

Penn State Marcellus Center for Outreach and Research (MCOR)

Thomas B. Murphy, Co-Director  
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Center Renewal  
Earth & Environmental Systems Institute

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**Rationale**

Natural gas is a critical resource in a changing global energy paradigm of a reduced carbon footprint and broader energy independence. Advances in horizontal drilling and gas shale stimulation techniques have increased access to North American and global shale gas reserves, but research is needed to develop more efficient and sustainable extraction methods that will reduce impacts on the natural environment. Research also is critical to help communities minimize the potential problems and use the economic opportunities and wealth generated as the basis for transition to sustainable local economies, and lessen the risk of “boom and bust” commonly associated with extractive industries.

Penn State’s Marcellus Center for Outreach and Research (MCOR) is committed to expanding research capabilities on technical and socio-economic aspects of shale energy development, providing science-based outreach programming on the Marcellus and other unconventional gas shales, and protecting the Commonwealth’s water resources, forests and transportation infrastructure. Serving state agencies, elected officials, communities, landowners, industry and environmental groups, MCOR brings together much of the University’s extensive expertise in shale gas geology, water resources and remediation, socioeconomic analysis, workforce development, market forces on development and exploration, educational programming, and natural gas technology. MCOR aims to be the research, information and education leader for the Appalachian region, North America, and the world by fostering, supporting and advancing research and science-based outreach on shale energy development. Additionally, the Center promotes collaborations and cooperative initiatives among disciplines and stakeholders in order to address the opportunities and challenges in shale development.

Penn State has a significant and recognized global leadership role on issues related to Marcellus and other gas shale development. The University has leading scholars working on many of the most critical areas of research and on extending that information to stakeholder groups, federal and state legislators, the natural gas industry, and the public. However, much more research and education is needed to take advantage of the formation’s energy reserves and to address potential adverse environmental and social impacts. Areas that could benefit from additional research include advancing technical capabilities of natural gas production to improve efficiencies; developing new production practices to reduce impacts to Pennsylvania’s water and environmental resources; developing more environmentally friendly fracturing techniques; and building international expertise in water resources and treatment. Assessing successful and evolving regulatory protocols and sharing that expertise with countries around the world with emerging interest in shale energy production is an equally important role being played by MCOR personnel.

MCOR seeks to coordinate on-campus research to address these issues through identifying relevant research RFPs, developing programs in conjunction with Penn State expertise at other University campuses, working collaboratively through state and national industry and NGO’s focused on shale, and in building collaborative

partnerships with other institutions, as well as Federal government partners. Through MCOR activities, Penn State is solidifying its reputation for innovative research and its role as a leader in outreach and educational programming associated with gas shale development in the Commonwealth and beyond. MCOR has had recent initiatives in over 50 countries related to shale energy and issues associated with its development and utilization.

The Marcellus Center's goals are three-fold:

- To coordinate University research and outreach on shale energy and its impacts, including environmental, economic, socio-economic, and workforce aspects.
- To spark additional cross-campus and international collaborations on shale energy.
- To address the issues related to the extraction and development of the Marcellus Shale in particular but of unconventional shale resources in general.
- To convey science-based educational outreach to a diverse and evolving stakeholder base globally

The Penn State Marcellus Center for Outreach and Research (MCOR) mission is a research, information dissemination, and education leader which fosters, supports, and advances research and science-based translational outreach on shale energy development, with a specific emphasis on natural gas. MCOR informs and serves a diverse group of stakeholders including landowners, government officials, business leaders, natural resource organizations, and the natural gas industry, as they are involved with or affected by the exploration, production, transmission, or utilization of unconventional hydrocarbons. By promoting collaborations and cooperative initiatives among disciplines and stakeholder groups, MCOR addresses the opportunities and challenges in shale energy development.

MCOR is fulfilling this mission by coordinating and facilitating programs of outreach and research, addressing, holistically, issues generated by the exploration and development of the Marcellus and other unconventional formations. Major outreach, research and educational activities that the Center will focus on in the 2016-2019 time period are summarized below.

### **Outreach Activities**

#### **1) Methane and Legacy Oil and Gas Infrastructure (MELI) Program**

Penn State was recently awarded \$91,500 by EPA to undertake the MELI program, which is designed to engender environmental stewardship by using citizen science to investigate interactions between methane concentrations in water and unplugged orphan and abandoned oil and gas wells (OAWs) in Pennsylvania. MELI will educate communities about the infrastructure of legacy oil and gas wells, teach nonscientists how to assess potential methane contributions from such legacy infrastructure, engage communities in citizen science through water sampling, galvanize communities into action, and ultimately promote long-lasting environmental stewardship.

#### **2) Translational Outreach for Pennsylvania Shale Energy Stakeholders**

There is great demand from stakeholders in the state ranging from landowners to elected officials to understand the trends associated to shale energy development in PA and beyond, as they impact individuals and communities of people. Examples include construction of new pipeline infrastructure, understanding emerging research on health implications of shale energy production, revenue generation policy, new legal precedents impacting municipalities and/or landowners, water resource protections, fugitive methane emission reduction, regulatory education, and a host of other important issues. MCOR is a trusted venue for this education and

provides the needed translational component as it has extensive and holistic experience with the topics and has earned credibility with a wide range of audiences. This will continue to be a priority program from MCOR.

### **3) Immersive Shale Experience**

MCOR, in conjunction with the Cooperative Extension Marcellus Education Team, has engaged hundreds of participants in this educational outreach program, providing a rich opportunity to view shale energy exploration first-hand, see the impact of development in the community, and learn directly from key regional voices embedded in the shale dialogue. The experience is unique for each delegation, aligned and customized to address the priorities of the group. Conducted for international embassy staff, U.S. government agency personnel, elected officials, O&G industry partners, media representatives, and distant university collaborators, these programs will continue to be a focus for MCOR's outreach efforts. As a secondary benefit, these programs have generated immediate and longer term funding opportunities for Penn State shale energy initiatives.

### **4) International Initiatives –Shale Outreach Globally**

As one of several global initiatives, MCOR has entered into a funded cooperative agreement with the U.S. Dept. of State to provide in-country and distant (digital) education to government officials in Argentina, related to the development of the Vaca Muerta shale resource in the western region of the country. This energy program, which is a priority of the U.S. and Argentine government's, also has a direct benefit to PA, as many companies from the Commonwealth are deploying technology, staff, and experience from the Marcellus to the Vaca Muerta. This is generating a two way exchange of lessons learned in each respective location to benefit the other. Our multi-disciplinary Penn State team provides information about the creation of successful regulatory protocols, governance, attainment of social license, local workforce and business development, environmental/water risk mitigation, and legislative initiatives including revenue generation.

More broadly, our experience and international networking has led to MCOR being recognized as one of the foremost entities in shale energy development issues, which reflects upon Penn State as a global leader in energy research, and is consistent with the Energy University concept. MCOR personnel have engaged with representatives from over 50 countries on 6 continents in order to exchange insights and research outcomes. Many of these efforts are in conjunction with PA's Department of Economic and Community Development. And we are often invited to speak on these themes worldwide.

### **5) Updated Maps and Graphics**

MCOR has created multiple maps and graphics that appeal to the general public and a variety of stakeholders that depict number of wells drilled, well locations, natural gas production, among others things. We will continue to update them for use by researchers, industry, regulators, media, and other interested parties.

## **Research Activities**

### **1) PASEIS – Seismic Network**

The Pennsylvania State Seismic Network (PASEIS) is operated by Penn State for the Department of Conservation and Natural Resources (DCNR) and the Department of Environmental Protection (DEP). The network consists of 30 broadband seismic stations spread across the Commonwealth recording data continuously. Data from the PASEIS stations are combined with data from 41 other seismic stations within and surrounding Pennsylvania to detect and locate seismic events in near-real time. Information about the network and seismic event locations can be found at [paseis.geosc.psu.edu](http://paseis.geosc.psu.edu)

## **2) PA Basement Mapping**

The goal of this project is to improve understanding of the depth to crystalline rocks (i.e. basement) underlying the sedimentary rocks of the Appalachian Basin. Existing maps of “depth to basement” for Pennsylvania are being improved by using seismic data and well log information to estimate the thickness of the sedimentary rocks in the basin. An improved understanding of the depth to basement is important for mitigating against seismicity induced by fluid injection into the subsurface at wastewater disposal wells and hydraulic fracturing wells.

## **3) PA Fault Database**

Coupled to the PA basement map project is a project to improve the database of faults within Pennsylvania, particularly within the Appalachian basin. The database of fault information is being assembled using existing open databases, published studies of faults, interpretations of regional seismic data, and well log information. An improved understanding of faults within the Appalachian Basin can be used to investigate natural gas emissions, groundwater systems, and induced seismicity.

## **4) Shale Depth and Thickness Mapping**

MCOR initially created depth and thickness maps for both the Marcellus and Utica/Point Pleasant shales that have been available to the general public via MCOR’s website. In the five years since those maps were generated thousands of wells have been drilled and their logs provide a more robust geologic data set that will allow these maps to be updated for use by researchers, industry, regulators and other stakeholders.

## **5) DEP Datasets**

A common challenge to conducting environmental research on shale energy development is the lack of publically accessible datasets. Regulatory agencies routinely collect large volumes of environmental data using taxpayer dollars, including air and water quality measurements, but making them openly available for research often is a low priority for the agencies. We will obtain hard-to-access data from the DEP that is related to oil and gas development, curate the data, and then make it publically available via existing online data repositories. Working with the DEP to make data readily available will facilitate a range of environmental studies and risk assessments related to potential health impacts, in addition to promoting public transparency.

## **Resident Instruction**

MCOR personnel have guest lectured in a wide array of classes ranging from accounting, communications, agricultural economics, engineering, geosciences, and petroleum and natural gas engineering. From this experience it is apparent that there is a demand for students to have a breadth of background in unconventional energy development, which has led us to begin to develop a general education course (297 level). This course will cover a broad array of shale energy-related topics including geology, resource assessment, drilling technology, hydraulic fracturing methods, environmental impacts, economics, workforce needs, infrastructure, utilization trends, regulation, energy policy, energy exports, international geopolitics, societal considerations, the future of unconventional energy and its relationship with other energy forms. We are designing the course to meet Gen Ed requirements for all students. This course will be first offered in Fall 2017 as a hybrid course, but we eventually hope to offer this and other courses via the World Campus to reach a broader audience.

## **Funding**

The Marcellus Center for Outreach and Research is currently supported internally, either directly or in-kind, by the Colleges of Agricultural Sciences, Earth and Mineral Sciences, Penn State Outreach and by the Penn State Institutes of Energy and the Environment (PSIEE).

External funding has been pursued and is now a growing component of our funding stream and will continue to be so going forward. To date, we have used our MCOR efforts to leverage over \$14 million in funds for collaborative work at PSU and partner universities.

MCOR does not currently seek any operating funds from the Earth and Environmental Systems Institute.

## **Center Needs**

MCOR requests continued use of the second floor office suite (217F) and the adjacent office in the EES Building. Minimal finance support is requested for processing budget entries and review.

## **Management structure**

MCOR Co-Directors are Andy Nyblade, professor of geosciences, and Thomas Murphy, extension program manager . This co-leadership reflects the Marcellus Center's equal commitment to both outreach and research responsibilities. Dave Yoxtheimer, P.G., EMS Extension Associate, is an outreach liaison between the University, natural gas industry, environmental organizations, local government and the public to advise stakeholders on key environmental issues.

MCOR utilizes an internal advisory committee that provides guidance to the Co-Directors and assists in evaluating the research and outreach missions of the Center. This committee offers input on Center activities from across the University and, by drawing on their external collaborations, from outside the University. It also functions to review and advise on the Center's strategic plan. Advisory committee members are:

Dennis Calvin, Director, Penn State Cooperative Extension, College of Ag (committee co-chair)

John Hellman, Associate Dean, College of Earth and Mineral Sciences (committee co-chair)

Lee Ahern, Associate Professor, College of Communications

Kathy Brasier, Associate Professor, Rural Sociology, College of Ag Sciences

Russell Burton, Senior Associate Dean, Smeal College

Lee Kump, Professor of Geosciences, College of Earth and Mineral Sciences

Tom Richard, Director, Penn State Institutes of Energy and the Environment (PSIEE)

Ross Pifer, Professor, Center for Ag and Shale Law, Penn State Dickinson School of Law

Craig Weidemann, Special Assistant to the Provost for Innovation and Education Technology Initiatives

**Andrew A. Nyblade**  
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University Park, PA 16802  
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**(a) Professional Preparation**

Wittenberg University	Springfield, Ohio	Geology	B.A.	1982
Wittenberg University	Springfield, Ohio	Earth Science Education	B.A.	1982
University of Wyoming	Laramie, Wyoming	Geophysics	M.S.	1985
University of Michigan	Ann Arbor, Michigan	Geology	Ph.D.	1992

**(b) Appointments**

2007 - Professor, Department of Geosciences, Pennsylvania State University  
2002 - 2007 Associate Professor, Department of Geosciences, Pennsylvania State University  
2004 - present Honorary Professor, University of the Witwatersrand, Johannesburg, South Africa  
2003 Cox/Blaustein Visiting Professor, Department of Geophysics, Stanford University  
2001 - present Faculty, Graduate Program in Acoustics, Pennsylvania State University  
1997 - 2002 Assistant Professor (tenure-track), Department of Geosciences, Pennsylvania State University  
1994 - 1997 Assistant Professor (fixed term), Department of Geosciences, Pennsylvania State University  
1992 - 1993 National Science Foundation Postdoctoral Fellow, Department of Geosciences, Pennsylvania State University  
  
1988 - 1991 Teaching and Research Assistant, Department of Geological Sciences, University of Michigan  
1986 - 1988 Math and Physics Instructor, grades 9-12, International School Moshi, Tanzania  
1985 - 1986 Exploration Geophysicist, Exxon Co. U.S.A., Denver, Colorado  
1982 - 1985 Teaching and Research Assistant, Department of Geology and Geophysics, University of Wyoming

**(c) Publications**

O'Donnell, J.P., K. Selway, **A. Nyblade**, R. Brazier, N. Tahir and R. Durrheim, Thick lithosphere, deep crustal earthquakes and no melt: A triple challenge for understanding extension in the western branch of the East African Rift, *Geophysical Journal International*, doi: 10.1093/gji/ggv492., 2016.

Ramirez, C., **A. Nyblade**, S. Hansen, D. Wiens, S. Anandakrishnan, R. Aster, A. Huerta, P. Shore, T. Wilson, Crustal and upper mantle structure beneath ice-covered regions in Antarctica from S-wave receiver functions and implications for heat flow, *Geophysical Journal International*, doi: 10.1093/gji/ggv542, 2016.

Kachingwe, M., **A. Nyblade**, and J. Julia, Crustal structure of Precambrian terranes in the southern African subcontinent with implications for secular variation in crustal genesis, *Geophysical Journal International*, 202, 533–547; doi: 10.1093/gji/ggv136, 2015.

Raveloson, A., **A. Nyblade**, S. Fishwick, A. Mangongolo, and S. Master, The upper mantle seismic velocity structure of south-central Africa and the seismic architecture of Precambrian lithosphere beneath the Congo Basin, in *The Geology and Resource Potential of the Congo Basin*, edited by M.J. de Wit, and F. Guillocheau, Springer-Verlag, DOI 10.1007/978-3-642-29482-2\_1, 2015.

Mulibo, G. and **A. Nyblade**, The P and S wave velocity structure of the mantle beneath eastern Africa and the African superplume anomaly, *Geochemistry, Geophysics and Geosystems*, doi:10.1002/ggge.20150, 2013.

Mulibo, G., and **A. Nyblade**, Mantle transition zone thinning beneath eastern Africa: Evidence for a whole mantle superplume structure, *Geophysical Research Letters*, 40, 1–5, doi:10.1002/grl.50694, 2013.

Bagley, B., and **A. Nyblade**, Seismic anisotropy in eastern Africa, mantle flow, and the African superplume, *Geophysical Research Letters*, 40, 1-6, doi:10.1002/grl.50315, 2013.

Hansen, S., **A. Nyblade**, and M. Benoit, Mantle structure beneath Africa and Arabia from adaptively parameterized P-wave tomography: Implications for the origin of Cenozoic Afro-Arabian tectonism, *Earth and Planetary Science Letters*, 319-320, doi:10.1016/j.epsl.2011.12.023, 23–34, 2012.

O'Donnell, J. P., A. Adams, **A. Nyblade**, G. Mulibo, F. Tugume, The uppermost mantle shear wave velocity structure of eastern Africa from Rayleigh wave tomography: Constraints on rift evolution, *Geophysical Journal International*, doi: 10.1093/gji/ggt135, 2013.

Tugume, F., **A. Nyblade** and J. Julia, Moho depths and Poisson's ratios of Precambrian crust in East Africa: Evidence for similarities in Archean and Proterozoic crustal structure, *Earth and Planetary Science Letters*, 355-356, 73–81, doi: 10.1016/j.epsl.2012.08.041, 2012.

**(d) Synergistic Activities**

Founder and co-Director of AfricaArray ([www.africaarray.org](http://www.africaarray.org)), 2004 - present.

Chair, Polar Networks Science Committee, 2013-2015

Member, Board of Directors, Incorporated Research Institutions for Seismology, 2015- present

Tectonics Editor, Books Board, American Geophysical Union, 2003 – 2010

Associate Editor, Journal of Geophysical Research, 1997 - 2000

**(e) Collaborators & Other Affiliations**

**Collaborators (Total - 31):** Rick Aster, Colorado St. U.; Estella Atekwana, Oklahoma State U., Ian Bastow, Imperial College; Robin Bell, Columbia U; Solomon Bililign, NCA&T U.; Grant Bybee, U. Witwatersrand; Eric Calais, Ecole Normale Superieure; Ian Dalziel, U of Texas; Ray Durrheim, U. Witwatersrand; Cindy Ebinger, U. of Rochester; Maureen Feineman, PSU; Jim Gaherty, Columiba U.; Steve Gao, Missouri U. of S&T; Roger Gibson, U. Witwatersrand; Samantha Hansen, U. of Alabama; Audrey Huerta, Central Washington U.; Erik Ivins, JPL; Katie Keranen, Cornell U.; Simon Klemperer, Stanford U.; Scott Nooner, UNC-Wilmington; Sarah Penniston-Dorland, U. of Maryland; Matt Prichard, Cornell U.; Carol Raymond, JPL; Chris Scholz, Syracuse U.; Donna Shillington, Columbia U.; Robert Smalley, U. of Memphis; Mark van der Meijde, U. of Twente; Susan Webb, U. Witwatersrand; Doug Wiens, Washington U.; Terry Wilson, Ohio State U.; Michael Wysession, Washington U.

**Graduate Advisors and Postdoctoral Sponsors (Total - 3):** Henry Pollack (Ph.D.) U. of Michigan; Peter Shive (M.S.) U. of Wyoming; Charles Langston (Postdoc), U. of Memphis

**Postdoctoral and Research Associates (Total - 13):** Brian Bagley (U. of Minnesota); Richard Brazier (PSU-DuBois); Mulugeta Dugda (NCA&T U.); Erica Emry (PSU); Samantha Hansen (U. of Alabama); Audrey Huerta (Central Washington U.); Alemayehu Jemberi (AON Inc, Chicago); Jordi Julia (U. Federal de Rio Grando do Norte, Brazil); Gabriel Mulibo (U. Dar es Salaam); John Paul O'Donnell (Leeds U.); Yongcheol Park (KORPI, South Korea); Ranto Raveloson (U. of the Witwatersrand), Sharmin Shamsalsadati (PSU).

**Graduate Students (Past and Present; Total - 33):** Aubreya Adams (Colgate U.); Nada Ahmed (U. Witwatersrand); Gabriella Arroyo (PSU); Margaret Benoit (College of New Jersey; NSF); Katie Boyle (Southwestern Energy); Priscilla Brownlow (RK&K); David Borrego (PSU); Christopher Casler (unknown); Mulugeta Dugda (NCA&T U.); Marco Finotello (Repsol); Juliette Florentin (unknown); Ashley Grijalva (PSU); Helio Inguane (U. Witwatersrand); Marsella Kachingwe (Chevron); Eldridge Kgaswane (Council of Geoscience); Ronald Knox (unknown); Robert Last (unknown); Andrew Lloyd (Washington U.); Azangi Mongongolo (Council for Geoscience); Gabriel Mulibo (U. of Dar es Salaam); Fenitra Ony (U. Witwatersrand); Kameron Ortiz (PSU); Yongcheol Park (KORPI, S. Korea); Tsitsi Rakotondraibe (U. Witwatersrand); Cristo Ramirez (PSU); Angela Reusch (IRIS/Passcal); Stewart Rouse (ESRI); David Soto (PSU); Fred Tugume (Uganda Geol. Surv.); Timothy Watson (Noble Energy); Austin White-Gaynor (PSU); Alysa Young (ENSCO), David Yoxtheimer (PSU).

**Thomas B. Murphy**  
Marcellus Center for Outreach and Research  
Pennsylvania State University  
University Park, PA

**Appointments**

2010-present Director, Marcellus Center for Outreach and Research (MCOR), Pennsylvania State University  
2008-present Principal, Marcellus Shale Education and Training Center (MSETC)  
2005- present Leader, Penn State Marcellus Education Team (MET);  
Chair, Penn State Extension Natural Gas Working Group  
1985- present Extension/Outreach Educator, Penn State Cooperative Extension

**Professional Preparation**

The Pennsylvania State University                      B.S. (Ag Sciences)                      1980

**Professional Interest:**

Programmatic thrust is predominately centered on initiatives involving the science and technology utilized in unconventional natural gas extraction and the related issues including socio-economic, workforce, legal, regulatory, environmental, LNG exports, and infrastructure. How they impact the various stakeholder groups in the shale regions of the U.S., North America, and globally. Involves development of educational programming relating to a core focus targeting shale energy development and the many associated implications. Provides leadership in multiple research and instruction-based shale related projects. Author of related subject matter articles directed to regional, state, and national publications.

**Related Research and Most Recent Publications:**

- The Natural Gas Supply Chain –CSCR Whitepaper (collaborator) 2016
- South Africa Strategic Environmental Assessment for Shale Gas Exploration, Development, and Production (reviewer) 2015
- Establishing Thresholds for Negative Effects on Vegetation and Soils from Marcellus Well Production Water (collaborator) 2015
- South Africa’s Technical Readiness to Support the Shale Gas Industry (reviewer) 2015
- Pathways to Shale Development in Asia-Pacific (reviewer) 2015
- Continuous, Regional Methane Emission Estimates in Northern Pennsylvania gas fields using atmospheric inversions (collaborator) 2014
- Economic Impact Study in 5 Pennsylvania Counties (reviewer) 2012
- Pennsylvania Marcellus Shale Workforce Needs Assessment (co-author) 2011
- Impacts to Municipalities and Businesses in Marcellus Shale Region (reviewer) 2011
- Local Development and Industrial Utilization (concept design, reviewer) 2011



- Murphy, T., *U.S. Shale Trends – Economic and Global Implications*, IOP Publishing, Journal of Physics:Conference Series 745, <http://iopscience.iop.org/article/10.1088/1742-6596/745/2/022004> September 2016
- C. Joel, R. Burcat, Stephen W. Saunders, Amy L. Barrette, Marc J. Bern, George A. Bibikos, Lauren M. Burge, Robert J. Burnett, John W. Carroll, Sean Cassidy, Brian J. Clark, Robert W. Diehl, Michael Dillon, Kevin J. Garber, Robert M. Jochen, Michael P. Joy, Tate J. Kunkle, Lisa C. McManus, Jeremy A. Mercer, Thomas B. Murphy, Joe Osborne, Ross H. Pifer, Jonathan E. Rinde, Russell L. Schetroma, Mark Szybist, Lauren M. Williams, Elizabeth U. Witmer, Matthew L. Wolford, Jordan B. Yeager, *The Law of Oil and Gas in Pennsylvania*, Second Edition, PBI Press, September 2016
- Lendel, Iryna; Thomas, Andrew R.; Townley, Bryan; Murphy, Thomas; and Kalynchuk, Ken, *Economics of Utica Shale in Ohio: Workforce Analysis*. Urban Publications. Paper 1330. [http://engagedscholarship.csuohio.edu/urban\\_facpub/1330](http://engagedscholarship.csuohio.edu/urban_facpub/1330) October 2015
- Liss, J., Murphy, T., [The Expanding Circle of Stakeholders: Shale Gas, Information Flows, and the Social License to Operate](#), OGEL 3 (2014), [www.ogel.org](http://www.ogel.org)
- Ratner, M., Blumsack, S., Murphy, T., *U.S. Shale Gas Development: Production, Infrastructure, and Market Issues*, Congressional Research Service, July, 2014
- Tieman, M., Folger, P., Carter, N., Arthur, M., Blumsack, S., Murphy, T., Yoxtheimer, D., Pifer, R., *Shale Energy Technology Assessment: Current and Emerging Water Practices*, Congressional Research Service, July, 2014
- Joel R. Burcat, Stephen W. Saunders, Amy L. Barrette, Marc J. Bern, George A. Bibikos, Lauren M. Burge, Robert J. Burnett, John W. Carroll, Sean Cassidy, Brian J. Clark, Robert W. Diehl, Michael Dillon, Kevin J. Garber, Robert M. Jochen, Michael P. Joy, Tate J. Kunkle, Lisa C. McManus, Jeremy A. Mercer, Thomas B. Murphy, Joe Osborne, Ross H. Pifer, Jonathan E. Rinde, Russell L. Schetroma, Mark Szybist, Lauren M. Williams, Elizabeth U. Witmer, Matthew L. Wolford, Jordan B. Yeager, *The Law of Oil and Gas in Pennsylvania*, PBI Press, September 2014
- Blumsack, S., Murphy, T., Yoxtheimer, D., *The Decision to Use Acidic Coal Mine Drainage for Hydraulic Fracturing of Unconventional Shale Gas Wells*, Journal of Environmental Studies Spring 2013.
- Blumsack, S., Murphy, T., Yoxtheimer, D., *Economic Implications for Use of Acid Mine Drainage for Hydraulic Fracturing*, Feasibility and Challenges of Using Coal Mine Drainage for Marcellus Shale Natural Gas Extraction (Conference Proceedings), RAND Corporation, Pittsburgh, PA, January 2012, pp 18-20.
- Kelsey, T., Murphy, T., *Economic Implications of Natural Gas Drilling in the Marcellus Shale Region*, Cascade Publication of the Federal Reserve Bank of Philadelphia, Issue #77, Spring/Summer 2011
- Kelsey, T., Murphy, T., *Impacts of Marcellus Shale on Housing Needs*, Cascade Publication of the Federal Reserve Bank of Philadelphia, Issue #77, Spring/Summer 2011

#### **Synergistic Activities:**

- 750+ presentations (2005- 2016) representing over 50 countries on unconventional shale topics to stakeholders including landowners, business groups, First Nations communities, elected officials, state/federal agencies, and professional associations.
- Legislative briefings (61) on shale energy development and related issues for elected officials at all levels including Pennsylvania and federal Congressional delegates and their respective staffs. Similar efforts with legislators in surrounding states, various embassy staff worldwide, and global governmental delegations. Briefings focus on technical, workforce development, social, and community development implications of shale gas extraction.

### **Recent Presentations:**

- Province of Alberta, *Unconventional Shale Energy Production: Emerging Trends, New Technology, Successful Regulations*, Calgary/Edmonton, Canada, February 2-5, 2014
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- Republic of South Africa/U.S. Dept of State Seminar, *Lessons from U.S. Shale Energy Production*, Pretoria, South Africa, February 10-11, 2014
- 
- Petroleum Exploration Society of Australia seminar series, *Shale Energy Production, Lessons from North America*, Brisbane, Sydney, Melbourne, Australia, February 17-20, 2014
- 
- University of Auckland Summer Energy Series, *The Development of Natural Gas in U.S., Economics, Risk, Workforce, and Environment*, Auckland, Wellington, New Zealand, March 1-4, 2014
- 
- Asian-Pacific Economic Cooperation Conference, *Unconventional Shale Gas Development: Convergence of Economics, Technology, and Policy*, Tokyo, Japan, March 25-27, 2014
- 
- Dickinson Law School Marcellus Series, *Shale Energy Development: U.S. Trends, Global Implications* , University Park, PA, April 25, 2014
- 
- Legg Mason Intellectual Capital Conference, *Global Shale Energy Development-- Expanding Economics, Trends, and Implications*, Baltimore, MD, May 7, 2014
- 
- World Bank Conference, *The Expanding Circle of Stakeholders: Shale gas, Information Flows, and the Social License to Operate*, Washington DC, June 2-3, 2014
- 
- U.S.-UA Working Group Annual Summit, *U.S. Shale Energy Production – Lessons for Ukraine*, Washington DC, June 19, 2014
- 
- Dept of Energy Quadrennial Energy Review, *The U.S. Natural Gas Infrastructure*, Carnegie Mellon University, Pittsburgh, PA, July 21, 2014
- 
- Dept of State/Ukrainian Documentary, *U.S. Shale Gas Production –Impacts and Opportunities*, PA and OH, July 28-Aug 9, 2014
- 
- Ohio State Univ. Shale Series, *Shale Energy Development – Emerging Trends, New Technology, Community Planning, and Successful Regulations*, Cambridge, OH, August 8, 2014
- 
- American Irish Business Forum, *Shale Gas Development in the U.S.- Implications Globally*, Dublin Ireland, August 28, 2014
- 
- Economic Forum, *Regional Gas Market in the Face of Global Developments*, Krynica, Poland, September, 4, 2014.

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- 9<sup>th</sup> International O&G Symposium, *Impacts of Social Media on Attainment of Social License*, Corner Brook, Newfoundland, Canada, September 11, 2014
- 
- Royal Canadian Mounted Police Seminar, *Shale Energy Production –Process and Global Trends*, Fredericton, New Brunswick, Canada, September 12, 2014
- 
- IAPG Seminars, *Shale Energy Development – U.S. and Global Implications*, Buenos Aires/Neuquen, Argentina, September 22-24, 2014
- 
- Latin Shale Seminar, *Attaining Social License to Operate in a World with Social Media*, Buenos Aires, Argentina, September 25, 2014
- 
- Lithuanian Prime Minister Seminar, *U.S. Shale Energy Production-Impacts to Eastern Europe and Global Security*, Pittsburgh, PA, October 7, 2014
- 
- Holland/DCED Business Seminar(by Webex), *Investment Opportunity Trends in Shale Energy Development in Pennsylvania*, October 11, 2014
- 
- Brazil Government Forum, *Academic Opportunity for Research and Outreach in Global Shale Production*, Pittsburgh, PA, October, 16, 2014
- 
- IEA Clean Coal Seminar, *The Shale Gas, Clean Coal Nexus*, University Park, PA, October 24, 2014
- 
- First Nations Council Meeting, *The Shale Gas Process - Economics and Environment*, London Ontario, October 28-29, 2014
- 
- World Shale Conference, *Social License in Emerging Shale Regions*, Dallas, TX, November 6, 2014
- 
- Georgia Technical Institute, *Conveying the Science of Risk – Evolving Perceptions within Non-Technical Audiences*, Atlanta, Georgia, November 13, 2014
- 
- Brazil Onshore Conference, *Global Shale Energy Development – Economic Trends, Social License, Water, and Regulation*, Natal, Brazil November 25, 2014
- 
- Triple Play Real Estate Conference, *Shale Energy Development –Local Impacts, Global Implications*, Atlantic City, NJ, December 10, 2014
- 
- Spilman Law Seminar, *Shale Energy Development -- Implications for Regional Workforce and Supply Chain*, Pittsburgh, PA, January 7, 2015
- 
- Seneca First Nations Webinar Series, *Shale Gas Drilling Overview –Economics, Environment, Workforce and Regulations*, Buffalo, NY, January 13, 2015
- IHS NAPE Conference, *Appalachian Shales – Trends in Policy, Resource Development, and Social License*, Houston, Texas, February 10-12, 2015
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- Algeria/Sonatrach/U.S. Embassy Outreach Series, *The Science of Shale Energy –The U.S. Experience*, Algiers, Algeria, February 16-20, 2015
- 
- EG-COIN Seminar, *Shale Energy Development: Finding the Gaps, Conveying the Science*, University of Calgary, Calgary, Alberta, March 3, 2015
- 
- Ontario Ministry of Environment/Natural Resources: *Shale Development in the U.S. –Trends, Policy, and the Way Forward*, Toronto, Ontario, March 20, 2015
- 
- University of Pittsburgh: *Global Trends in Shale Energy Development*, via Skype, April 1, 2015
- 
- Bluegrove: *Implications of U.S. and Global Shale Gas to World LNG Markets*, Jakarta, Indonesia, April 8-10, 2015
- 
- U.S. State Dept/Bulgaria, *Economic Impacts of Shale Energy Development in the U.S. and Globally*, Williamsport, PA, May 7-9, 2015
- 
- U.S. State Dept/Romania, *Shale Development in the U.S.- Implications to the Local Economy*, Williamsport, PA, May 11-16, 2015
- 
- OECD Rural Leadership Conference, *Increasing Citizen Engagement and Trust –Global Shale Energy Development*, Memphis, TN, May 18-21, 2015
- 
- East Coast Energy Connection, *Lessons Learned in U.S. Shale Energy Development –Localizing the Benefit*, Saint John, New Brunswick, June 8-10, 2015
- 
- Dept of Energy/NETL/Sonatrach, *The Science of Shale and the U.S. Experience –Contrasts with Algeria*, Washington, PA, June 11, 2015
- 
- EU/Australia Research Tour, Northcentral PA, June 12, 2015
- 
- Latin America/World Shale Conference, *Local Communities –Achieving Positive Engagement and Communication*, Neuquen, Argentina, June 22-25, 2015
- 
- Washington Energy Series w/U.S. State Department, *Shale Energy Development: Lessons Learned in North America*, Washington, DC, August 19, 2015
- 
- American Chamber of Commerce/Argentina, *North American Shale Gas Development and Current Economic Trends*, Neuquen and Buenos Aires, Argentina, September 7-10, 2015
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- Texas Christian University Global Impacts of Unconventionals Conference, *Eastern U.S. Shale Development – Implications for North America and Globally Involving Economic, Social License, Public Policy, and Environmental Impacts*, Fort Worth, TX, September 20-22, 2015
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- Pennsylvania Bar Institute Oil and Gas Colloquium, *Local Implications of Natural Gas Pipelines*, Pittsburgh, PA, September 24-25, 2015
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- New Brunswick/Newfoundland Provincial Commissions on Shale Energy Development, *Holistic Overview of Shale Energy Development –Workforce to Environmental Policy*, Penn College of Technology, Williamsport, PA September 28-30, 2015
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- Union Gas Seminar Series, *Shale Energy Development – Implications and Lessons Learned*, Penn State University, Williamsport, PA October 19-21, 2015
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- Penn State Natural Gas Utilization Conference, *Global Shale Energy Development—Opportunity or Headwind*, Pittsburgh, PA October 27-29, 2015
- 
- John Hopkins Research Tour, *Shale Energy Development – Implications and Lessons Learned*, Penn State University, Williamsport, PA November 2, 2015
- 
- Penn State Webinar Series, *Liquefied Natural Gas(LNG) –From Wellhead to Geopolitics*, Penn State University, University Park, PA November 12, 2015
- 
- Grand Challenge Forum on Responsible Development of Low Permeability Hydrocarbon Resources, *Eastern U.S. Shale Development –Public Outreach to Communities*, University of Calgary, Calgary, Alberta, November 22-24, 2015
- 
- American Energy, *LNG Export Opportunities and Global Markets*, Linde Corp, Allentown, Pennsylvania, January 14, 2016
- 
- Eastern Canadian Shale Development, *Review of Emerging Regulatory Review in New Brunswick and Newfoundland*, University Park, Pennsylvania, February 1, 2016
- 
- Rural Leadership Seminar, *U.S. Shale Energy Trends – From Wellhead to LNG Export*, Leola, Pennsylvania, February 19, 2016
- 
- National Association of Counties, *Hydraulic Fracturing –Science of the Process*, Washington, DC, February, 20, 2016
- 
- CCAP Energy Caucus, *LNG Exports and Upstream Production*, Harrisburg, Pennsylvania, March 12, 2016
- 
- eXtension i-Three Corps Seminar, *Energy Development in Non-Legacy Regions –Development of Social License*, San Antonio Texas, March 24, 2016
- 
- Pakistan Shale Development, *Overview of Shale Development in Eastern U.S. Shales*, Penn College of Technology, Williamsport, PA, March 31, 2016
- 
- National Association of Royalty Owners, *U.S. LNG in a Global Market*, Penn State University, University Park, Pennsylvania, April 1, 2016
- 
- European FracRisk Research Partnership Seminar, *U.S. Eastern Shale Development –Technology to Regulation*, Penn College of Technology, Williamsport, Pennsylvania, April 5, 2016
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- National Farm Management Seminar, *Shale Energy Development in Agricultural Regions*, Sioux Falls, South Dakota, June 13, 2016
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- U.S. Congressional Briefings, *Marcellus Trends and Technology Developments*, U.S. Capital Bldg, Washington, DC, June 15, 2016
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- U.S. State Dept. Energy Forum, *Marcellus Development in the U.S. – Trends and Technology*, Washington DC, June 16, 2016
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- Ukraine-U.S Business Council, *Energy and the Geopolitics of Ukraine*, University Club, Washington, DC, June 16, 2016
- 
- Eurotherm Conference, *Shale Energy in the U.S.—Emerging Trends of the Evolving Power Market*, APH University, Krakow, Poland, June 21, 2016
- 
- Argentina Shale Development, *Holistic Review of Shale Energy Technologies, Trends, and Regulatory Protocols of the U.S.*, Government to Government Exchange, Buenos Aires and Neuquen Argentina, June 26 –July 2, 2016
- 
- Ontario Rule Leadership Seminar, *Eastern U.S. Shale Trends –Economics to Regulations*, Penn State University, State College, Pennsylvania, July 11, 2016
- 
- Washington Embassy Energy Forum, *Economics and Technology of the Marcellus*, Penn College of Technology, Williamsport, Pennsylvania, July 14-15, 2016
- 
- PA Bar Institute, *Global LNG Trends and the Emergence of U.S. Exports*, Pittsburgh, Pennsylvania, July 27, 2016
- 
- Marcellus Shale Insights Conference, *Permitting Interstate Pipelines in the Face of Significant, Organized Public Opposition*, Pittsburgh, PA, September 21, 2016
- 
- DCED/China Seminar, *Eastern Shale Energy Economics and Development Overview*, State College, PA, September 23, 2016
- 
- Ontario First Nations/Union Gas Seminar, *Marcellus and Utica Shale Development –Environment, Water, and Regulatory Considerations*, Northcentral PA, September 26-27, 2016
- 
- Indian Shale Energy Series, *Sustainable Shale Gas Development –Lessons From North America and Globally*, Pandit Deendayal Petroleum University(PDPU), Gandhinagar, India, October 6, 2016
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- Argentina Unconventional Gas Development, *Sustainable Shale Gas Production in the Vaca Muerta Resource of Western Argentina*, Neuquen, Argentina, November 7-9, 2016
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- Brazilian Unconventional Gas Conference, *Sustainable Shale Gas Development –Lessons From North American Appalachian Shales*, University of Sao Paulo, Brazil, November 16-17, 2016
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- UK Shale Development, *Stakeholder Engagement –Techniques and Successes from Major U.S. Shale Basins*, Dallas, TX, Pittsburgh, PA, Denver, CO, November 28 – December 2, 2016