources,” Aug. 2020–present

\* The student has taken and passed the PhD qualifier exam

### M.S. Program Students

- Christopher Peralta, “Distance protection for grids powered by converter-based resources”, Jan. 2022–present
- Abdel M. Mannan, “Fault induced delayed voltage recovery of grids with hybrid PV inverters,” Aug. 2021–present

### B.S. Program Students

- Heather Junk, “Analysis of electric machinery using physics informed neural networks,” Jun. 2021–Aug. 2022
- Micheal Thai, “Feedback control approaches for restoration,” Summer 2021
- Hoang Dang, “Power-hardware-in-the-loop and real-time simulation techniques,” Nov. 2020–April 2021
- Joseph Miller, “Feedback control approaches for restoration,” May 2020–May 2021 (now with Burns & McDonnell)
- Brandon Johnson, “Positive-sequence grid-forming controls,” Summer 2020

## Iowa State University Service

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### Departmental Committees

4. Area Chair of the systems and controls academic area committee, Department of Electrical and Computer Engineering, present
3. Graduate student seminar committee, Department of Electrical and Computer Engineering, 2021–2022
2. Election and oversight committee, Department of Electrical and Computer Engineering, 2020–2022
1. Faculty search subcommittee, Department of Electrical and Computer Engineering, 2019–2020, 2022–2023

### Extra Departmental Committee

1. Reviewer for the Kiewit Scholarship Program, Iowa State University Foundation, Spring 2022, Spring 2023

### Program of Study Committees

4. Cody J. Newlun, “Co-optimized expansion planning for power system resilience and adaptation,” Dec. 17, 2021 (acting substitute for Prof. Zhaoyu Wang)
3. Burhan Hyder, “Cyber-Physical System Security for the Smart Grid using Game Theory and Machine Learning,” Sep. 30, 2021
2. Zhe Wang, “Risk-Informed Design Optimization of Vertically Distributed Tuned Liquid Wall Dampers for Multi-Hazard Mitigation,” Sep. 14, 2021
1. Vivek Kumar Singh, “Anomaly detection and federation testbed-based experimental evaluation for wide-area protection and control in smart grid,” Sep. 25, 2020

### External Service

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- Proposal Reviewer, U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, since 2022
- Member of Inverter-Based Resource Performance Subcommittee, North American Electric Reliability Corporation, since 2022
- Associate Editor of IET Generation, Transmission & Distribution, since 2020
- Member of Inverter-Based Resource Performance Working Group, North American Electric Reliability Corporation, 2020–2022
- Reviewer of Research Proposals for Universidad Técnica de Babahoyo since 2019
- Reviewer of *IET Renewable Power Generation* since 2015
- Reviewer of *IEEE Transactions on Industry Applications* since 2014
- Reviewer of *Electric Power Systems Research* since 2014
- Reviewer of *IEEE Power and Energy Technology Systems Journal* since 2014
- Reviewer of *IEEE Transactions on Sustainable Energy* since 2013
- Reviewer of *IEEE Transactions on Energy Conversion* since 2012
- Reviewer of *IEEE Transactions on Power Systems* since 2012

### Presentations

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14. “Blackstart and Fault Ride-Through Capability of DFIG-Based Wind Turbines,” Inverter-Based Resource Performance Subcommittee of the North American Electric Reliability Corporation (via webex), Nov. 17, 2022. **100+ attendants from industry, national labs, and universities**
13. “Advances to the positive-sequence simulation and control of grid-forming PV power plants,” ECE 590 I Power & Energy Systems Seminar: Department of Electrical and Computer Engineering at University of Illinois Urbana-Champaign, Oct. 17 2022.
12. “Advances to the Blackstart and Fault Ride-Through Capability of Inverter-Based Resources (IBRs),” Power Systems Engineering Research Center (via zoom), Sep. 21, 2022. **attendants from industry, national labs, and universities**
11. “EMT simulation of grid-forming inverters facing unbalanced loads and asymmetrical faults,” Inverter-Based Resource Performance Subcommittee of the North American Electric Reliability Corporation (via webex), Jun. 17, 2022. **118+ attendants from industry, national labs, and universities**
10. “Black-start and fault ride-through capability of Type 4 wind turbines,” Inverter-Based Resource Performance Working Group of the North American Electric Reliability Corporation (via webex), Nov. 9, 2021. **90+ attendants from industry, national labs, universities, and U.S. media**

9. “Reachability analysis of wind energy conversion subsystems” Colorado State University (via webex), Fort Collins, CO, Apr. 29, 2021
8. “Inverter design and control for microgrids” EPRC short course (via webex), Iowa State University, Ames, IA, Oct. 27, 2020
7. “Application of physics, mathematics, and computations in Power Engineering” Physics Colloquium Series (via webex), St. Olaf College, Northfield, MN, Oct. 21, 2020
6. “Advances to the dynamic analysis of power converter-based systems,” presented at the Department of Electrical and Computer Engineering, Iowa State University, Ames, IA, Mar. 6, 2019
5. “Advances to the dynamic analysis of power converter-based systems,” presented at The Edward S. Rogers Sr. Department of Electrical & Computer Engineering, University of Toronto, Toronto, ON, Feb. 11, 2019
4. “Model identification of inverter nonlinear control dynamics,” presented at *Proc. 3rd IEEE Workshop Electron. Grid*, Charleston, SC, Nov. 12–14, 2018
3. “Voltage ride-through capability verification of wind turbines with fully-rated converters using reachability analysis,” presented at *Proc. IEEE Power & Energy Soc. Gen. Meet.*, Denver, CO, Jul. 2015
2. “Analysis of very low frequency oscillations in hydro-dominant power systems using multi-unit modeling,” presented at *Proc. IEEE Power & Energy Soc. Gen. Meet.*, Denver, CO, Jul. 2015
1. “Modeling and analysis of speed controls in hydro-turbines for frequency performance”, presented at *Proc. 2011 IEEE North American Power Symp.*, Boston, MA, Aug. 2011

## Languages

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- Spanish, mother tongue
- English, proficient