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AREAS OF EXPERTISE

National climate strategies, including climate target setting, assessment, implementation, and Nationally Determined Contributions (NDCs) under the Paris Agreement; U.S. NDCs and Long-Term Strategy; International climate policy; U.S.-China climate engagement and collaboration; Role of subnational actors to support national and global action; Rapid coal phaseout strategies; National climate strategies in China, Indonesia, Brazil, India, and others.

HISTORY OF EMPLOYMENT

U.S. Department of State	Distinguished Senior Advisor for Climate Ambition, Office of the Special Presidential Envoy for Climate (2024-)
University of Maryland	Founder & Director, Center for Global Sustainability (2016-) Professor, School of Public Policy (2021-) Associate Professor, School of Public Policy (2012-21) Assistant Professor, School of Public Policy (2008-12)
U.S. Department of State	Senior Advisor, Office of the Special Presidential Envoy for Climate (2021-22)
White House	Deputy Associate Director for Energy & Climate Change, Council on Environmental Quality (2014-16)
Georgetown University	Assistant Professor, School of Foreign Service (2003-2007)

OTHER APPOINTMENTS

Joint Global Change Research Institute	2008-	Associate Director (<i>JGCRI is a collaboration of University of Maryland & U.S. DOE Pacific Northwest National Laboratory</i>)
The Brookings Institution	2014- 2008-2013	Nonresident Senior Fellow Nonresident Fellow
University of Oxford	2006-2009 2006-2007	Associate Fellow, Institute for Science, Innovation, & Society Visiting Fellow, Environmental Change Institute

Note: On leave from all academic appointments during periods of government service

EDUCATION

Ph.D.	University of California, Berkeley Energy & Resources (2003)
M.S.	University of California, Berkeley Energy & Resources (1999)
B.A.	Carleton College Physics, concentration in Environment & Technology Studies (1996)

AWARDS

2019	World Citizen Prize for Environment. Assn. for Public Policy Analysis & Mgmt. (APPAM)
2012	Best Comparative International Paper. APPAM & Int'l Comparative Analysis Forum
1996-97	Fulbright Fellowship. Stockholm University, Sweden
1996	Lawrence McKinley Gould Prize in Natural Science. Carleton College

PUBLICATIONS IN PEER-REVIEWED JOURNALS

1. Zhao, A., K. O'Keefe, M. Binsted, H. McJeon, A. Bryant, C. Squire, M. Zhang, S. Smith, R. Cui, Y. Ou, G. Iyer, S. Kennedy, **N. Hultman** (2024) High-ambition climate action in all sectors can achieve 65% greenhouse gas emissions reduction in the United States by 2035. *npj Climate Action* 3(63) 11 pp. doi.org/10.1038/s44168-024-00145-x
2. Kennedy, K.M., M.R. Edwards, C. Doblinger, Z.H. Thomas, M.A. Borrero, E.D. Williams, **N.E. Hultman**, K. Surana (2024). The effects of corporate investment and public grants on climate and energy startup outcomes. *Nature Energy* 11 pp. doi.org/10.1038/s41560-024-01530-w

3. Zhu, M., S.J. Smith, M. Chen, M. Evans, Q. Chai, F. Teng, P. Wang, X. Cheng, W. Li, J. Behrendt, S. Yu, S. Fu, H. Zhang, R.Y. Cui, J. Lou, M. Ahluwalia, **N. Hultman**, Y. Wang (2024). A comparative review of methane policies of the United States and China in the context of U.S.-China climate cooperation. *Climate Policy*, 1–19. doi.org/10.1080/14693062.2024.2366902
4. Lou, J., X. Shen, D.A. Niemeier, **N. Hultman** (2024). Income and racial disparity in household publicly available electric vehicle infrastructure accessibility. *Nature Communications* 15:5106 https://doi.org/10.1038/s41467-024-49481-w
5. Qiu, Y., N. Deng, B. Wang, X. Shen, Z. Wang, **N. Hultman**, H. Shi, J. Liu, Y.D. Wang (2024). Power supply disruptions deter electric vehicle adoption in cities in China. *Nature Communications* 15:6041. doi.org/10.1038/s41467-024-50447-1
6. Poggio, M., M. Império, L.B. Baptista, R. Schaffer, A.F.P. Lucena, A. Szklo, P.R.R. Rochedo, **N. Hultman**, H. McJeon, L. Clarke (2024). The Role of Bioenergy in Brazil's Low-Carbon Future. *Energy and Climate Change* 100123. 10.1016/j.egycc.2023.100123
7. Lou, J., **N. Hultman**, A. Patwardhan, and I. Mintzer (2023). Corporate Motivations and Co-benefit Valuation in Private Climate Finance Investments Through Voluntary Carbon Markets. *npj Climate Action* 2:32 10.1038/s44168-023-00063-4
8. Surana, K., M.R. Edwards, K.M. Kennedy, M.A. Borrero, L. Clarke, R. Fedorchak, **N. Hultman**, H. McJeon, Z.H. Thomas, E.D. Williams, (2023). The role of corporate investment in start-ups for climate-tech innovation. *Joule*, 7(4), 611-618.
9. Zhu, M., V. Chaturvedi, L. Clarke, K. Hochstetler, **N. Hultman**, A. Vogt-Schilb, P. Wang (2023). Bridging the global stocktake gap of climate mitigation: A framework to measure political economy progress. *One Earth* 6(9): 1104-1130.
10. Iyer, G., R. Cui, J. Edmonds, A. Fawcett, **N. Hultman**, H. McJeon, Y. Ou (2023). Taking stock of nationally determined contributions: Continued ratcheting of ambition is critical to limit global warming to 1.5° C. *One Earth* 6 (9), 1089-1092.
11. Shen, X., Y.L. Qiu, X. Bo, A. Patwardhan, **N. Hultman**, B. Dong (2023). The impact of co-adopting electric vehicles, solar photovoltaics, and battery storage on electricity consumption patterns: Empirical evidence from Arizona. *Resources, Conservation and Recycling* 192:106914.
12. Ou, Y., G. Iyer, A. Fawcett, **N. Hultman**, H. McJeon, S. Ragnauth, S.J. Smith, J. Edmonds (2022). Role of non-CO₂ greenhouse gas emissions in limiting global warming. *One Earth* 5(12):1312–1315. 10.1016/j.oneear.2022.11.012
13. Iyer, G., Y. Ou, J. Edmonds, A.A. Fawcett, **N. Hultman**, J. McFarland, J. Fuhrman, S. Waldhoff, & H. McJeon (2022). Ratcheting of climate pledges needed to limit peak global warming. *Nature Climate Change* 10.1038/s41558-022-01508-0.
14. Horowitz, R., M. Binsted, M. Browning, A. Fawcett, C. Henly, **N. Hultman**, J. McFarland, H. McJeon (2022). The energy system transformation needed to achieve the U.S. long-term strategy. *Joule* 6(7):1357–1362.
15. Doblinger, C., Surana, K., **N. Hultman**, L. Diaz-Anodon (2022). How do global manufacturing shifts affect long-term clean energy innovation? A study of wind energy suppliers. *Research Policy* 51 (7), 104558.
16. Lou, J., **N. Hultman**, A. Patwardhan, Y.L. Qiu (2022). Integrating sustainability into climate finance by quantifying the co-benefits and market impact of carbon projects. *Nature Communications Earth and Environment* 3:137 https://doi.org/10.1038/s43247-022-00468-9.
17. Cui, R., **N. Hultman**, W. Cai, H. McJeon, L. Clarke, J. Yuan. A U.S.-China Coal Phaseout and the Global 1.5-degree Pathway (2022). *Advances in Climate Change Research*. https://doi.org/10.1016/j.accre.2021.09.005
18. Cui, Y., S. Waldhoff, L. Clarke, **N. Hultman**, A. Patwardhan, E.A. Gilmore (2022). Evaluating the regional risks to food availability and access from land-based climate policies in an Integrated Assessment Model. *Environment Systems and Decisions*.
19. Qiu, Y., B. Xing, A. Patwardhan, **N. Hultman**, H. Zhang (2022). Heterogeneous changes in electricity consumption patterns of residential distributed solar consumers due to battery storage adoption. *iScience* 6(17):104352. https://doi.org/10.1016/j.isci.2022.104352
20. Ou, Y., G. Iyer, J. Edmonds, A.A. Fawcett, **N. Hultman**, J. McFarland, S. Waldhoff, M.J. Gidden, H. McJeon (2022). Transparency crucial to Paris climate scenarios—Response. *Science* 375(6583):828.

21. Edwards, M., R. Cui, M. Bindl, **N. Hultman**, K. Mathur, H. McJeon, G. Iyer, J. Song, A. Zhao (2022). Quantifying the regional stranded asset risks from new coal plants under 1.5°C. *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/ac4ec2>
22. Zhu, M., Y. Qi, **N. Hultman** (2022). Low-carbon energy transition from the commanding heights: how state-owned enterprises have driven China's wind power "miracle." *Energy Research and Social Sciences*. <https://doi.org/10.1016/j.erss.2021.102392>
23. Sampedro, J., R.Y. Cui, H. McJeon, S.J. Smith, **N. Hultman**, L. He, A. Sen, R. Van Dingenen, I. Cazarro. (2021). Quantifying the reductions in mortality from air-pollution by cancelling new coal power plants. *Energy & Climate Change 2*: 100023. <https://doi.org/10.1016/j.egycc.2020.100023>
24. Ou, Y., G. Iyer, L. Clarke, J. Edmonds, A.A. Fawcett, **N. Hultman**, J. McFarland, M. Binsted, R. Cui, C. Fyson, A. Geiges, S. Gonzales-Zuñiga, M.J. Gidden, N. Höhne, L. Jeffery, T. Kuramochi, J. Lewis, M. Meinshausen, Z. Nicholls, P. Patel, S. Ragnauth, J. Rogelj, S. Waldhoff, S. Yu, H. McJeon (2021). Can updated climate pledges limit warming well below 2°C? *Science*. 374(6568):693-695. doi: 10.1126/science.abl8976.
25. D.J. van de Ven, M. Westphal, M. Gonzalez-Eguino, A. Gambhir, G. Peters, I. Sognaes, H. McJeon, **N. Hultman**, K. Kennedy, T. Cyr, L. Clarke (2021). The impact of U.S. re-engagement in climate on the Paris targets. *Earth's Future*. <https://doi.org/10.1029/2021EF002077>
26. Lamb, R.L., L. Ma, R. Sahajpal, J. Edmonds, **N. Hultman**, R.O. Dubayah, J. Kennedy, G.C. Hurtt (2021). "Geospatial assessment of the economic opportunity for reforestation in Maryland, USA" *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/ac109a>
27. He, L. and **N. Hultman** (2021). "Urban agglomerations and cities' capacity in environmental enforcement and compliance." *Journal of Cleaner Production*. 313: 127585. <https://doi.org/10.1016/j.jclepro.2021.127585>
28. Edmonds, J., S. Yu, D. Forrister, J. Aldy, **N. Hultman**, R. Cui, S. Waldhoff, L. Clarke, H. McJeon (2021). "How much could Article 6 enhance Nationally Determined Contribution ambition toward Paris Agreement goals through economic efficiency?" *Climate Change Economics* 2150007. DOI 10.1142/S201000782150007X
29. Lamb, R.L., G. Hurtt, T.J. Boudreau, E. Campbell, E. Sepúlveda Carlo, H.-H. Chu, J. de Mooy, R.O. Dubayah, D. Gonsalves, M. Guy, **N. Hultman**, S. Lehman, B. Leon, A. Lister, C. Lynch, L. Ma, C.R. Martin, N.P. Robbins, A. Rudee, C. E Silva, C. Skoglund, H. Tang (2021). "Context and future directions for integrating forest carbon into sub-national climate mitigation planning in the RGGI region of the U.S." *Environmental Research Letters*. 16 063001.
30. Chan, S., I. Boran, H. van Asselt, P. Ellinger, M. Garcia, T. Hale, L. Hermwille, K. Liti Mbeva, A. Mert, C. B. Roger, A. Weinfurter, O. Widerberg, P. Bynoe, V. Chengo, A. Cherkaoui, T. Edwards, M. Gütschow, A. Hsu, **N. Hultman**, D. Levaï, S. Mihnar, S. Posa, M. Roelfsema, B. Rudyk, M. Scobie, M. Kumar Shrivastava (2021). "Climate Ambition and Sustainable Development for a New Decade: A Catalytic Framework." *Global Policy* <https://doi.org/10.1111/1758-5899.12932>
31. Cui, R.Y., **N. Hultman**, K. Jiang, D. Cui, H. McJeon, S. Yu, M. Edwards, A. Sen, K. Song, C. Bowman, L. Clarke, J. Kang, J. Lou, F. Yang, J. Yuan, W. Zhang, M. Zhu (2021). "A plant-by-plant strategy for high-ambition coal power phaseout in China" *Nature Communications* 12:1468 <https://doi.org/10.1038/s41467-021-21786-0>
32. Cropper, M., R. Cui, S. Guttikunda, **N. Hultman**, P. Jawahar, Y. Park, X. Yao, X. Song (2021). "The Mortality Impacts of Current and Planned Coal-Fired Power Plants in India." *Proceedings of the National Academy of Sciences* 118 (5) e2017936118
33. Sampedro, J., R.Y. Cui, H. McJeon, S.J. Smith, **N. Hultman**, L. He, A. Sen, R. Van Dingenen, I. Cazarro (2021). Quantifying the reductions in mortality from air-pollution by cancelling new coal power plants. *Energy & Climate Change 2*:10023. <https://doi.org/10.1016/j.egycc.2020.100023>
34. **Hultman, N.**, L. Clarke, C. Frisch, K. Kennedy, H. McJeon, T. Cyr, P. Hansel, P. Bodnar, M. Manion, M.R. Edwards, R. Cui, C. Bowman, J. Lund, M. Westphal, A. Clapper, J. Jaeger, A. Sen, J. Lou, D. Saha, W. Jaglom, K. Calhoun, K. Igusky, J. deWeese, K. Hammoud, J.C. Altimirano, M. Dennis, C. Henderson, G. Zwicker, J. O'Neill (2020). "Fusing national and sub-national climate action is central to rapid near-term decarbonization: The case of the United States." *Nature Communications* 11:5255 <https://doi.org/10.1038/s41467-020-18903-w>
35. Surana, K., C. Doblinger, L. Diaz Anodon, **N. Hultman** (2020). "Technology complexity affects the emergence and evolution of wind manufacturing locations along global value chains." *Nature Energy* 5: 811–821. <https://doi.org/10.1038/s41560-020-00685-6>
36. **Hultman, N.**, J. Lou, and S. Hutton (2020). "A review of community co-benefits of the Clean Development Mechanism (CDM)." *Environmental Research Letters* 15:5. doi: 10.1088/1748-9326/ab6396

37. Cui, R.Y., **N. Hultman**, M. Edwards, L. He, A. Sen, K. Surana, H. McJeon, G. Iyer, P. Patel, S. Yu, T. Nace, C. Shearer (2019). "Quantifying operational lifetimes for coal power plants under the Paris goals." *Nature Communications* 10: 4759. <https://doi.org/10.1038/s41467-019-12618-3>
38. Hsu, A., N. Höhne, T. Kuramochi, M. Roelfsema, A. Weinfurter, Y. Xie, K. Lütkehermöller, S. Chan, J. Corfee-Morlot, P. Drost, P. Faria, A. Gardiner, D.J. Gordon, T. Hale, **N. Hultman**, J. Moorhead, S. Reuvers, J. Setzer, N. Singh, C. Weber, O. Widerberg (2019). "A research roadmap for quantifying non-state and subnational climate mitigation action." *Nature Climate Change* 9:11-17.
39. Iyer, G., K. Calvin, L. Clarke, J. Edmonds, **N. Hultman**, C. Hartin, H. McJeon, J. Aldy, B. Pizer (2018). "Implications of sustainable development considerations for comparability across NDCs." *Nature Climate Change* 8:124–129.
40. Malone, E.L., **N. Hultman**, K. Anderson, V. Romeiro (2017). "Stories about Ourselves: How national narratives influence the diffusion of large-scale energy technologies." *Energy Research & Social Science* 31:70-76. doi:10.1016/j.erss.2017.05.035
41. Iyer, G.C., L.E. Clarke, J.A. Edmonds, **N. Hultman**, "Do national-level policies to promote low-carbon technology deployment pay off for the investor countries?" (2016). *Energy Policy* 98:400-411. doi:10.1016/j.enpol.2016.08.017
42. Dutta, V., P. Dasgupta, **N. Hultman**, G. Gadag (2016). "Evaluating expert opinion on India's climate policy: opportunities and barriers to low-carbon inclusive growth." *Climate and Development* doi: 10.1080/17565529.2015.1067181
43. Fawcett, A.A., G.C. Iyer, L.E. Clarke, J.A. Edmonds, **N.E. Hultman**, H.C. McJeon, J. Rogelj, R. Schuler, J. Alsalam, G.R. Asrar, J. Creason, M. Jeong, J. McFarland, A. Mundra, W. Shi (2015). "Can Paris Pledges Avert Severe Climate Change?" *Science* 350(6265):1168-1169 doi: 10.1126/science.aad5761
44. Iyer, G.C., J.A. Edmonds, L.E. Clarke, G.R. Asrar, **N. Hultman**, M. Jeong, A. Mundra, W. Shi, J. Alsalam, J. Creason, A.A. Fawcett, J. McFarland, H.C. McJeon (2015). "The contribution of Paris to limit global warming to 2°C." *Environmental Research Letters*. 10(125002). doi: 10.1088/1748-9326/10/12/125002
45. Iyer, G.C., L.E. Clarke, J.A. Edmonds, B.P. Flannery, **N. Hultman**, H.C. McJeon, D.G. Victor (2015), "Improved Representation of Investment Decisions in Integrated Assessment Models." *Nature Climate Change*. 5(36–440) doi:10.1038/nclimate2553
46. Iyer, G.C., **N.E. Hultman**, J. Eom, H. McJeon, P. Patel, L. Clarke (2015). "Diffusion of low-carbon technologies and the feasibility of long-term climate targets." *Technological Forecasting and Social Change*. DOI: 10.1016/j.techfore.2013.08.025
47. Iyer, G.C., L. E. Clarke, J. A. Edmonds, **N.E. Hultman**, and H.C. McJeon (2015), "Long-term payoffs of near-term low-carbon deployment policies." *Energy Policy*, 86, 493–505, doi:10.1016/j.enpol.2015.08.004.
48. Iyer, G.C., **N. Hultman**, S. Fetter, S.H. Kim (2014). "Implications of small modular reactors for climate change mitigation." *Energy Economics* 45: 144–154. DOI: 10.1016/j.eneco.2014.06.023
49. **Hultman**, N. and Koomey, J.G. (2013). "Three Mile Island: The driver of US nuclear power's decline?" *Bulletin of the Atomic Scientists*. 69(3) 63–70. doi: 10.1177/0096340213485949.
50. **Hultman**, N., E.L. Malone, E.L., P. Runci, G. Carlock, K. Anderson (2012). "Factors in low-carbon energy transformations: Comparing nuclear and bioenergy in Brazil, Sweden, and the U.S." *Energy Policy* 40:131–146. doi:10.1016/j.enpol.2011.08.064
51. **Hultman**, N., E. Sulle, C. Ramig, S. Sykora-Bodie (2012). "Biofuels Investments in Tanzania: Policy Options for Sustainable Business Models." *Journal of Environment & Development* 21(3) 339–361.
52. **Hultman**, N., S. Pulver, R. Deshmukh, L. Guimarães, and J. Kane (2012). "Carbon market risks and rewards: Firm perceptions of CDM investment decisions in Brazil and India." *Energy Policy* 40: 90–102. <https://doi.org/10.1016/j.enpol.2010.06.063>
53. **Hultman**, N., D. Rebois, M. Scholten, C. Ramig (2011). "The greenhouse impact of unconventional gas for electricity generation." *Environmental Research Letters* 6(04408): 1–9. doi:10.1088/1748-9326/6/4/044008.
54. **Hultman**, N., S. Pulver, S. Pacca, S. Saran, L. Powell, V. Romeiro, T. Benney (2011). "Carbon Markets and Low-carbon Investment in Emerging Economies." *Energy Policy*, 39: 6698–6700. DOI: 10.1016/j.enpol.2011.08.006.
55. **Hultman**, N. (2011). "The Political Economy of Nuclear Energy." (Invited). *Wiley Interdisciplinary Reviews: Climate Change* 2(3) 397-411. DOI 10.1002/wcc.113

56. **Hultman, N.**, Hassenzahl, D.M., and Rayner, S. (2010). "Climate Risk." (Invited). *Annual Reviews of Environment and Resources*, 35: 283-303.
57. Pulver, S., **N. Hultman**, and L. Guimaraes. "Carbon market participation by sugar mills in Brazil" (2010). *Climate and Development 2*: 248-262.
58. Bozmoski, A. and **N. Hultman** (2010). "Participant perceptions of risk and benefit in carbon forestry: Evidence from central Tanzania." *Journal of Environment and Development 19*: 4-27.
59. **Hultman, N.**, Emily Boyd, J. Timmons Roberts, John Cole, Esteve Corbera, Johannes Ebeling, Katrina Brown, and Diana M. Liverman (2009), "How can the Clean Development Mechanism better contribute to sustainable development?" *Ambio 38*(2): 120-122.
60. Boyd, E., **N. Hultman**, J.T. Roberts, E. Corbera, J. Cole, A. Bozmoski, J. Ebeling, R. Tippman, K. Brown, D.M. Liverman (2009). "Reforming the Clean Development Mechanism for Sustainable Development: Lessons learned and future prospects." *Environmental Science & Policy 12*(3): 820-831.
61. **Hultman, N.** and J.G. Koomey (2007). "The risk of surprise in energy technology costs." *Env. Research Letters 2* (034002): 1-6.
62. Koomey, J.G. and **N. Hultman** (2007). "A Reactor-level analysis of busbar costs for U.S. nuclear plants, 1970-2005." *Energy Policy 35*(11): 5630-5642. doi:10.1016/j.enpol.2007.06.005.
63. **Hultman, N.**, J.G. Koomey, and D.M. Kammen (2007). "What history can teach us about the future costs of nuclear power." *Env. Science & Technology*, 41(7): 2088-2093.
64. **Hultman, N.** (2006). "Geographic Diversification of Carbon Risk: A Methodology for Assessing Carbon Investments using Eddy Correlation Measurements." *Global Environmental Change 16*: 58-72.
65. **Hultman, N.** and A.S. Bozmoski (2006). "The Changing Face of Normal Disaster: Risk, Resilience, and Natural Security in a Changing Climate." *Journal of International Affairs*, 59 (2): 25-41.
66. **Hultman, N.** (2006). "Worth More than Good Advice: Lessons of Hurricane Katrina for Development in a Changing Climate." *Georgetown Journal of Public Policy 11*(1): 47-56.
67. **Hultman, N.** (2004). "Emerging Carbon Markets and the Future of Climate Policy." *Georgetown Journal of International Affairs*, Winter/Spring, 5(1): 107-113.
68. Law, B.E., A.H. Goldstein, P.M. Anthoni, M.H. Unsworth, J.A. Panek, M.R. Bauer, J.M. Fracheboud, **N. Hultman**. (2001) "CO₂ and water vapor exchange by young and old ponderosa pine ecosystems during a drought year." *Tree Physiology*, 21, 299-308.
69. Baer, P., J. Harte, B. Haya, A.V. Herzog, J. Holdren, **N. Hultman**, D.M. Kammen, R.B. Norgaard, and L. Raymond (2000). "Climate change: Equity and greenhouse gas responsibility." *Science 289* (5488): 2287.
70. Goldstein, A.H., **N. Hultman**, J.M. Fracheboud, M.R. Bauer, J.A. Panek, M. Xu, Y. Qi, A.B. Guenther, W. Baugh (2000). "Effects of climate variability on the carbon dioxide, water, and sensible heat fluxes above a ponderosa pine plantation in the Sierra Nevada (CA)." *Agricultural and Forest Meteorology 101*(2-3):113-129.
71. Bauer, M.R., J.A. Panek, **N. Hultman**, and A.H. Goldstein (2000) "Ozone deposition to a ponderosa pine plantation in the Sierra Nevada Mountains (CA): a comparison of two different climatic years." *J. Geophys. Res.*, 105(D17): 22123-22136.

RESEARCH REPORTS AND PAPERS (SELECTED)

1. Kennedy, S., C. Wade, L. Ma, H. Leslie-Bole, C. Dahl, A. Favero, A. Zhao, K. Kennedy, A. Trivedi, S. Edelstein, A. Joel Canton, A. Denvir, K. Clark-Sutton, S. Wood, G. Hurtt, **N. Hultman**, (2024). Harnessing the Land Sector to Achieve U.S. Climate Goals: An all-of-society approach to meeting our climate goals and bolstering the carbon sink by 2035. University of Maryland Center for Global Sustainability and America Is All In. 21 pp.
2. Peng, W., Huang, X., Zhao, A., Ou, Y., Kennedy, S., Iyer, G., McJeon, H., Cui, R., **Hultman, N.** (2023). All-In climate action for improved U.S. air quality & health benefits. University of Maryland Center for Global Sustainability and America Is All In. 14 pp.
3. Cui, R., Wejnert-Depue, C., Dahl, C., Westphal, M., **Hultman, N.** (2023). State of global coal power 2023. Center for Global Sustainability, University of Maryland. Available at: StateOfGlobalCoal.org.
4. Martinez Guzman, J., Joyce, P., Kennedy, K., **Hultman, N.** (2023). State Spending on Greenhouse Gas Reduction In Maryland. University of Maryland Center for Global Sustainability and Maryland Department of the Environment Technical Report. 27 pp.

5. Bertram, C., Smith, S., Kennedy, S., Behrendt, J., McJeon, H., Cui, R., **Hultman, N.** (2023). Ramping up methane emissions reductions in this decade: Implications of methane emissions for near- and medium-term warming. University of Maryland Center for Global Sustainability. 5 pp.
6. Cui, R., Behrendt, J., Miller, A., Zwerling, M., Bertram, C., Kennedy, S., Westphal, M., Borrero, M., Kreis, A., Walton, D., Zhao, A., Canton, J., Iyer, G., Kennedy, K., Khan, Z., Li, Y., Lou, J., McJeon, H., O'Keefe, K., Zhu, M., **Hultman, N.** (2023). An All-of-Society Climate Pathway: Key Policy Levers for 1.5°C-Aligned Action. University of Maryland Center for Global Sustainability technical report and global dataset. 37 pp.
7. Zhu, M., Lou, J., Cui, R., Cheng, X., Li, S., Li, D., Tumiwa, F., Arinaldo, D., Li, W., **Hultman, N.** (2023). Decarbonizing captive coal power plants in Indonesia and implications for Chinese stakeholders: Trends, challenges and opportunities. University of Maryland Center for Global Sustainability. 40 pp.
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1. West, T. O., N. P. Gurwick, M. E. Brown, R. Duren, S. Mooney, K. Paustian, E. McGlynn, E. L. Malone, A. Rosenblatt, **N. Hultman**, and I. B. Ocko, 2018: Chapter 18: Carbon cycle science in support of decision making. In *Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report* [Cavallaro, N., G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 728-759, <https://doi.org/10.7930/SOCCR2.2018.Ch18>.

2. Clarke L., K. Jiang, K. Akimoto, M. Babiker, G. Blanford, K. Fisher-Vanden, J.-C. Hourcade, V. Krey, E. Kriegler, A. Löschel, D. McCollum, S. Paltsev, S. Rose, P.R. Shukla, M. Tavoni, B.C.C. van der Zwaan, and D.P. van Vuuren, with H. Böttcher, K. Calvin, K. Daenzer, M. den Elzen, S. Dhar, J. Eom, S. Hoeller, N. Höhne, **N. Hultman**, P. Irvine, J. Jewell, N. Johnson, A. Kanudia, A. Kelemen, K. Keller, P. Kolp, M. Lawrence, M. Longden, J. Lowe, A. Frossard, P. de Lucena, G. Luderer, G. Marangoni, N. Moore, I. Mouratiadou, N. Petermann, P. Rasch, K. Riahi, J. Rogelj, M. Schaeffer, S. Schäfer, J. Sedlacek, L. Sokka, C. von Stechow, I. Sue Wing, N. Vaughan, T. Wiertz, T. Zwickel. (2014) Chapter 6: Assessing Transformation Pathways. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 413–510.
3. Sathaye, J., O. Lucon, A. Rahman, J. Christensen, F. Denton, J. Fujino, G. Heath, S. Kadner, M. Mirza, H. Rudnick, A. Schlaepfer, A. Shmakin, with G. Angerer, C. Bauer, M. Bazilian, R. Brecha, P. Burgherr, L. Clarke, F. Creutzig, J. Edmonds, C. Hagelüken, G. Hansen, **N. Hultman**, M. Jakob, S. Kadner, M. Lenzen, J. Macknick, E. Masanet, Y. Nagai, A. Olhoff, K. Olsen, M. Pahle, A. Rabl, R. Richels, J. Roy, T. Schei, C. von Stechow, J. Steckel, E. Warner, T. Wilbanks, Y. Zhang (2011). Chapter 9: Renewable Energy in the Context of Sustainable Development. In: *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 707-790. <https://www.ipcc.ch/site/assets/uploads/2018/03/Chapter-9-Renewable-Energy-in-the-Context-of-Sustainable-Development-1.pdf>

INVITED LECTURES AND HIGH-LEVEL EVENTS (SELECTED)

- Keynote: “All-In Climate Action in the United States.” High-Level COP28 Local Climate Action Summit (LCAS). States and Regions: Driving Local Climate Action, Dubai (2023)
- Keynote, “Climate Policy in the United States.” Peking University High-Level Roundtable on U.S.-China Climate Collaboration, Beijing (2023).
- Keynote, “Climate Policy in the United States.” Chinese Academy of Sciences – UMD Center for Global Sustainability Workshop on U.S.-China Climate Collaboration, Beijing (2023).
- Invited Lectures, “Climate Policy in the United States and Opportunities for U.S-China Climate Collaboration.” Peking University College of Environmental Sciences and Engineering, Beijing (2023); Tsinghua University Institute of Environment, Energy, and Economy, Beijing (2023); Tsinghua University - Schwarzman College, Beijing (2023); Beijing University of Technology - Institute for Circular Economy, Beijing (2023).
- Public Lecture, “All-In Climate Policy and Action in the United States and Opportunities for Enhanced Action with Indonesia.” Hosted by the Executive Office of the President of Indonesia and the Institute for Essential Services Reform. National Museum of Indonesia, Jakarta (2022).
- Moderator, Plenary Session, “Smoothing the Green and Just Energy Transition.” T20 Summit as part of G20 Process, Bali, Indonesia (2022).
- Lecture, “Raising climate ambition in 2022 to keep 1.5 C within reach: “All of Society” Climate Policy Strategies in the United States.” University of Indonesia, Faculty of Economics & Business, Jakarta (2022).
- Keynote, Roundtable on Domestic and International Climate Policy in the United States and Opportunities for Enhanced Action with Indonesia. Indonesia Clean Energy Forum, Jakarta (2022).
- Lecture, “Climate Action in 2022” Michigan State University Environmental Science and Policy Program (2022).
- Discussant, “Korea’s 2030 and 2050 Pathways” Inclusive Korea 2021 Conference. High-level Track 1.5 Conference, Korea Development Institute (2021).
- Keynote, “Transatlantic Leadership for Climate Neutrality?” High-level Transatlantic Lectures. Leuven Centre for Global Governance Studies and America Europe Fund, Brussels. With Jos Debelke. (2021)
- Keynote, China Energy Modeling Forum. “Accelerating America’s Pledge: Scenarios for Decarbonization to 2030 and Beyond.” Beijing, China (2020).
- Tsinghua University, School of Public Policy. “Accelerating America’s Pledge: Subnational Action to Drive Global Climate Ambition.” Beijing, China (2020).

Peking University, College of Environmental Sciences & Engineering. “Accelerating America’s Pledge: Scenarios for Decarbonization to 2030 and Beyond.” Beijing, China (2020).

Johns Hopkins University, School of Advanced International Studies. “America’s Pledge and Beyond: Harnessing State, City, and Businesses Actions to Raise Climate Ambition Globally.” Washington, DC (2019).

United States Department of Energy. “How cities, states, and businesses are leading the United States to a low-carbon future.” Solar Energy Technologies Office Speaker Series. Washington, DC (2019).

Harvard University Radcliffe Institute for Advanced Study. “Can we do it? ‘The Undiscovered’ in Climate Change.” Cambridge, Mass. (2018).

Princeton University, Andlinger Center for Energy and the Environment. “Fulfilling America’s Pledge: How States, Cities, and Businesses Are Leading the United States to a Low-Carbon Future.” Princeton, NJ (2018).

MIT Energy Initiative. “The Engine of Ambition to Achieve the Paris Climate Goals.” Cambridge, MA. (2017).

Keynote, World Bank Treasury Annual Meeting. “Technology and Innovative Finance to Deliver on the Paris Goals.” Washington, DC (2016).

Earlier invited lectures (selected): EPA Forestry and Agriculture GHG Modeling Forum (2016). World Resources Institute (2016). London School of Economics (2016). U.S. Department of Energy & U.S. Environmental Protection Agency, Washington, DC (2016). Global Green Growth Summit, Seoul, Korea (2013). University of São Paulo, Brazil (2013, 2009, 2008). Georgetown University at Qatar (2012). University of Bahrain (2010). The Atlantic Council and The National Intelligence Council. Washington, DC (2008). British Embassy in Washington (2007). United States Agency for International Development (2007). Yale University, School of Forestry and Environmental Sciences (2007).

PANEL PRESENTATIONS AND OTHER ENGAGEMENT (SELECTED)

COP28 Dubai (2023): Presentation: “U.S. Climate Policy” A Call for Urgent Climate Action – A Civil Society Dialogue among China, Europe, and The U.S.; Invited Comments: China-U.S. Track II Dialogue: Enhancing the Implementation of the Sunnylands Statement; Presentation: Advisory Roundtable on China’s Long-term Strategy for Low-GHG Emission Development; Panel: Circular Economy: A Path to Climate Solutions and Sustainable Development

COP27 Sharm El Sheikh (2022). Opening comment for China Electrification event, U.S. methane event, others. T20 Summit (2022). “Global Cooperation in Climate Action” Panelist. Bali, Indonesia.

National Academy of Sciences (2022), Presentation on “The Long-Term Strategy of the United States: Pathways and Policy Platforms.” Roundtable and Webinar on “How can we accelerate decarbonization to mitigate climate change?”

Brookings Energy Security Roundtable (2020). “U.S. Climate Action to 2030.”

Electric Power Research Institute (2020). “Electrification and Economy-Wide Analysis”

Energy Transition and Coal Power Decarbonization Workshop, Beijing (2020). “Accelerating America’s Pledge: Going All-In to Build a Prosperous, Low-Carbon Economy for the United States” Organized by Center for Global Sustainability with the Energy Research Institute (National Development and Reform Commission), North China Electric Power University, and NRDC-China, and hosted by Beijing University of Technology. Beijing, China.

COP25 Madrid (2019). “Accelerating America’s Pledge: Going All-In to Build a Prosperous, Low-Carbon Economy for the United States.” UN Framework Convention on Climate Change, 25th Conference of Parties – COP25. Keynote presentation at America’s Pledge Report Launch Event, U.S. Climate Action Center. High Level event included contributions from UNFCCC Executive Secretary Patricia Espinosa, UN Special Envoy for Climate Action Michael Bloomberg, Harrison Ford, and UK Central Bank President Mark Carney. Co-Organized by Bloomberg Philanthropies, University of Maryland Center for Global Sustainability, Rocky Mountain Institute, World Resources Institute, We Are Still In, and U.S. Climate Action Center. Madrid, Spain.

COP25 Madrid (2019). “Needs for Mitigation Information and Mechanisms in the Global Stocktake.” (2019). UN Framework Convention on Climate Change, 25th Conference of Parties – COP25. Presentation at official UNFCCC Side Event, “Building an Inclusive Global Stocktake: Independent and transparent assessments for greater ambition.” Organized by ClimateWorks. Madrid, Spain.

European Union in Washington DC (2019). “Accelerating America’s Pledge.” European Union, Country Delegation Head Climate Councillors, Washington, DC.

- COP24 Katowice (2018). “Contributions of the Independent Global Stocktake to Mitigation in the Global Stocktake.” UN Framework Convention on Climate Change, 24th Conference of Parties – COP24. Presentation at official UNFCCC Side Event, “In Formation: Laying the foundation for an inclusive Global Stocktake.” Organized by ClimateWorks and Wuppertal Institute. Katowice, Poland.
- COP24 Katowice “America’s Pledge and Beyond: Harnessing State, City, and Businesses Actions to Raise Ambition Globally.” UN Framework Convention on Climate Change, 24th Conference of Parties – COP24. At official UNFCCC Side Event, “Raising Ambition by Linking National with Non-Party Action.” Organized by University of Maryland Center for Global Sustainability. Katowice, Poland.
- U.N. Climate Week (2018). “America’s Pledge and Beyond: Harnessing State, City, and Businesses Actions to Raise Ambition Globally.” Climate Week 2018, Organized by the Climate Group. New York, NY.
- Global Climate Action Summit (2018). “Mid-Century Strategy Development and Progress.” US-China Track 2 Dialogue on Long-Term Development Strategies. Organized by University of Maryland Center for Global Sustainability and Energy Foundation China. San Francisco, CA.
- Global Climate Action Summit (2018). “Fulfilling America’s Pledge.” San Francisco, CA.
- COP23 Fiji/Bonn (2017). “Integrating national SDG, NDC, and LTS processes with enhanced research capacity.” UN Framework Convention on Climate Change, 23rd Conference of Parties – COP23. At official UNFCCC Side Event, “Reframing the Climate Debate: Enhancing the Paris Agreement and SDG linkages.” Co-organized by International Institute of Applied Systems Analysis (IIASA), University of Maryland Center for Global Sustainability, Ca’Foscari University, Venice (UNIVE), and Future Earth International. Bonn, Germany.
- UK Parliament (2016). “Low emissions development and energy security.” At session, “Energy Security, Energy Access & Transparency.” International Parliamentary Conference on Sustainability, Energy and Development. UK Parliament. London, UK.
- COP22 Marrakesh (2016). “Delivering Paris: Accelerating Ambition beyond 2025 through Improved Global NDC Practice.” UN Framework Convention on Climate Change, 22nd Conference of Parties – COP22. At official Side Event, “Advancing (I)NDC implementation and ambition: bridging research and practice.” Co-organized by NewClimate Institute, Netherland National Institute of Public Health and the Environment (RIVM), and University of Maryland Center for Global Sustainability. Marrakesh, Morocco.
- Earlier presentations (selected):* Center for Global Development, Washington, DC (2012). UN Conference on Sustainable Development (Rio+20) side event, Rio de Janeiro, Brazil (2012). COP16 Cancun side event, World Business Council on Sustainable Development (2010). 7th Transatlantic Energy Governance Dialogue, European Commission &, Global Public Policy Institute, Berlin, Germany (2010). Doha Carbon and Energy Forum. Doha, Qatar (2010). COP15 Copenhagen side event, University of Maryland; Watson Institute of International Studies, Brown University; Environmental Defense Fund (2009). Korea Development Institute & Association for Public Policy Analysis and Management, Seoul, Korea (2009). Embassy of Norway and Carnegie Institution, Washington, DC (2007).

INTERNATIONAL POLICY MEETINGS

U.N. Framework Convention on Climate Change

United States Delegation: COP26 Glasgow (2021), COP21 Paris (2015), COP20 Lima (2014).

Non-Governmental Observer: COP28 Dubai (2023), COP27 Sharm el Sheikh (2022), COP25 Madrid (2019), COP24 Katowice (2018), SBSTA Bonn 2018, COP23 Fiji/Bonn (2017), COP22 Marrakesh (2016), SBSTA Bonn 2016, COP19 Warsaw (2013), COP18 Doha (2012), COP17 Durban (2011), COP16 Cancun (2010), COP15 Copenhagen (2009), SBSTSA Bonn (2007), COP7 Marrakesh (2001), COP6 The Hague (2000), COP4 Buenos Aires (1998), COP3 Kyoto (1997).

U.N. Conference on Sustainable Development: *Non-Governmental.* Rio+20 meeting, Rio de Janeiro (2012)

PROFESSIONAL SERVICE (SELECTED)

Governmental Service: Participation in and input to U.S. climate engagements

- *The Long-Term Strategy of the United States of America: Pathways to Net-Zero Greenhouse Gas Emissions by 2050.* U.S. Department of State and White House Executive Office of the President. Washington, DC (2021).
- U.S.-China Joint Glasgow Declaration on Enhancing Climate Action in the 2020s (2021).
- *2016 Second Biennial Report of the United States to the United Nations Framework Convention on Climate Change.* Washington, DC: U.S. Department of State. 75 pp.

- The Nationally Determined Contribution of the United States of America (2014–15)
- Support for Paris Agreement (2015); U.S.-China Joint Announcement (2014); U.S.-Brazil Joint Statement (2015), U.S.-China Joint Statement (2015); Other bilateral U.S. consultations (2014–15, 21-)

Non-governmental service: Legislative Testimony and Other Non-Governmental Input to Policy Discussions

1. **Center for Global Sustainability** (2021-24). Diverse inputs to U.S. government climate processes: U.S. NDC, U.S. Long Term Strategy, U.S. bilateral engagements with approximately 15 countries
2. **Center for Global Sustainability** (2022). Report for State of Maryland Governor and Legislature on opportunities for rapid emissions reduction in manufacturing sector, fulfilling Maryland legislative requirement.
3. **Hultman, N.** (2019). Testimony to United States Congress, House of Representatives, Energy & Commerce Committee, Environment and Climate Change Subcommittee. Hearing on “We’ll always have Paris: Filling the Leadership Void Caused by Federal Inaction on Climate Change.” Feb 28, 8 pp. Available at: <https://energycommerce.house.gov/committee-activity/hearings/hearing-on-we-ll-always-have-paris-filling-the-leadership-void-caused-by>
4. **Hultman, N.** (2018). Testimony to the State of Maryland General Assembly. Hearing on “House Bill 993: Maryland Pension Climate Change Risk Act,” Feb 22, 5 pp.
5. **Hultman, N.** (2018) Testimony to the State of Maryland General Assembly, Appropriations Committee with Office of the Attorney General. Hearing on “Trump Administration's proposed repeal of the Clean Power Plan.” Jan 11, 5 pp.
6. **Hultman, N.** (2012). “Science, Technology, & Innovation for Development” United Nations General Assembly: ECOSOC.
7. **Hultman, N.** (2010). Testimony to the State of Maryland General Assembly, Senate Finance Comm & House Economic Matters Committee. Hearing on “Solar PV and RPS policy in Maryland: Evaluating the Rationale for increased support.” Feb 16.
8. **Hultman, N.** (2010). Testimony to the State of Maryland General Assembly, Senate Finance Committee. Hearing on “SB 1067: Task Force on Solar Hot Water Systems in Prince George’s County.” Mar 23.
9. **Hultman, N.** (2009). Testimony to the State of Maryland General Assembly, Joint Committee on Information Technology & Biotechnology. Hearing on “Clean Energy Innovation: International Experience and Lessons for Maryland.” Oct 7.

Other Professional Service

- Editor, Rolling Special Issue on National Decarbonization Strategies, *Energy & Climate Change* (2023–)
- Steering Committee, GCAM-China (2024–)

Reviewer: Academic Journals: *Science*, *PNAS*, *Global Env. Change*; *Nature Climate Change*; *Energy Policy*; *Climate Policy*, *Env. Sci. & Tech.*; *Ecol. Econ.*; *Accounting, Organizations, & Society*; *J. of Env. & Dev.*; *J. of Greenhouse Gas Measurement & Mgmt.*; *Atmosphere*; *Policy Studies J.*; *The Geog. J.*; *Env. Sciences*; *Rev. of Policy Res.*; *Envt. & Planning C*; *Afr. J. of Env. Sci. & Tech.*; *Georgetown J. of Intl. Affairs*. **Academic Presses:** Cambridge Univ. Press; Routledge Press; Earthscan Press; **Funding Agencies:** National Science Foundation; AAAS India-US Science & Technology Forum. **International Organizations:** IPCC, World Bank.

Media. Since 2019 over 300 quotes and research mentions in major national and international media, including featuring CGS research on the front page of *The New York Times* and in *The Wall Street Journal*. **TV:** BBC World Service, PBS NewsHour, CNN, C-SPAN, Bloomberg, Al Jazeera, NHK Japan, German Television News, DW, others. **Radio:** NPR-Morning Edition, NPR-Marketplace, NPR-Here and Now, NPR-Diane Rehm & Kojo Nnamdi, Bloomberg, BBC Radio, Deutsche Welle. **Print:** *New York Times*, *Wall Street Journal*, *Washington Post*, *Politico*, *The Hill*, *Forbes*, *Financial Times*, *Los Angeles Times*, *Science*, *Nature*, *WIRED*, *Vox*, *Grist*, *Axios*, *NBC News*, *ABC News*, *E&E*, *Neue Zürcher Zeitung*, *Xinhua*, *Exame* (Brazil), *Correio Braziliense* (Brasília), *Al-Riyadh* (Saudi Arabia), *Sankei Shimbun* (Japan), *Auckland Herald*, *Sydney Morning Herald*, *The Australian*, roughly 20 other international outlets.

TEACHING AND MENTORING

Courses Taught

University of Maryland: Energy & Climate Policy (PLCY 699); Climate Science and Policy (PLCY 798); Global Environmental Problems (PLCY 741); Practicing Public Policy (PLCY 688); Introduction to Sustainability (PLCY 301); Cross-examining Climate Change

Georgetown University: Climate Science and Policy; The Future of World Energy; Quantitative Methods for Policy; Science and Technology in the Global Arena; Science, Nature, and Environmental Values.

Postdoctoral Advisees

Mengye Zhu (2021–23), Kathleen Kennedy (2021–23), Jiehong Lou (2020–21), Morgan Edwards (2018–20), Anna Ebers Broughel (2017–19)

Ph.D. Dissertations Advised

Chair

Brinda Yarlagadda, 2024. The Roles and Implications of Agricultural and Energy Resources Trade in a Climate-Change-Mitigating World.

Patrick O'Rourke, 2024. Assessing the Opportunities and Impacts of an Expanded Global Hydrogen Economy.

Simran Singh, 2023. Socio-economic Aspects of First-generation Biofuel Production in Thailand: The role of producers in considerations of sustainability.

Mel George, 2023. Energy Equity and Justice Implications of Climate Change Mitigation Pathways.

Jiehong Lou, 2020. Integrating Sustainable Development Goals into Climate Finance Projects: Assessing the Market Impact of Co-Benefits from Carbon Offsets.

Arijit Sen, 2020. The Decarbonization Transformation: Essays on the role of constituent entities in the U.S. Electricity sector transition to a low-carbon future.

Anjali Sharma, 2020. Analysis of the Labor Impacts of Clean Energy Transitions in the Power Sector in India.

Linlang He, 2019. Do regional integration plans promote joint prevention and control of air pollution? Lessons from China's major city clusters.

Sha Yu, 2017. Heterogeneity and Mitigation Potential of the Chinese Buildings Sector.

Minji Jeong, 2017. National Renewable Energy Policy in a Global World.

Ryna Yiyun Cui, 2016. Risks to Food Availability and Access from Climate Policies.

Gokul Iyer, 2015. Low-carbon Technologies and Climate Change Mitigation Policy in an Imperfect World.

Halley Aelion, 2013. Environmental Stewardship in the Private Sector: Arriving at a Green Hands Theory.

In progress: Cam Wejnert.

Dissertation Committees: A.J. Bi (U. of Delaware), A. Birky, M. Borowitz, F. de la Chesnaye, C. Delhotal, D. Karetnikov, M. Gillenwater (Princeton), N. Graham, P. Hannam (Princeton), I. Kumar, R. Lamb, J. Liang, L. Liu, H. McJeon, R. Munoz Castillo, J. Nurmis, K. O'Keefe, V. Romeiro (U. of Sao Paulo), X. Shen, K. Song, P. Sapatnekar, J. Wayland, Junming Zhu.