The National Academies of
SCIENCES • ENGINEERING • MEDICINE

Geographical Sciences Committee

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National Academy of Sciences
2101 Constitution Avenue NW
Washington, DC

Room 125

Vulnerability of U.S. Energy Infrastructure to Coastal Flooding

Essential components of energy infrastructure are located along U.S. coastlines, where the increasing probability for storm damage creates a pressing need to plan ahead to minimize disruption to the nation's energy systems. NOAA predicts that under what is now considered an intermediate scenario high-tide flooding will become daily flooding (365 days/year with high-tide flooding) for nearly all coastal regions. Strauss and Ziemlinski (2012) identified 287 energy facilities in the lower 48 U.S. states at coastal elevations within 4 feet of ordinary high-tide level. These facilities lie at elevations at which NOAA classifies probable flood impacts to infrastructure as minor (about 1.5 feet), moderate (about 2.5 feet), and major (4 feet) at these heights above average daily highest tide.

Energy infrastructure that could be affected by coastal flooding (as analyzed by Strauss and Ziemlinski, 2012) includes natural gas infrastructure, electric power plants, and oil and gas refineries in 22 states. More than half of the vulnerable facilities (most for natural gas) are located in Louisiana, while Florida, California, New York, Texas, and New Jersey each have 10 to 30 sites within 4 feet of the high-tide level. On-shore coastal energy infrastructure also includes the electrical grid, pipelines, and port facilities. Consequences of coastal flooding range from local power outages and unavailability of petroleum products to broader-scale power losses, economic stress, and ripple effects of those changes, such as effects to health care facilities and communications.

From the 2005 hurricanes Rita and Katrina, the oil industry learned that closures of gas-processing plants were caused not only by flooding, debris, and destruction of equipment, but also by external conditions, such as lack of electricity, inaccessibility of the plant site because of road damage or other problems, lack of upstream supplies to the processing plant caused by production shut-ins or pipeline problems, and downstream problems related to the disposal of natural gas liquids or Y-grade liquids (DOE, 2006). Because flood depths are predicted to increase as sea level rises, the frequency and severity of coastal flooding is expected to increase and storm surges are expected to extend farther inland. As one example, for southeastern Florida, a Union of Concerned Scientists report (2015) predicted a doubling of the number of major substations exposed to flooding from a Category 3 storm by 2050 and tripling by 2070. The need to prepare the nation's energy systems to withstand new regimes of coastal flooding is evident but complicated by politically, economically, socially, and environmentally difficult choices.

In this half-day meeting, the Geographical Sciences Committee will consider the following questions:

1. What additional scientific knowledge is needed to support efforts to reduce flood damage to coastal energy infrastructure?

2. What impacts are likely to affect large geographical areas and/or persist for substantial periods of time?

3. Is the relative importance of different ports, production, and distribution systems, and the extents of ripple effects of damage to them well understood?

OPEN AGENDA

1:30 pm	Welcome **Carol Harden**, GSC chair and Professor Emerita of Geography, The University of Tennessee, Knoxville
1:45 pm	Introduction **Marilyn Brown**, GSC member and Regents' and Brook Byers Professor of Sustainable Systems, School of Public Policy, Georgia Institute of Technology
2:00 pm	*Climate Change, Coastal Flooding, and the Electric Power Grid* **Frank Felder**, Research Professor and Director of the Center for Energy, Economic & Environmental Policy, Rutgers, The State University of New Jersey
2:30 pm	*Oregon's Energy Sector Vulnerabilities* **Yumei Wang**, Geotechnical Engineer, Oregon Department of Geology and Mineral Industries
3:00 pm	Break
3:15 pm	*Sea Level and Storm Surge Exposure of Coastal Energy Assets: Insights from Port and Water Infrastructure Assessments from Norfolk to Charleston* **Tom Allen**, Professor of Geography, Old Dominion University
3:45 pm	Discussion
5:00 pm	Adjourn

Speaker Biographies

Tom Allen is Professor of Geography in the Department of Political Science & Geography at Old Dominion University in Norfolk, Virginia. Allen is the program head for the Climate and Sea Level Science area of the university's Institute for Coastal Adaptation and Resilience (ICAR.) His research specializes in coastal geography and the spatial understanding of coastal hazards, coastal ecosystem change, and geomorphology, primarily utilizing GIS and remote sensing. He has recently published research on sea level rise and coastal hazard risk assessments for the Port of Virginia, the City of Charleston's water infrastructure preparedness with support of the NOAA Climate Program Office and Sea Grant, and conducted a Mid-Atlantic Risk and Resilience Demonstration Study with the NASA Applied Sciences Disasters Program. Allen routinely collaborates with local, state, and federal agencies on coastal change and risk assessment. He is a past Chair of the AAG Coastal and Marine Specialty Group and a Fulbright Scholar to the University of Turku (Finland.)

Frank Felder is an expert in energy policy and electricity markets. He is the Director of the Rutgers Energy Institute and Research Professor at the Bloustein School of Planning and Public Policy, Rutgers University. His research and teaching interests include the reliability and economics of electricity markets, state energy policy, energy efficiency and renewable energy evaluation, and integrated energy modeling. He has been awarded numerous research grants by the National Science Foundation, the U.S. Department of Energy, the U.S. Department of the Interior, the New Jersey Board of Public Utilities, and the New Jersey Department of Environmental Protection. Professor Felder has published in policy, engineering and economic journals including *Energy Policy*, *The Electricity Journal*, *IEEE Transactions on Power Systems*, *Electric Power Systems Research*, *Utilities Policy*, *Proceedings of the IEEE*, and *The Energy Journal*. Professor Felder teaches undergraduate and graduate level courses in Energy Engineering, Economics and Policy; Energy Policy and Planning; and the Science, Technology and Policy of Climate Change. He has also taught short courses on electricity markets in Africa, Asia, Canada, Europe and the United States. He holds doctoral and master degrees from MIT in Technology, Management and Policy and completed his undergraduate studies at Columbia College and the School of Engineering and Applied Sciences. Before joining the Bloustein School faculty, Professor Felder was an assistant professor of Management at the Manhattan College School of Business, an economic consultant, and a nuclear engineer in the U.S. Navy.

Yumei Wang is a resilience engineer at the Oregon Department of Geology and Mineral Industries (DOGAMI). She focuses on building resilience to natural hazards and earthquake risk management, including on schools, emergency response facilities and critical lifelines infrastructure. She advises the Governor's Office and the Chief Financial Office at the Oregon Department of Administrative Services (DAS CFO) on special projects and long range resilience planning. She serves on the Board of the Cascadia Region Earthquake Workgroup, and has been an advisor to the National Earthquake Hazards Reduction Program (NEHRP), and to the 2013 Oregon Resilience Plan, as well as co-led post-earthquake damage assessments on the 2011 Tohoku, Japan, 2010 Maule, Chile and other disasters. Wang has been a guest on PBS NewsHour, been interviewed by The New York Times, and appeared in documentaries produced by Oregon Public Broadcast (www.opb.org/news/series/unprepared), NOVA, National Geographic, and Discovery. Wang served as a Congressional Fellow in the U.S. Senate in Washington DC, and worked as a geotechnical consultant in California. She is the recipient of the 2018 Le Val Lund Award for Practicing Lifeline Risk Reduction.

References

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Strauss, B. and Ziemlinski, R. (2012) Sea level rise threats to energy infrastructure. A Surging Seas Brief Report by climate Central, April 19, 2012. https://www.energy.senate.gov/public/index.cfm/files/serve?File_id=b5051061-ae72-41e0-b221-9eb24e5cfed0

Union of Concerned Scientists (2015) Lights Out? Storm surge and blackouts in the Delaware Valley and how clean energy can help. www.ucsusa.org/lightsout

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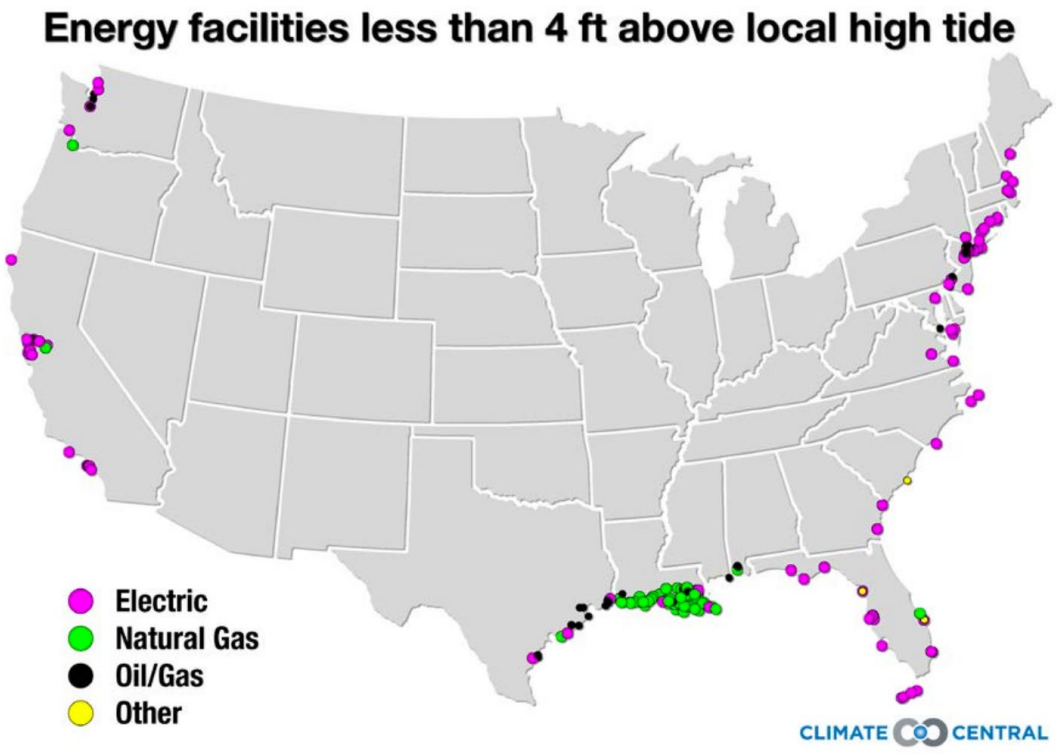

Source: Strauss and Ziemlinski (2012) (sealevel.climatecentral.org)