Robert Leonard Kleinberg

Curriculum Vitae

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SYNOPSIS

Robert L. Kleinberg holds appointments as Adjunct Senior Research Scholar at the Center for Global Energy Policy of Columbia University, and as Senior Fellow of the Institute for Sustainable Energy at Boston University. His present activities focus on energy policy and economics, and on environmental issues connected with energy development. From 1980 to 2018 he was employed by Schlumberger, the premier oilfield service company, attaining the rank of Schlumberger Fellow, one of about a dozen who held this rank in a workforce of 100,000. His work at Schlumberger focused on geophysical instrumentation and measurements. He has served on or advised numerous government and academic committees on energy policy and is a coauthor with Harvard faculty of a textbook on energy technology, in preparation.

Dr. Kleinberg was educated at the University of California, Berkeley (B.S. Chemistry, 1971) and the University of California, San Diego (Ph.D. Physics, 1978). From 1978 to 1980 he was a post-doctoral fellow at the Exxon Corporate Research Laboratory in Linden, NJ. Dr. Kleinberg has authored more than 120 academic and professional papers, holds 41 U.S. patents, and is the inventor of several geophysical instruments that have been commercialized on a worldwide basis. Dr. Kleinberg is a member of the U.S. National Academy of Engineering.

BIRTH

3 August 1949, San Francisco, California. U.S. Citizen.

EDUCATION

Ph.D. Physics, University of California, San Diego, 1978

Studied properties of superfluid ^{3}He at temperatures below 0.003°K. Performed early measurements of phase transitions, heat capacity, heat transport, ultrasonic propagation, and nuclear spin dynamics. Thesis: "Texture Transformation and Flow in Superfluid ^{3}He-A". Advisor: Professor John C. Wheatley.

B.S. Chemistry (Honors), University of California, Berkeley, 1971

Proofread entire 4th Edition of Kittel, *Introduction to Solid State Physics*. Received published acknowledgement.

EMPLOYMENT

Columbia University Center on Global Energy Policy, 2018 - Present
Adjunct Senior Research Scholar

Boston University Institute for Sustainable Energy, 2018 - Present
Non-Resident Senior Fellow

Federal Government

- Organized and coordinated comments to the Environment Protection Agency from a dozen companies developing continuous monitoring solutions for well site methane emission detection [4,5,6].
- Studied effectiveness of Environmental Protection Agency methane emission regulations [8,11,12].
- Studied the Environmental Protection Agency use of the notice and comment process [10].
- Submitted comments in 2018, 2019, and 2021 to the Environmental Protection Agency on amendments to methane emission regulations for the oil and gas source category [9,30,32].
- Requested by the office of Rep. Diana DeGette to prepare an outline for an amendment to HR 2711 [29].
- Reviewed proposed bills on methane emission control as requested by the offices of Sen. Sheldon Whitehouse and Rep. Scott Peters.

State Governments

- Submitted comments to the Commonwealth of Pennsylvania and the State of New Mexico on proposed methane and volatile organic compound regulations [19,22,25].

European Union

- Organized two symposia on measurement and regulation of methane emissions at the European Union Delegation to the United States, for the European Commission Directorate-General of Energy, 4 March 2020 and 20 November 2020. Formulated agendas with European Union Delegation staff, selected and recruited speakers, and chaired the meetings.

- Submitted written comments and presentations to the European Commission and EU agencies on methane emission control technologies and policies [14,21,23].

International Organizations

- Wrote a major report for the World Bank on methane emissions from the fossil fuel industries of the Russian Federation [3].

- One of two international academic reviewers to advise on creation and structure of the United Nations Environment Programme International Methane Emissions Observatory (IMEO) [18,20].

- Served as rapporteur for the International Energy Agency workshop on methane policy and regulation, 15 January 2020 [26]

- Regular reviewer for International Energy Agency World Energy Outlook.

- Advisor to the Guyana Petroleum Resources Governance and Management Project, supported by the World Bank. Screened candidates to staff the Department of Energy in the Ministry of the Presidency.

Academic

- Demonstrated that Global Warming Potential, the most commonly used tool to compare the effects of greenhouse gases, is in some cases misleading, and proposed an alternate metric [7,15,16].

- Instructor for Columbia University School of International and Public Affairs seminar on oilfield flaring reduction, Spring 2020.

- Initiated a Design of Regulation study to investigate present practices of federal rulemaking, and how they might be improved to encourage technological innovation.

- Quantitative study of the greenhouse gas footprint of oilfield flares [27].

- Studied relationship between innovation cycles and business cycles in the U.S. upstream oil and gas industry [28].

Press

- New York Times, commissioned 1300 word commentary on future prospects of the oil industry [31].

Publications & Other Works (2018 - Present)

1. R. Kleinberg, "Unconventional Fossil Fuels" in M.J. Aziz and A.C. Johnson, Introduction to Energy Technology, Harvard University School of Engineering and Applied Sciences textbook, in preparation

2. J. Shaw, R. Kleinberg, "Oil and Gas" in M.J. Aziz and A.C. Johnson, Introduction to Energy Technology, Harvard University School of Engineering and Applied Sciences textbook, in preparation

3. R.L. Kleinberg, Methane Emissions from the Fossil Fuel Industries of the Russian Federation, commissioned by the World Bank. 19 May 2022. https://eartharxiv.org/repository/view/3342/

4. Continuous Monitoring is an Efficient and Effective Means of Characterizing and Remediating Methane Emissions, Comment submitted by LongPath Technologies, Inc. et al., Posted by the Environmental Protection Agency on Feb 2, 2022
https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0317-0759

5. Comment on Deployment of Continuous Optical Gas Imaging (C-OGI) Measurement Technologies for Methane Emission Detection. Comment submitted by CleanConnect.AI et al. Posted by the Environmental Protection Agency on Feb 2, 2022
https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0317-0762

6. Proposed Regulatory Implementation Approach for Continuous Monitoring of Methane Emissions and Answers to EPA's Questions about Continuous Monitoring. Comment submitted by Airdar et al. Posted by the Environmental Protection Agency on Feb 2, 2022
https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0317-0760

7. A.E. Pomerantz and R.L. Kleinberg, Present Global Warming (PGW): An Intuitive Single Scaling Factor to Compare Short Lived Climate Pollutants, American Geophysical Union Fall Meeting, December 2021.

8. R.L. Kleinberg, Methane Emission Controls: Redesigning EPA Regulations for Greater Efficacy, Columbia University Center on Global Energy Policy, October 2021.
https://www.energypolicy.columbia.edu/research/commentary/methane-emission-controls-redesigning-epa-regulations-greater-efficacy

9. R.L. Kleinberg, Reducing Emissions of Methane and Other Air Pollutants from the Oil and Natural Gas Sector: Recommendations to the Environmental Protection Agency, Public submission posted by the EPA. July 6, 2021. Data File: Public submission posted by the EPA. August 2, 2021.
https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0295-0035
https://www.regulations.gov/comment/EPA-HQ-OAR-2021-0295-0071

10. P. Agri, R.L. Kleinberg, Response of the Environmental Protection Agency to Public Submissions: Notice and Comment Process in Methane Emission Deregulation, Boston University Institute for Sustainable Energy, July 2021. https://www.bu.edu/ise/research/response-of-epa-to-public-submissions-in-methane-emission-deregulation/

11. R.L. Kleinberg, Methane Emission Controls: Toward More Effective Regulation, Social Science Research Network Working Paper, 4 June 2021. http://dx.doi.org/10.2139/ssrn.3860311

12. R.L. Kleinberg, EPA Methane Emission Controls, Obama vs Trump vs Biden: What Needs to Be Fixed and What Should be Left Alone, Social Science Research Network Working Paper, 23 March 2021.
http://dx.doi.org/10.2139/ssrn.3810337

13. R.L. Kleinberg, Opportunity for US-EU Cooperation on Methane Emission Control, Florence School of Regulation, 9 March 2021
https://fsr.eui.eu/opportunity-for-us-eu-cooperation-on-methane-emission-control/

14. R.L. Kleinberg, Comments on Proposal for a legislative act to reduce methane emissions in the oil, gas and coal sectors, Inception Impact Assessment, Ref. Ares(2020)7864968 - 22/12/2020, European Commission, 23 January 2021
http://www.bu.edu/ise/files/2021/01/Kleinberg-Comment-on-Legislative-Proposal-22-12-2020-210123-BU.pdf

15. R.L. Kleinberg, The Global Warming Potential is Inconsistent with the Physics of Climate Change and Misrepresents the Effects of Policy Interventions, American Geophysical Union Fall Meeting, December 2020. Poster SY012-0005. https://www.essoar.org/doi/10.1002/essoar.10504991.1

16. R.L. Kleinberg, The Global Warming Potential Misrepresents the Physics of Global Warming Thereby Misleading Policy Makers, EarthArXiv Working Paper, 25 October 2020.
https://eartharxiv.org/repository/view/1686/ ; https://doi.org/10.31223/X5P88D

17. J.H. Elkind, E.M. Blanton, H. Denier van der Gon, R.L. Kleinberg, A. Leemhuis, Nowhere to Hide: Implications for Policy, Industry, and Finance of Satellite-Based Methane Detection, Columbia University Center on Global Energy Policy and Netherlands Organisation for Applied Scientific Research, October 2020. https://www.energypolicy.columbia.edu/research/commentary/nowhere-hide-implications-policy-industry-and-finance-satellite-based-methane-detection

18. R.L. Kleinberg, Comments on the Proposed International Methane Emissions Observatory, solicited by and submitted to European Commission Directorate-General for Energy, 12 September 2020

19. A.E. Pomerantz, R.L. Kleinberg, New Technologies of Alternative Equipment Leak Monitoring, Submission in Response to New Mexico Environment Department Draft Version of Ozone Precursor Rules, 20 August 2020

20. R.L. Kleinberg, Comments on the Proposed Mineral Methane Mechanism / International Methane Emissions Mechanism, solicited by and submitted to the European Commission Directorate-General for Energy, 8 August 2020

21. R.L. Kleinberg, A.E. Pomerantz, "Elements of Efficient and Effective Methane Emission Reduction", Submission in Response to EU Methane Strategy, Ref. Ares(2020)3600489 - 08/07/2020, 5 August 2020
https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12504-EU-methane-strategy/F540916

22. R.L. Kleinberg, A.E. Pomerantz, "Control of VOC Emissions from Existing Oil and Natural Gas Sources: Technical Deficiencies", Re: Commonwealth of Pennsylvania Proposed Rulemaking, 25 PA. CODE CHS. 121 AND 129, Control of VOC Emissions from Oil and Natural Gas Sources, 27 July 2020

23. R.L. Kleinberg, "Support Letter for TANGO Mission", submitted to European Space Agency, 25 June 2020

24. R.L. Kleinberg, Reduction of Energy-Related Methane Emissions in the European Union and the United States: Minutes of the Symposium, European Union Delegation to the United States, 4 March 2020

25. R.L. Kleinberg, "Comment on Report of Methane Advisory Panel, Fall, 2019, Convened by New Mexico Environment Department and New Mexico Energy, Minerals and Natural Resources Department", 17 February 2020

26. R.L. Kleinberg, IEA Workshop: Network of Methane Policy and Regulatory Experts, Rapporteur's Summary of the Symposium, International Energy Agency, 15 January 2020

27. R.L. Kleinberg, "Greenhouse Gas Footprint of Oilfield Flares Accounting for Realistic Flare Gas Composition and Distribution of Flare Efficiencies", Earth and Space Science Open Archive Working Paper, December 2019. https://doi.org/10.1002/essoar.10501340.1

28. R.L. Kleinberg, M. Fagan, Business Cycles and Innovation Cycles in the U.S. Upstream Oil & Gas Industry USAEE Working Paper No. 19-423, 1 December 2019. http://dx.doi.org/10.2139/ssrn.3508466

29. R.L. Kleinberg, K. Konschnik, A.E. Pomerantz, R.M. Webb, "Suggestions for Improvement of H.R. 2711, the Methane Waste Prevention Act", solicited by the office of Rep. Diana DeGette. 12 November 2019.

30. R.L. Kleinberg, A.E. Pomerantz, "Rescinding Limits on Methane Emissions: Impact on Technological Innovation" Re: Docket ID No. EPA-HQ-OAR-2017-0757; EPA's 'Oil and Natural Gas Sector: Emission Standards for New, Reconstructed, and Modified Sources Reconsideration; Proposed Rule'; 84 FR 50244 (24 September 2019), 25 November 2019.
https://www.regulations.gov/document?D=EPA-HQ-OAR-2017-0757-2195

31. R.L. Kleinberg, "Is the U.S. Oil Industry Dominant? On the Verge of Oblivion? Neither", New York Times, 7 October 2019. https://www.nytimes.com/2019/10/07/business/United-States-tight-oil-market.html

32. R.L. Kleinberg, "Re: Emission Standards for New, Reconstructed, and Modified Sources Reconsideration (2018). Docket ID No. EPA-HQ-OAR-2017-0483. Proposed Revision of Alternative Means of Emission Limitation (AMEL) 40 CFR 60.5398a", 14 December 2018
https://www.regulations.gov/document?D=EPA-HQ-OAR-2017-0483-0760

Schlumberger, 1980-2018

Schlumberger Fellow (1999-2018)

One of approximately a dozen in a workforce of 100,000. Advised CEO and senior management on business strategy. Topics included the roles of fossil fuels and alternative energy sources in the world economy; business models for carbon capture and sequestration, geothermal energy, and unconventional fossil fuel resources; the structure and future of research; the balance of technical disciplines in the company workforce; personnel policies. Recommended creation of and monitored development of carbon sequestration and geothermal energy business units.

Unconventional Fossil Fuel Resources (2007-2018)

Launched Schlumberger oil shale program. Led core-log correlation case study in Piceance Basin, Colorado, including five weeks of field work analyzing core samples, and designing and executing a borehole logging program. Coordinated design of cross-well monitoring program for production test. Organizer and principal lecturer for gas shale and oil shale school at TOTAL E&P Recherche & Developpement, Pau. Directed laboratory study of oil shale pyrolysis, including complete physical and chemical characterization of all pyrolysis products.

Principal technical advisor to Schlumberger Business Consulting for "Developing the [redacted] Oil Shale Deposit: Resource & Technology Assessment, Business Plan". Consultant to Schlumberger Business Consulting Energy Institute.

Led Schlumberger side of $5 million MIT-Shell-Schlumberger X-Shale project, investigating transport and mechanical properties of gas shale. Technical lead for tight oil reservoir description project.

Contributed to or reviewed several stages of Health Effects Institute study on potential impacts of oil and natural gas development in the Appalachian region.

Methane Hydrate Studies (1999-2007)

Mated a wireline nuclear magnetic resonance borehole logging tool to a remotely operated deep sea submersible vehicle for seafloor experiments on methane hydrates. In field studies, assayed methane hydrate synthetically produced at the seafloor in rock and unconsolidated sand samples. Determined growth habit of methane hydrate in porous media, and showed how it influences deposit accumulation, hydraulic permeability, and seafloor slope stability.

Studies of methane hydrate reservoirs, including job planning and log analysis of test wells in the Gulf of Mexico, the Canadian Arctic, offshore Japan and offshore India. Five week deployment on Alaska North Slope drilling rig for core-log correlation study of pore-scale properties of permafrost. Organizer of and/or principal lecturer at methane hydrate short courses in Japan and India.

Devised theory of marine reservoir architecture and geomechanics, and showed its application to exploration geophysics of methane hydrate deposits. Co-convener of "Austin Hydrate Days" at the University of Texas Bureau of Economic Geology to create methane hydrate exploration strategy for the Gulf of Mexico. Active participant in meetings of the US Department of Energy Methane Hydrate Advisory Committee.

Borehole Gravimeter; Flow Line Sensors (1997-2002)

Evaluated or experimentally characterized a variety of gravity sensors to determine the one most suitable for borehole application. Built a temperature control system and a tilt meter that greatly improved the noise and drift characteristics of a quartz gravity meter. Carried out worldwide market survey with extensive client contact. Gravity meter project transferred to Schlumberger engineering center in Houston for borehole prototype build.

Invented NMR and bubble point flow line sensors to characterize captured fluid samples. Supervised design and development of measurement methodology, and laboratory verification. NMR sensor transferred to Houston engineering center and bubble point sensor transferred to Tokyo engineering center.

Nuclear Magnetic Resonance Borehole Logging Tool; NMR of Fluids in Rock (1984-1999)

Invented "inside-out" borehole nuclear magnetic resonance instrument. Built and tested numerous laboratory sensors and a state of the art NMR spectrometer. Invented a new pulse sequence that measured longitudinal and transverse relaxation rates faster than any existing laboratory technique. Department created at Schlumberger engineering center in Houston to implement the technology. Resulting CMR family of borehole measurement instruments commercialized and deployed worldwide. Total revenue to date ~ $1 billion.

Theoretical, laboratory, and field investigations of the effects of gas, light oil, OBM filtrates, bitumen, and clay on nuclear magnetic resonance borehole logging tool (CMR) response. Developed efficient logging modes, now implemented worldwide. Principal lecturer at many internal and client NMR schools worldwide. Participated in planning and analysis of CMR jobs worldwide.

Studied the nuclear magnetic relaxation properties of fluids in rocks, including the relationship between the transverse and longitudinal relaxation times, and the effects of elevated temperature and pressure. Formulated theory of NMR relaxation at fluid-solid interfaces, and tested it by measuring relaxivity of water in well-characterized magnetic oxide powders. Measured the time dependent diffusion coefficient of water and oil in rocks and other porous media, and verified its connection to the pore space surface-to-volume ratio and tortuosity. Supervised the associated M.S. or Ph.D. research of M.A. Horsfield, R. Akkurt, P.P. Mitra, L.L. Latour and I. Foley.

Borehole Pressure Gauges; Sonic Logging Tools (1983-1985)

Studied thermodynamic and heat transport characteristics of borehole pressure gauges. Identified important parameters in the design of rapidly responding gauges and presented a set of design specifications to improve performance. These specifications were implemented in subsequently constructed gauge housings.

Developed a theory of sonic velocity and attenuation in sandstones. The theory incorporates the effects of surface energy and fluid flow in the grain contacts. Journal article in *Geophysics* nominated for Best Paper of 1986 by Society of Exploration Geophysicists.

Studied the effect of lossy mandrel coatings on sonic tool waveforms. Showed that such coatings are useful in suppressing undesirable borehole fluid modes, and in facilitating the identification of formation arrivals.

Borehole Electrical Imaging (1982-1985)

Invented microinduction sensors for high resolution electrical resistivity measurements of earth formations surrounding a borehole. Built a series of laboratory prototypes and subjected them to exhaustive performance tests. Specified hardware design. Section created at Schlumberger engineering center in Paris to implement the device. Resulting OBDT commercialized and deployed worldwide. Total revenue to date ~ $150 million.

Borehole Ultrasonic Logging (1980-1982)

Invented Offset Acoustic Path method for detecting fractures in earth formations surrounding a borehole using circumferential propagation of ultrasonic waves. Tested this technique through laboratory experiments; specified hardware design. Project transferred to Schlumberger engineering center in Paris for prototype development.

Exxon Corporate Research Laboratory, 1978-1980

Post-Doctoral Fellow

Investigated properties of lithium battery cathodes in the laboratory of M. Stanley Whittingham (2019 Nobel Prize in Chemistry). Used various nuclear magnetic resonance relaxation techniques to determine their structures, local electric field gradients, and conduction electron densities. Studied atomic and molecular diffusion in systems of reduced dimensionality.

SUMMARY OF PUBLICATIONS AND PATENTS

41 U.S. patents and more than 120 scientific and professional papers, review articles, and book chapters. Google Scholar: 9455 citations; h-Index = 50 (accessed 25 April 2022). Full list available upon request.

SELECTED PRESENTATIONS

Selected academic presentations: Stanford University Natural Gas Initiative, Harvard University School of Engineering & Applied Science, Harvard Kennedy School, Harvard Business School, and Harvard Law School; Massachusetts Institute of Technology, Yale University, Princeton University, Cornell University (Moses Passer Memorial Lecture), University of Texas, Texas A&M, Colorado School of Mines, Scripps Institution of Oceanography.

Selected presentations to international and other organizations: OPEC Technical Workshop on US Tight Oil Prospects, World Bank, Federal Reserve Banks of Kansas City and Dallas Joint Meeting, Fermi National

Accelerator Laboratory colloquium, American Chemical Society Hydraulic Fracturing Symposium keynote address, Energy Information Administration Conference principal speaker. Invited lecture or panel participant at New York Public Library, Bolivian Academy of Sciences, German Marshall Fund, Harvard Arab Weekend, Cambridge Energy Research Associates CERA Week, Energy Future Coalition, Union of Concerned Scientists, Health Effects Institute, American Society of Mechanical Engineers, American Institute of Chemical Engineers, International Association for Energy Economics, National Academy of Engineering. Center for Strategic & International Studies, Brookings Institution (Washington and Doha), Florence School of Regulation.

FEDERAL ADVISORY COMMITTEES AND OTHER PUBLIC SERVICE

- Board on Earth Sciences and Resources, National Academies of Sciences, Engineering, and Medicine, 2019-2021
- Department of Energy Methane Hydrate Advisory Committee, 2016-2019. Oversaw federally funded methane hydrate research.
- Contributed to or reviewed several stages of Health Effects Institute study of potential impacts of oil and natural gas development on human health (2014-2015).
- Department of Energy Unconventional Resources Technology Advisory Committee 2010-2013; Chairman, Environmental Research Subcommittee. Oversaw federally-funded gas shale research.
- Department of Energy Office of Naval Petroleum and Oil Shale Reserves, Unconventional Fuels Working Group, 2009.
- National Petroleum Council report to the Department of Energy, 2006-2007. Primary author of *Facing the Hard Truths about Energy* chapters on methane hydrate and oil shale chapters.
- Energy technology briefings for US Department of State, Government Accountability Office, National Academy of Sciences, Environmental Protection Agency, Federal Energy Regulatory Commission, National Governors Association, Interstate Oil & Gas Compact Commission, California Council of Science and Technology, National Intelligence Council, an unidentified US government intelligence agency, and many others.

ACADEMIC SERVICE

- Guest lecturer for Boston University Questrom School of Business and the School of Public Health, 2021
- Regular guest lecturer for Harvard Engineering Sciences 231 (Energy Technology), 2011-present. Accompanying textbook in preparation.
- Regular guest lecturer for Harvard Law School seminar on Contemporary Issues in Oil and Gas Law, 2014-2017.
- Organizer of and principal lecturer for MIT short course, "Science & Engineering of Gas Shales".
- Advisor to MIT Energy Initiative for *Future of Natural Gas* report.

HONORS AND AWARDS

- Elected to the National Academy of Engineering

- American Physical Society Distinguished Lecturer on the Applications of Physics, 2018-2019
- U.S. Association for Energy Economics Distinguished Lecturer, 2020

PROFESSIONAL SOCIETY MEMBERSHIPS

- American Physical Society
- American Geophysical Union

- Society of Petroleum Engineers
- Society of Petrophysicists and Well Log Analysts

- U.S. Association for Energy Economics (Councilor 2018-2020)
- National Association for Business Economics

27 May 2022