



# Arne Olson

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**ENERGY AND ENVIRONMENTAL ECONOMICS, INC.**  
*Senior Partner*

San Francisco, CA

Mr. Olson has 25 years of experience in energy analysis, and he is a frequent speaker at energy conferences on the role renewable energy will play in decarbonizing the grid. He joined E3 in 2002 and became a partner in 2010. Mr. Olson leads E3's Bulk Energy Infrastructure practice area helping clients navigate changes to bulk electric system operations and investment needs brought about by increasing policy and market interest in clean and renewable energy production. He has led a number of landmark studies of the feasibility and cost of achieving deep decarbonization and high renewable penetration goals for electric utilities, including studies of 100% renewables in California, the Pacific Northwest and the Midwest. He consults extensively for utilities, asset owners, project developers and electricity consumers in support of resource planning and commercial transactions involving renewable, conventional and energy storage resources. He also provides technical and strategic support to numerous utility regulators, state agencies and environmental organizations. He has provided expert witness testimony in regulatory and legal proceedings in California, Oregon, Georgia, Alberta and Ontario. Prior to joining E3 in 2002, he served for six years in the Energy Policy Division of the Washington State Energy Office and its successor agencies.

Mr. Olson has led the development of E3's industry-leading resource planning software including the RESOLVE model that develops optimal portfolios of renewable, conventional and energy storage resources and the RECAP model that calculates Loss-of-Load Probability and related statistics to ensure that power systems can meet load reliably under high renewable penetrations. His clients have included most of the major utilities and market participants in the West including the California Independent System Operator, Pacific Gas and Electric, Southern California Edison, Puget Sound Energy, PacifiCorp, Arizona Public Service, Sacramento Municipal Utilities District, Los Angeles Department of Water and Power, the Bonneville Power Administration, Calpine, NextEra, NRG, TransAlta and many others. Eastern clients have included Xcel Energy – Northern States Power, Florida Power & Light, Tampa Electric Company, Nova Scotia Power, Hydro-Quebec TransEnergie, TransElect, Long Island Power Authority, and the Georgia Large-Scale Solar Association. He also works extensively with government agencies and industry organizations such as the California Public Utilities Commission, California Energy Commission, Oregon Public Utilities Commission, the Western Electric Coordinating Council, the Western Interstate Energy Board, and the New York State Research and Development Authority.

### Electricity Resource Adequacy:

Mr. Olson is a prominent expert on resource adequacy issues and has led many projects that evaluate the need for effective capacity to ensure resource adequacy during the clean energy transition.

Examples include:

- Currently leading a team that is advising PJM Interconnection on application of ELCC concepts to renewable resources within the context of PJM's Reliability Pricing Model (RPM) forward capacity market.
- Leads a multi-company team that supports the California Public Utilities Commission (CPUC) staff for the Integrated Resource Planning (IRP) Proceeding. The IRP proceeding is considering the need for new capacity resources to ensure resource adequacy in California.
- Led a team that prepared a report on regional resource adequacy programs in support of the Northwest Power Pool's effort to stand up such a program in the Pacific Northwest. The study evaluated regional programs operated by each of the major market operators in North America for their potential application to the unique circumstances of the Pacific Northwest.
- Led a team at E3 that developed the Renewable Energy Capacity Planning (RECAP) Model, a loss-of-load probability (LOLP) model designed explicitly to measure the need for capacity on highly renewable electricity systems, as well as the contribution of dispatch-limited resources such as wind, solar, energy storage and demand response toward meeting those needs.
- Has led numerous teams that utilized RECAP to calculate resource needs, Planning Reserve Margins (PRMs), and Effective Load-Carrying Capability (ELCC) values for dispatch-limited resources for clients including the California ISO, California PUC, Western Electric Coordinating Councils, Portland General Electric, Hawaiian Electric Company, Los Angeles Department of Water and Power, Sacramento Municipal Utilities District, NorthWestern Energy, Northwest Power Pool, Xcel Energy, NV Energy, El Paso Electric, Nova Scotia Power, Calpine Corporation, and others.
- Led a team that evaluated the need for "clean firm" capacity to ensure reliable electric service under 100% carbon reduction scenarios for California, sponsored by the Environmental Defense Fund and the Clean Air Task Force.
- Led a team that used RECAP to calculate ELCC values for solar, wind, storage and hybrid resources to support NorthWestern Energy's evaluation of bids received in its 2020 capacity solicitation, and is providing expert witness testimony to the Montana Public Service Commission.
- Reviewed Duke Energy Carolinas and Duke Energy Progress's IRPs on behalf of Cypress Creek Renewables and Carolinas Clean Energy Business Association and provided expert witness testimony in North Carolina and South Carolina regarding Duke's resource adequacy studies, the capacity value attributed to solar and battery storage resources, and their incorporation in Duke's capacity expansion modeling.
- Led a project team that evaluated alternative methods for calculating the capacity value of solar resources on behalf of the Oregon Public Utilities Commission staff.
- Led a team in 2019-2020 that utilized RECAP to calculate the capacity contribution of demand response and energy storage resources in California using the ELCC method on behalf of the California ISO.
- Currently serving as expert witness in a wholesale market tariffs case for Nova Scotia Power, considering issues related to effective capacity determination for third-party resources.
- Led a team in 2019 that evaluated what types of resources would be needed to maintain resource adequacy in a deeply-decarbonized, 2050 California electricity system, in a study sponsored by the Calpine Corporation.

- For a group of 13 utilities in the Pacific Northwest, led studies in 2017 and 2018 that examined scenarios achieving 50% renewables and up to 100% carbon reductions across the region, focusing on policy mechanisms to achieve the goals at least cost and on the nature and quantity of complementary resources that are needed to maintain reliable electric service.
- For the Los Angeles Department of Water and Power, led a study that evaluated the reliability implications of closing three in-city natural gas-fired generating stations and replacing them with alternative resource portfolios including new gas, demand response, solar energy, energy storage and new transmission.
- Led a project that evaluated flexible capacity needs under high renewable penetration across the Western Interconnection on behalf of the Western Electric Coordinating Council and the Western Interstate Energy Board. The team included technical contributions from E3, NREL and Energy Exemplar.
- Led a team in 2016 that performed analysis on behalf of Calpine and presented to the California Public Utilities Commission (CPUC) to recommend the use of the effective load carrying capability (ELCC) metric in the Resource Adequacy (RA) program for wind and solar resources. The CPUC ultimately adopted this recommendation along with several market design features proposed by E3.

*Electricity Resource Planning and Decarbonization:*

Mr. Olson has led numerous projects supporting utility system integrated resource planning efforts. Many of these projects have considered the cost, reliability and operational implications of achieving very high levels of renewables. Examples include:

- Led a team at E3 that evaluated alternative policy options for achieving a deep decarbonization and high penetrations of clean energy resources across the PJM system. The study considers alternative clean energy policy mechanisms and geographic footprints.
- Led a team consisting of E3 and Energy Futures Initiative that evaluated economy-wide deep decarbonization pathways for New England. The *Net Zero New England* study considers alternative scenarios for building decarbonization including High Fuels and High Electrification scenarios, as well as optimal portfolios of electricity resources to meet electric demand reliably while reducing carbon emissions to 2-3 MMT by 2050. Alternative resources considered include onshore and offshore wind, ground-mounted and rooftop solar, imported hydroelectric power, conventional and advanced nuclear power, fossil generation with carbon capture and sequestration, and hydrogen.
- Led a team that supported Nova Scotia Power's 2020 Integrated Resource Plan, which seeks to reduce carbon emissions by over 90% by replacing coal generation with a combination of in-province clean energy resources as well as potential clean imports.
- Leads a team that is supporting El Paso Electric Company's 2021 IRP.
- Leads a team that is studying regional transmission and clean energy projects on behalf of four Atlantic Canada provinces, several utilities, and Natural Resources Canada.
- Leads a team that is developing an economy-wide deep decarbonization study for a large, dual-fueled Midwestern utility.
- Leads a team at E3 that has supported the California Public Utilities Commission staff since 2014 in developing an electricity Reference System Plan for California and designing and implementing integrated resource planning standards for California load-serving entities.
- For the Sacramento Municipal Utilities District, led the development of their 2018 IRP which considered scenarios and resource portfolios for meeting California's and SMUD's own aggressive

renewables goals including 100% renewables by 2040 and provides ongoing IRP and strategic planning support.

- For Xcel Energy, led an effort to support development of Northern States Power's 2018-19 IRP examining high renewable scenarios within the context of the company's stated goal of completely decarbonizing their electric resource portfolio by 2050.
- In 2018, led a study of the value of partially- and fully-dispatchable solar and solar+storage power plants on the Tampa Electric Company (TECO) system. The study was funded by First Solar but it involved extensive participation by a wide range of TECO staff and included detailed TECO power system data. The study was recognized by Public Utilities Fortnightly as among its 2018 Top Innovators and nominated as a finalist for the Smart Electric Power Alliance 2019 Power Players Award in the Change Agent of the Year category, and for the 2019 Platts Global Energy Awards in the Grid Edge category.
- For a group comprising the five largest utilities in California (Los Angeles Department of Water and Power, Pacific Gas and Electric Company, Sacramento Municipal Utilities District, San Diego Gas & Electric Company, and Southern California Edison), I led a landmark 2014 study of the feasibility, cost implications and complementary measures for achieving 50% renewables by 2030.
- Participated in several other E3 resource planning studies of achieving very high renewable penetrations for the Hawaiian Electric Company, the New York State Energy Research and Development Authority, and several electric utilities in the Southwest.
- For Portland Generic Electric, led a team that evaluated the need for resource adequacy capacity and flexible generation capacity in 2014-2016.
- For the Western Electric Coordinating Council and Western Interstate Energy Board, led teams that assessed electricity-natural gas infrastructure issues with regards to electric sector reliability under a changing resource mix including reduced reliance on coal generation and increased reliance on variable renewables and natural gas generation.
- For the Sacramento Municipal Utilities District, led a team that investigated the capacity contribution of new wind, solar and demand response (DR) resources.
- For the Colorado Public Utilities Commission, assisted in developing long-term scenarios to use across a range of energy infrastructure planning dockets.
- Provided expert testimony in front of the California Public Utilities Commission on rates and revenue requirements associated with several alternative portfolios of demand-side and supply-side resources, on behalf of Pacific Gas and Electric Company, Southern California Edison, and San Diego Gas & Electric.
- Served as lead investigator in assisting the California Public Utilities Commission (CPUC) in its efforts to reform the long-term procurement planning process in order to allow California to meet its aggressive renewable energy and greenhouse gas reduction policy goals.
- On behalf of the CPUC, investigated a number of strategies for achieving a 33% Renewables Portfolio Standard in California by 2020, and estimated their likely cost and rate impacts using the 33% RPS Calculator, a publicly-available spreadsheet model developed for this project.
- Served as lead investigator in developing integrated resource plans for numerous publicly-owned utilities including PNGC Power, Lower Valley Energy, Umatilla Electric Cooperative and Platte River Power Authority.
- Investigated for Bonneville Power Administration (BPA) the economics and feasibility of investing in new, long-line transmission facilities connecting load centers in the Pacific Northwest with remote areas that contain large concentrations of high-quality renewable energy resources. The study informed BPA about cost-effective strategies for procuring renewable energy supplies in order to meet current and potential future renewable renewables portfolio standards and greenhouse gas reduction targets.

### Asset Valuation:

- Provides market evaluation and strategic advisory services for numerous asset owners and developers in California, the Southwest and the Pacific Northwest.
- Leads a team that develops medium- and long-term market price forecasts for energy, capacity, ancillary services and renewable energy credits (RECs) under very high renewable energy penetration at various market pricing points in the Western Interconnection.
- Led the team that developed renewable and conventional resource cost and performance characteristics for use in the WECC's Regional Transmission Expansion Planning process.
- On behalf of the Wyoming Governor's Office, developed a model of the cost of developing wind resources in Wyoming relative to neighboring states to inform policy debate regarding taxation. The model included detailed representations of state-specific taxes and capacity factors.

### Transmission Planning and Pricing:

- Provided generation and transmission asset valuation services to a number of utility and independent developer clients.
- Currently advising several transmission developers seeking approval for projects through the CAISO's Transmission Planning Process.
- Served as technical support to the Western Electric Coordinating Council's Scenario Planning Steering Group (SPSG). The SPSG is developing scenarios for long-term transmission planning in the Western Interconnection.
- Led a team that investigated the use of Production Cost Modeling for the purpose of allocating costs of new transmission facilities on behalf of the Northern Tier Transmission Group and contributed to NTTG's Order 1000 compliance filing.
- Served as an expert witness in front of the Alberta Utilities Commission in a case regarding the Alberta Electric System Operator's proposed methodology for allocating Available Transmission Capacity among interties during times of congestion.
- Retained by a consortium of southwestern utilities and state agencies including the Wyoming Infrastructure Authority, Xcel Colorado, Public Service Company of New Mexico, and the Salt River Project to perform an economic feasibility study of the proposed High Plains Express (HPX) transmission project, a roadmap for transmission development in the Desert Southwest and Rocky Mountain regions.
- Conducted numerous screening studies of long-distance transmission lines connecting to remote renewable energy zones for multiple western utilities.
- Assisted in the development of a methodology for evaluating the renewable energy benefits of the Sunrise Powerlink transmission project in support of expert testimony on behalf of the California ISO.
- Assisted British Columbia Transmission Corporation and Hydro-Quebec TransEnergie with open access transmission tariff design.
- Provided assistance to the Seattle City Council to develop guidelines for the evaluation of large electric distribution and transmission projects by Seattle City Light (SCL). Guidelines specified the types of evaluations SCL should perform and the information the utility should present to the City Council when it seeks approval for large distribution or transmission projects.
- Led studies in 2009, 2011 and 2012 to develop generation and transmission capital cost assumptions for use in WECC's Transmission Expansion Planning and Policy Committee (TEPPC) studies.

- Contributed to a study of the benefits of North-South transmission expansion in Alberta on behalf of AltaLink.
- Co-authored *Load-Resource Balance in the Western Interconnection: Towards 2020*, a study of west-wide infrastructure needs for achieving aggressive RPS and greenhouse gas reduction goals in 2020 for the Western Electric Industry Leaders (WEIL) Group, comprised of CEOs and executives from a number of utilities through the West, and presented results indicating that developing new transmission infrastructure to integrate remote renewable resources can result in cost savings for consumers under aggressive policy assumptions.

#### Market Analysis:

- Currently supporting an effort by Pacific Northwest utilities to evaluate the benefits and costs of regional capacity planning reserve sharing mechanisms.
- Co-led a study for the California Independent System Operator in 2017 to estimate the benefits of forming an organized regional electricity market across much of the Western Interconnection. The study estimated benefits from more efficient capacity expansion, reduced operating reserves, reduced fuel and O&M costs, reduced renewable curtailment, reduced planning reserve margins, and others.
- Led a study for WECC to estimate the benefits of developing a centralized Energy Imbalance Market (EIM) across the Western Interconnection. The study estimated benefits due to increased generation dispatch efficiency resulting from reduced market barriers and increased load and resource diversity among western Balancing Authorities. Led several follow-up studies of alternative Western EIM footprints for potential EIM participants.
- Led a study to estimate the benefits of EIM participation for Seattle City Light and Chelan County Public Utilities District.
- Participated in studies of the benefits of joining the Western EIM for numerous utilities including PacifiCorp, Portland General Electric, Idaho Power, NorthWestern Energy, the Balancing Area of Northern California, Tucson Electric Power, Public Service Company of New Mexico, and the Bonneville Power Administration.
- Represented BC Hydro in RTO West market design process in areas of congestion management, ancillary services, and transmission pricing.

#### Cost of Service and Rate Design:

- For a medium-sized Northwest public utility district, led a team that analyzed financial risks to native ratepayers of fulfilling service requests for significant new quantities of industrial electric loads.
- For a large Northwest rural electric cooperative, developed a new large load policy to provide electricity service at cost-of-service rates while minimizing upward rate pressure on existing customers.
- For a large Northwest rural electric cooperative, developed a cost-of-service model and redesigned retail electric rates to provide customers with incentives to manage growth in electric loads while equitably allocating benefits from low-cost federal hydropower resources.
- For the British Columbia Hydro and Power Authority, assisted with the developed of Stepped Rates for BC Hydro's large industrial customer class.
- For a medium-sized Northwest rural electric cooperative, led a team that evaluated the rate benefits and rate design options of merging its operations with a neighboring utility.

- For a Northwest generation and transmission cooperative, led a team that evaluated alternative options for structuring pooled generation investments, including design of the pool's wholesale rates to its member cooperatives.
- For a Northwest rural electric cooperative, evaluated the benefits of membership in alternative power pool options, including an evaluation of which design's wholesale rate structure was best suited to the utility's load characteristics.

Energy and Climate Policy:

- Developed policy themes and integrated them into the four long-term planning scenarios under consideration by WECC's Scenario Planning Steering Group.
- Led a team that developed a model of deep carbon dioxide emissions reductions scenarios in the western United States and Canada on behalf of the State-Provincial Steering Committee, a body of western state and provincial officials that provides oversight for WECC.
- Led a study of likely changes to power flows and market prices at western electricity trading hubs following California's adoption of a cap-and-trade system for regulating greenhouse gas emissions in 2013.
- For BC Hydro, evaluated the impact of BC's provincial greenhouse gas reduction policies on future electric load as part of BC Hydro's 2011 Integrated Resource Plan.
- Served as advisor, facilitator and drafter to the Interim Committee in developing Idaho's first comprehensive, statewide energy plan in 25 years. The Interim Committee and subcommittees held 18 days of public meetings and received input from dozens of members of the public in developing state-level energy policy recommendations. This process culminated in Mr. Olson drafting the 2007 Idaho Energy Plan, which was approved by the Legislature and adopted as the official state energy plan in March 2007.
- Developed a model that forecasted renewable and conventional generating resources in the WECC region in 2020 as part of an E3 project to advise the California Public Utilities Commission, California Energy Commission and California Air Resources Board about the cost and feasibility of reducing greenhouse gas emissions in the electricity and natural gas sectors.

**WASHINGTON OFFICE OF TRADE AND ECONOMIC DEVELOPMENT**

*Senior Energy Policy Specialist*

Olympia, WA

1996-2002

- **Electricity Transmission:** Lead responsibility for developing and representing agency policy interests in a variety of regional forums, with a primary focus on pricing and congestion management issues. Lead negotiator on behalf of agency in IndeGO and RTO West negotiations in areas of Congestion Management, Ancillary Services, and Transmission Planning. Participated in numerous subgroups developing issues including congestion zone definition, nature of long-term transmission rights, and RTO role in transmission grid expansion.
- **Western Regional Transmission Association, 1996-2001:** Member, WRTA Board of Directors. Participated in WRTA Tariff, Access and Pricing Committee. Participated in sub-groups examining "seams" issues among multiple independent system operators in the West and developing a proposal for tradable firm transmission rights in the Western interconnection.
- **Wholesale Energy Markets:** Monitored and analyzed trends in electricity, natural gas and petroleum markets. Editor and principal author of Convergence: Natural Gas and Electricity in Washington, a survey of the Northwest's natural gas industry in the wake of the extreme price events of winter 2000-2001, and on the eve of a significant increase in demand due to gas-fired

power plants. Authored legislative testimony on the ability of the Northwest's natural gas industry to meet the demand from new, gas-fired power plants.

- **Electricity Restructuring:** Co-authored Washington Electricity System Study, legislatively-mandated study of Washington's electricity system in the context of ongoing trends and potential methods of electric industry restructuring. Authored legislative testimony on the impact of restructuring on retail electricity prices in Washington, electric industry restructuring and Washington's tax system, and the interactions between restructured electricity and natural gas markets.
- **Energy Data:** Managed three-person energy data team that collected and maintained a repository of state energy data. Developed Washington's Energy Indicators, a series of policy benchmarks and key trends for Washington's energy system; second edition published in January 2001.

## **DECISION ANALYSIS CORPORATION OF VIRGINIA**

*Associate*

Vienna, VA

1993-1996

- **Energy Modeling and Analysis:** Developed energy demand forecasting models for Energy Information Administration's National Energy Modeling System. Results are published each year in EIA's Annual Energy Outlook.

## Education

University of Pennsylvania  
Institut de Francais du Petrole  
*M.S., International Energy Management & Policy*

Philadelphia, PA  
Rueil-Malmaison, France

University of Washington  
*B.S., Mathematical Sciences, B.S. Statistics*

Seattle, WA

## Citizenship

United States

## Expert Witness Testimony

1. *Nova Scotia Utility and Review Board, 2021, testified on behalf of Nova Scotia Power regarding wholesale electricity market design issues.*
2. *South Carolina Public Service Commissions, 2021, testified on behalf of the Carolinas Clean Energy Business Association regarding Duke Energy Carolinas and Duke Energy Progress's resource adequacy studies, the capacity value attributed to solar and battery storage resources, and their incorporation in Duke's capacity expansion modeling in their 2020 IRP processes.*



3. *Ontario Superior Court of Justice, 2021, testified on behalf of the Province of Ontario regarding Ontario's Feed-in Tariff policies and the resulting renewable energy contracts.*
4. *Georgia Public Service Commission, 2020, testified on behalf of the Georgia Large-Scale Solar Association, Georgia Power's Capacity and Energy Payments to Cogenerators Under PURPA and Georgia Power Company's Green Energy Program.*
5. *New Mexico Public Regulation Commission, 2020, testified on behalf of El Paso Electric Company regarding independent analysis that E3 performed of the Company's selection of solar, energy storage and new gas resources stemming from its 2018 all-source capacity solicitation.*
6. *Georgia Public Service Commission, 2019, testified on behalf of the Georgia Large-Scale Solar Association in Georgia Power's Integrated Resource Plan (IRP) proceeding regarding the quantity of large-scale solar energy that Georgia Power could procure in order to maximize customer benefits.*
7. *Oregon Public Utilities Commission, 2017, testified on behalf of Commission staff regarding methodologies for assessing the value of customer-owned solar resources.*
8. *Oregon Public Utilities Commission, 2016, testified on behalf of Portland General Electric Company regarding methodologies for assessing the capacity contribution of variable renewable energy resources.*
9. *Province of Ontario, Commercial Arbitration, 2015, testified regarding policies related to renewable energy procurement and determination of available transmission capacity.*
10. *California Energy Commission, 2014, testified on behalf of Abengoa and BrightSource Energy regarding the cost and feasibility of distributed generation and energy storage alternatives to a large, concentrating solar power plant project in the context of a power plant siting case.*
11. *California Energy Commission, 2013, testified on behalf of BrightSource Energy regarding the cost and feasibility of distributed generation alternatives to a large, concentrating solar power plant project in the context of a power plant siting case.*
12. *Alberta Electric Utilities Commission, 2012, testified on behalf of Powerex Corporation reviewing industry practices regarding treatment of existing transmission capacity, in the case when new transmission lines are interconnected.*
13. *California Public Utilities Commission, 2011, provided testimony on behalf of Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company regarding cost, revenue requirement, average retail rates, and cost of carbon reductions from alternative resource portfolios in the Long-Term Procurement Planning Proceeding.*
14. *California Public Utilities Commission, 2010, testified on behalf of BrightSource Energy and First Solar regarding the need for the he Eldorado-Ivanpah Transmission Project (EITP) proposed by Southern California Edison (SCE) to help integrate over 1000 MW of utility-scale solar generation.*

15. *California Energy Commission, 2010, testified on behalf of BrightSource Energy regarding the cost and feasibility of distributed generation alternatives to a large, concentrating solar power plant project in the context of a power plant siting case.*

## Publications

1. Baik, Ejeong, Kiran P. Chawla, Jesse D. Jenkins, Clea Kolster, Neha S. Patankar, Arne Olson, Sally M. Benson, Jane C.S. Long, "What is different about different net-zero carbon electricity systems", *Energy and Climate Change*, Volume 2, December 2021, <https://www.sciencedirect.com/science/article/pii/S2666278721000234>
2. Arne Olson and Adam Simpson, "Greening the Microgrid: Moving beyond backup with cleaner sources of firm energy", *Power Engineering*, June 21, 2021, <https://www.power-eng.com/on-site-power/greening-the-microgrid-moving-beyond-backup-with-cleaner-sources-of-firm-energy/#qref>
3. Long, Jane C.S., Ejeong Baik, Jesse D. Jenkins, Clea Kolster, Kiran Chawla, Arne Olson, Armond Cohen, Michael Colvin, Sally M. Benson, Robert B. Jackson, David G. Victor, and Steven P. Hamburg. "Clean Firm Power is the Key to California's Carbon-Free Energy Future." *Issues in Science and Technology*, March 24, 2021, <https://issues.org/california-decarbonizing-power-wind-solar-nuclear-gas/>
4. Scott Burger, Marco Ferrara, Roderick Go, and Arne Olson, "To build a zero-carbon grid, we first need to model it accurately", *Utility Dive*, December 23, 2020, <https://www.utilitydive.com/news/to-build-a-zero-carbon-grid-we-first-need-to-model-it-accurately/592704/>
5. Nick Schlag, Zachary Ming and Arne Olson, "Adding it all up: Counting the capacity contribution of variable and duration-limited resources", *Utility Dive*, September 10, 2020, <https://www.utilitydive.com/news/adding-it-all-up-counting-the-capacity-contribution-of-variable-and-durati/584843/>
6. Wu, Grace; Leslie, Emily; Sawyerr, Oluwafemi; Cameron, D. Richard; Brand, Erica; Cohen, Brian; Allen, Douglas; Ochoa, Marcela; Olson, Arne, "Low-impact land use pathways to deep decarbonization of electricity", *Environmental Research Letters*, Volume 15, Number 7, 10 July 2020
7. Arne Olson and Dan Mullen, "For a smart transition to 100% clean energy: Renewables, storage and, in some cases, new gas", *Utility Dive*, December 18, 2019, <https://www.utilitydive.com/news/for-a-smart-transition-to-100-clean-energy-renewables-storage-and-in-so/569279/>
8. Woo, C.K., J. Zarnikau, Y. Chen, A. Olson, J. Moore, T. Ho, Y. Liu, and X. Luo (2017) "An empirical analysis of California's hybrid capacity options" *The Electricity Journal*, Volume 31, Issue 2, March 2018, Pages 7-12

9. Woo, C.K., A. Olson, Y. Chen, J. Moore, N. Schlag, A. Ong, and T. Ho (2017) "Does California's CO2 price affect wholesale electricity prices in the Western U.S.A.?" *Energy Policy*, 110, 9–19
10. Olson, A., C.K. Woo, N. Schlag and A. Ong (2016) "What Happens in California Does Not Always Stay in California: The Effect of California's Cap-and-Trade Program on Wholesale Electricity Prices in the Western Interconnection," *The Electricity Journal*, 29(7), 18-22
11. Woo, C.K., J. Moore, B. Schneiderman, T. Ho, A. Olson, L. Alagappan, K. Chawla, N. Toyama, J. Zarnikau (2016) "Merit-order effects of renewable energy and price divergence in California's day-ahead and real-time electricity markets," *Energy Policy*, 92, 299-312
12. Woo, C.K., J. Moore, B. Schneiderman; A. Olson; R. Jones; T. Ho; N. Toyama; J. Wang; and J. Zarnikau, "Merit-order Effects of Day-ahead Wind Generation Forecast in the Hydro-rich Pacific Northwest", *The Electricity Journal*, Vol. 28, Issue 9, November 2015
13. Olson, A., A. Mahone, E. Hart, J. Hargreaves, R. Jones, N. Schlag, G. Kwok, N. Ryan, R. Orans and R. Frowd, "Halfway There: Can California Achieve a 50% Renewable Grid?", *IEEE Power and Energy Magazine*, Volume:13, Issue: 4, pp. 41-52, July-Aug. 2015
14. Olson, A., R. Jones, E. Hart and J. Hargreaves, "Renewable Curtailment as a Power System Flexibility Resource," *The Electricity Journal*, Volume 27, Issue 9, November 2014, pages 49-61
15. Hargreaves, J., E. Hart, R. Jones and A. Olson, "REFLEX: An Adapted Production Simulation Methodology for Flexible Capacity Planning," *IEEE Transactions on Power Systems*, Volume:30, Issue: 3, September 2014, pages 1306 - 1315
16. Woo, C.K., T. Hob, J. Zarnikau, A. Olson, R. Jones, M. Chait, I. Horowitz, J. Wang, "Electricity-market price and nuclear power plant shutdown: Evidence from California", *Energy Policy*, 2014, vol. 73, issue C, pages 234-244
17. Woo, C.K., Zarnikau J, Kadish J, Horowitz I, Wang J, Olson A. (2013) "The Impact of Wind Generation on Wholesale Electricity Prices in the Hydro-Rich Pacific Northwest," *IEEE Transactions on Power Systems*, 28(4), 4245-4253.
18. Orans, R., A. Olson, J. Moore, J. Hargreaves, R. Jones, G. Kwok, F. Kahrl, and C.K. Woo (2013) "Energy Imbalance Market Benefits in the West: A Case Study of PacifiCorp and CAISO," *Electricity Journal*, 26:5, 26-36.
19. Olson A., R. Jones (2012) "Chasing Grid Parity: Understanding the Dynamic Value of Renewable Energy," *Electricity Journal*, 25:3, 17-27.
20. Woo, C.K., H. Liu, F. Kahrl, N. Schlag, J. Moore and A. Olson (2012) "Assessing the economic value of transmission in Alberta's restructured electricity market," *Electricity Journal*, 25(3): 68-80.
21. DeBenedictis, A., D. Miller, J. Moore, A. Olson, C.K. Woo (2011) "How Big is the Risk Premium in an Electricity Forward Price? Evidence from the Pacific Northwest," *Electricity Journal*, 24:3, 72-76.

22. Woo, C.K., I. Horowitz, A. Olson, A. DeBenedictis, D. Miller and J. Moore (2011) "Cross-Hedging and Forward-Contract Pricing of Electricity in the Pacific Northwest," *Managerial and Decision Economics*, 32, 265-279.
23. Moore, J., C.K. Woo, B. Horii, S. Price and A. Olson (2010) "Estimating the Option Value of a Non-firm Electricity Tariff," *Energy*, 35, 1609-1614.
24. Olson A., R. Orans, D. Allen, J. Moore, and C.K. Woo (2009) "Renewable Portfolio Standards, Greenhouse Gas Reduction, and Long-line Transmission Investments in the WECC," *Electricity Journal*, 22:9, 38-46.
25. Moore, J., C.K. Woo, B. Horii, S. Price, A. Olson (2009) "Estimating the Option Value of a Non-firm Electricity Tariff," *Energy*, 35, 1609-1614.
26. Woo, C.K., I. Horowitz, N. Toyama, A. Olson, A. Lai, and R. Wan (2007) "Fundamental Drivers of Electricity Prices in the Pacific Northwest," *Advances in Quantitative Analysis of Finance and Accounting*, 5, 299-323.
27. Lusztig, C., P. Feldberg, R. Orans, and A. Olson (2006) "A survey of transmission tariffs in North America," *Energy-The International Journal* 31, 1017-1039.
28. Woo, C.K., A. Olson, I. Horowitz and S. Luk (2006) "Bi-directional Causality in California's Electricity and Natural-Gas Markets," *Energy Policy*, 34, 2060-2070.
29. Woo, C.K., I. Horowitz, A. Olson, B. Horii and C. Baskette (2006) "Efficient Frontiers for Electricity Procurement by an LDC with Multiple Purchase Options," *OMEGA*, 34:1, 70-80.
30. Woo, C.K., A. Olson and I. Horowitz (2006) "Market Efficiency, Cross Hedging and Price Forecasts: California's Natural-Gas Markets," *Energy*, 31, 1290-1304.
31. Woo, C.K., A. Olson and R. Orans (2004) "Benchmarking the Price Reasonableness of an Electricity Tolling Agreement," *Electricity Journal*, 17:5, 65-75.
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## Research Reports

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2. *Powering a Green Nova Scotia, Together: 2020 Integrated Resource Plan*, E3 project lead and contributing author, November 2020, [https://irp.nspower.ca/files/key-documents/E3\\_NS-Power\\_2020\\_IRP\\_Report\\_final\\_Nov-27-2020.pdf](https://irp.nspower.ca/files/key-documents/E3_NS-Power_2020_IRP_Report_final_Nov-27-2020.pdf)

3. *Net-Zero New England: Ensuring Electric Reliability in a Low-Carbon Future*, Energy and Environmental Economics, Inc. and Energy Futures Initiative, project lead and contributing author, November 2020, [https://www.ethree.com/wp-content/uploads/2020/11/E3-EFI\\_Report-New-England-Reliability-Under-Deep-Decarbonization\\_Full-Report\\_11-17-2020\\_Release.pdf](https://www.ethree.com/wp-content/uploads/2020/11/E3-EFI_Report-New-England-Reliability-Under-Deep-Decarbonization_Full-Report_11-17-2020_Release.pdf)
4. *Pacific Northwest Zero-Emitting Resources Study*, prepared for Energy Northwest, project lead and contributing author, January 2020, <https://www.ethree.com/wp-content/uploads/2020/02/E3-Pacific-Northwest-Zero-Emitting-Resources-Study-Jan-2020.pdf>
5. *Least Cost Carbon Reduction Policies in PJM*, project lead and contributing author, October 2020, <https://www.ethree.com/wp-content/uploads/2020/10/E3-Least-Cost-Carbon-Reduction-Policies-in-PJM-1.pdf>
6. “Capacity and Reliability Planning in the Era of Decarbonization: Practical Application of Effective Load Carrying Capability in Resource Adequacy”, E3 White Paper, contributing author, August 2020, <https://www.ethree.com/wp-content/uploads/2020/08/E3-Practical-Application-of-ELCC.pdf>
7. *Minnesota Energy Storage Cost-Benefit Analysis*, December 2019, prepared for the Minnesota Department of Commerce, Division of Energy Resources, <https://www.ethree.com/wp-content/uploads/2020/01/E3-Minnesota-energy-storage-cost-benefit-study-2020.pdf>
8. *Capacity Needs of the Pacific Northwest*, December 2019, prepared for National Grid, <https://www.ethree.com/wp-content/uploads/2019/12/E3-PNW-Capacity-Need-FINAL-Dec-2019.pdf>
9. *Exploring a Resource Adequacy Program for the Pacific Northwest*, October 2019, prepared on behalf of the Northwest Power Pool, project lead and contributing author, [https://www.nwpp.org/private-media/documents/2019.11.12\\_NWPP\\_RA\\_Assessment\\_Review\\_Final\\_10-23.2019.pdf](https://www.nwpp.org/private-media/documents/2019.11.12_NWPP_RA_Assessment_Review_Final_10-23.2019.pdf)
10. *California Offshore Wind: Workforce Impacts and Grid Integration*, September 2019, with the University of California – Berkeley Labor Center, contributing author, <https://laborcenter.berkeley.edu/offshore-wind-workforce-grid/>
11. *Xcel Energy Low Carbon Scenario Analysis: Decarbonizing the Generation Portfolio of Xcel Energy’s Upper Midwest System*, July 2019, prepared on behalf of Xcel Energy, project lead and contributing author, [https://www.ethree.com/wp-content/uploads/2019/08/E3\\_Xcel\\_MN\\_IRP\\_Report\\_2019-07\\_FINAL.pdf](https://www.ethree.com/wp-content/uploads/2019/08/E3_Xcel_MN_IRP_Report_2019-07_FINAL.pdf)
12. *Electricity System Reliability Under Long-Run Deep Decarbonization Pathways in California*, June 2019, prepared on behalf of the Calpine Corporation, project lead and contributing author, [https://www.ethree.com/wp-content/uploads/2019/06/E3\\_Long\\_Run\\_Resource\\_Adequacy\\_CA\\_Deep-Decarbonization\\_Final.pdf](https://www.ethree.com/wp-content/uploads/2019/06/E3_Long_Run_Resource_Adequacy_CA_Deep-Decarbonization_Final.pdf)

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15. *Western Interconnection Gas-Electric Interface Study, June 2018, prepared on behalf of the Western Electric Coordinating Council, contributing author,*  
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16. *Pacific Northwest Low Carbon Scenario Analysis, December 2017, prepared on behalf of the Public Generating Pool, project lead and contributing author,*  
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17. *2025 California Demand Response Potential Study - Charting California's Demand Response Future, March 2017, prepared on behalf of the California Public Utilities Commission, contributing author,* <http://eta-publications.lbl.gov/sites/default/files/lbnl-2001113.pdf>
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19. *Senate Bill 350 Study: The Impacts of a Regional ISO-Operated Power Market on California, July 2016, prepared on behalf of the California Independent System Operator, project lead and contributing author,*  
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21. *Natural Gas Infrastructure Adequacy in the Western Interconnection: An Electric Sector Perspective, July 2014, prepared on behalf of the Western Interstate Energy Board, project lead and contributing author,* [https://ethree.com/public\\_projects/wieb.php](https://ethree.com/public_projects/wieb.php)
22. *"Capital Cost Review of Power Generation Technologies: Recommendations for WECC's 10- and 20-Year Studies, March 2014, prepared for the Western Electric Coordinating Council*
23. *Investigating a Higher Renewables Portfolio Standard for California, January 2014, prepared on behalf of the Los Angeles Department of Water and Power, Pacific Gas and Electric Company, Sacramento Municipal Utilities District, San Diego Gas & Electric, and Southern California Edison, technical lead and lead author,*

[http://www.ethree.com/public\\_projects/renewables\\_portfolio\\_standard.php](http://www.ethree.com/public_projects/renewables_portfolio_standard.php)

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26. *Cost and Performance Review of Generation Technologies: Recommendations for WECC 10- and 20-Year Study Process*, October 2012, prepared on behalf of the Western Electric Coordinating Council, editor and contributing author, [http://www.wecc.biz/committees/BOD/TEPPC/TAS/121012/Lists/Minutes/1/121005\\_GenCapCostReport\\_finaldraft.pdf](http://www.wecc.biz/committees/BOD/TEPPC/TAS/121012/Lists/Minutes/1/121005_GenCapCostReport_finaldraft.pdf).
27. *Economic Assessment of North/South Transmission Capacity Expansion in Alberta*, January 2012, prepared on behalf of AltaLink, contributing author.
28. *Energy Imbalance Market Benefits Study*, October 2011, prepared on behalf of the Western Electric Coordinating Council, project lead and contributing author, <http://www.wecc.biz/committees/EDT/EDT%20Results/EDT%20Cost%20Benefit%20Analysis%20Report%20-%20REVISED.pdf>
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31. *Recommendations for Documentation of Seattle City Light Energy Delivery Capital Expenditures*, February 2010, prepared on behalf of the Seattle City Council, project lead and contributing author, <http://clerk.seattle.gov/~ordpics/31219exA.pdf>
32. *California Public Utilities Commission, 33% Renewables Portfolio Standard Implementation Analysis, Preliminary Results*, June 2009, project lead and contributing author, <http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf>
33. *California Public Utilities Commission, Energy Division Straw Proposal on LTPP Planning Standards*, June 2009, project lead and contributing author, <http://www.cpuc.ca.gov/NR/rdonlyres/1865C207-FEB5-43CF-99EB-A212B78467F6/0/33PercentRPSImplementationAnalysisInterimReport.pdf>
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36. *Load-Resource Balance in the Western Interconnection: Towards 2020*, prepared on behalf of the Western Electric Industry Leaders Group, January 2008, contributing author, [http://www.weilgroup.org/E3\\_WEIL\\_Complete\\_Study\\_2008\\_082508.pdf](http://www.weilgroup.org/E3_WEIL_Complete_Study_2008_082508.pdf)
37. *Umatilla Electric Cooperative 2008 Integrated Resource Plan*, January 2009, contributing author.
38. *Lower Valley Energy 2007 Integrated Resource Plan Update*, February 2007, contributing author.
39. *2007 Idaho Energy Plan*, January 2007, prepared on behalf of the Idaho Legislative Council Interim Committee on Energy and Technology, [http://www.legislature.idaho.gov/sessioninfo/2007/energy\\_plan\\_0126.pdf](http://www.legislature.idaho.gov/sessioninfo/2007/energy_plan_0126.pdf)
40. *Base Case Integrated Resource Plan for PNGC Power*, April 2006, author.
41. *Integrated Resource Planning for Coos-Curry Electric Cooperative*, August 2005, author.
42. *Integrated Resource Planning for Lower Valley Energy*, December 2004, author.
43. "A Forecast Of Cost Effectiveness: Avoided Costs and Externality Adders", prepared for the California Public Utilities Commission, February 2004, contributing author.
44. *Stepped Rate Design Report*, prepared for BC Hydro and filed with the BCUC, May 2003, contributing author.
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47. *Study of Electricity Taxation*, contributing author. Washington Department of Revenue, December 1999. <http://www.energy.cted.wa.gov/papers/taxstudy.doc>
48. *Washington Energy Indicators*, author. Washington Department of Community, Trade and Economic Development, February 1999. <http://www.energy.cted.wa.gov/Indicators99/Contents.htm>



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### Selected Public Presentations

1. *Northwest Power Pool Resource Adequacy Symposium, "Report From the Region"*, invited panelist, August 3, 2021
2. *"Scalable Markets for the Energy Transition: A Blueprint for Wholesale Electricity Market Reform"*, IEEE Power and Energy Society General Meeting Super Session, Impact of Climate Change on the Power Grid, invited panelist, July 29, 2021
3. *OurEnergyPolicy Energy Leaders Webinar Series: Proposed Federal Clean Energy Standards*, invited panelist, July 28, 2021, <https://www.ourenergypolicy.org/the-proposed-federal-clean-energy-standard/>
4. *"Opportunities and Challenges in Achieving Pacific Northwest Climate Goals"*, Oregon Rural Electric Cooperative Association, invited speaker, July 13, 2021
5. *"Rethinking Resource Adequacy in a Decarbonized World"*, GridForward Building the Decarbonized Grid Summit, invited panelist, June 9, 2021
6. *"Green Hydrogen: How Production, Infrastructure and End Uses Will Power an Economic Revolution"*, Infocast webinar, invited panelist, June 3, 2021
7. *"Resource Adequacy Challenges in 2021 and Beyond"*, Energy Systems Integration Group Spring Meeting Plenary Session, invited panelist, April 8, 2021
8. *"Opportunities and Challenges in Achieving Pacific Northwest Climate Goals"*, Pacific Northwest Economic Region Forum, invited panelist, March 24, 2021
9. *"Wholesale Electricity Market Reforms for the Clean Energy Transition: an E3 Perspective"*, PJM Interconnection Capacity Market Workshop, March 12, 2021

10. *“Electric Resource Adequacy: California and the West”, NewsData and CJB Energy Economics Webinar, invited speaker, January 28, 2021*
11. *“Keeping the Lights on in California”, Power Markets Today Webinar, invited panelist, December 2, 2020*
12. *“Resource Adequacy: Now and in the Future”, Western Electric Coordinating Council Resource Adequacy Forum, invited speaker, November 18, 2020*
13. *“Accreditation of Dispatch-Limited Resources in Organized Capacity Markets”, Organization of PJM States, invited panelist, October 20, 2020*
14. *“The Role of Electricity in Meeting Economy-wide Carbon Goals”, Centre for Energy Advancement through Technological Innovation (CEATI), invited panelist, October 15, 2020*
15. *Federal Energy Regulatory Commission, Technical Conference regarding Carbon Pricing in Organized Wholesale Electricity Markets, invited panelist, September 30, 2020*
16. *“California and the Western Market: Trends and Opportunities”, opening speaker, Independent Energy Producers Association Annual Meeting, September 23, 2020*
17. *“Decarbonizing the Power System: Summary of Lessons Learned”, opening speaker, Columbia University – Johns Hopkins University Future Power Markets Forum, Session 1, June 2, 2020*
18. *“Decarbonizing Electric Power Systems”, invited speaker, Minnesota Rural Electric Association Annual Meeting, April 8, 2020*
19. *“Resource Adequacy under High Renewable Penetration”, Austin Electricity Conference, invited speaker, Austin, Texas, March 5, 2020*
20. *“Long-Run Resource Adequacy under Deep Decarbonization Pathways for California”, invited speaker, California Energy Commission, California Public Utilities Commission and California Air Resources Board SB100 Technologies & Scenarios Workshop, San Francisco, California, November 18, 2019*
21. *“Resource Adequacy in the Pacific Northwest: Summary of existing studies and benefits of a regional program”, invited speaker, Northwest Power Pool Resource Adequacy Symposium, Portland, Oregon, October 2, 2019*
22. *“California Energy Outlook: Where Are We?”, invited speaker, California Independent Energy Producers Association Annual Meeting, Fallen Leaf Lake, California, September 23, 2019*
23. *“Resource Adequacy in the Pacific Northwest”, invited speaker, Northwest and Intermountain Power Producer Coalition Annual Meeting, Union, Washington, September 10, 2019*
24. *“Northwest Resource Adequacy Outlook”, invited speaker, Oregon Public Utilities Commission, NW Resource Adequacy Outlook Workshop, Salem, Oregon, May 28, 2019*

25. *“Achieving New York’s “Green New Deal” And Deep Decarbonization Of the Electric Sector”, invited speaker, Independent Power Producers of New York 33rd Annual Spring Conference, May 8, 2019, Albany, New York*
26. *“Grid Flexible Solar: Leveraging Utility-Scale Solar for Flexible Dispatch & Operations” invited speaker, Committee on Regional Electric Cooperation and Western Interconnection Regional Advisory Board, Salt Lake City, Utah, April 18, 2019*
27. *“Resource Adequacy in a Postmodern World”, invited speaker, Committee on Regional Electric Cooperation and Western Interconnection Regional Advisory Board, Salt Lake City, Utah, April 18, 2019*
28. *“The Economic & Business Implications of Energy Storage”, invited panelist, Austin Electricity Conference, Austin, Texas, April 4, 2019*
29. *“Resource Adequacy and Planning Reserve Sharing in Bilateral and Organized Markets”, invited speaker, Northwest Power Markets Design Informational Seminar, Portland, Oregon, October 24, 2018*
30. *“Future Energy Systems: The Role for Natural Gas in a High-Renewables, Decarbonizing World”, invited speaker, Stanford Natural Gas Initiative Symposium, Palo Alto, California, October 16, 2018*
31. *“Charged, Smart and Ready: Getting the most out of new consumer technologies”, invited speaker, Northwest and Intermountain Power Producers Coalition Annual Meeting, Alderbrook Resort, Union, Washington, October 9, 2018*
32. *“Getting to 100% ‘Clean Energy’”, invited speaker, Independent Energy Producers Association’s 37th Annual Meeting, Fallen Leaf Lake, South Lake Tahoe, California, October 3, 2018*
33. *“Pacific Northwest Low Carbon Scenario Analyses: Achieving Least-Cost Carbon Emissions Reductions in the Electricity Sector”, invited appearance before the Washington State Legislature Energy Supply & Energy Conservation Joint Committee, September 24, 2018*
34. *“Achieving High Renewable Penetration with Grid-Friendly Operations”, invited panelist, Austin Electricity Conference, Austin, Texas, April 12, 2018*
35. *“Electric industry trends and their impacts on hydropower”, invited speaker, Bonneville Power Administration Strategic Plan Implementation Public Workshop, Portland, Oregon, March 2, 2018*
36. *“Customer Engagement: An Adaptive Survival Strategy for Electric Utilities”, invited speaker, Energy NewsData Utility Customer Engagement Conference, Portland, Oregon, November 17, 2017*
37. *“Grid of the Future, Industry of the Future”, Platinum Seminar at the Northwest and Intermountain Power Producer Coalition Annual Meeting, Union, Washington, September 11, 2017*
38. *“California’s Solar Buildout: Implications for Electricity Markets in the West”, invited speaker, EPIS Electric Market Forecasting Conference, Las Vegas, Nevada, September 7, 2017*

39. *"Value of Hydro in a GHG-Constrained World", invited panelist, HydroVision International, Session 1A: How Does Hydro 'Play' in the Energy Playground? Welcome to the New Wild West, Denver, Colorado, June 28, 2017*
40. *"Resource Adequacy and Planning Reserve Margins", invited speaker, Technical Conference on Capacity Planning and Resource Adequacy, Montana Public Service Commission, Helena, Montana, June 8, 2017*
41. *"That Faint Whooshing Sound: California Solar and Changing Western Power Markets", invited speaker, Northwest Power Markets: Mapping the Road Ahead, presented by Energy NewsData and CJB Energy, Portland, Oregon, May 24, 2017*
42. *"Observations on Current Resource Adequacy Practices", invited speaker, Committee for Regional Electric Power Cooperation/Western Interconnection Regional Advisory Body, Boise, Idaho, April 13, 2017*
43. *"Assessing Flexibility Needs in Highly Renewable Systems," invited speaker, Wärtsilä Symposium, Portland, Oregon, September 27, 2016*
44. *"Review: Natural Gas Infrastructure Adequacy in the Western Interconnection," invited speaker, Committee for Regional Electric Power Cooperation/Western Interconnection Regional Advisory Body, San Diego, California, October 31, 2016*
45. *"PATHWAYS to Deep Decarbonization: California", Western Electric Coordinating Council, Transmission Expansion Planning and Policy Committee, Salt Lake City, Utah, August 17, 2016*
46. *"Renewable Euphoria and the 'Big Long': How Renewable Energy Will Impact Western Markets", invited speaker, Mid-C Seminar, Wenatchee, Washington, July 27, 2016*
47. *"The Role of Renewables in Meeting California's Greenhouse Gas Goals", invited speaker, Renewable Energy Integration Summit, San Diego Regional Chamber of Commerce, July 18, 2016*
48. *"Essential Reliability Services", invited panelist, Western Electric Coordinating Council, Western Reliability Summit, Salt Lake City, Utah, May 18, 2016*
49. *"Meeting a 50% RPS for California", invited panelist, Infocast California Energy Summit, Santa Monica, California, May 11, 2016*
50. *"The Future of Resource Planning", invited keynote speaker, Great Plains Institute's e21 Initiative, St. Paul, Minnesota, April 5, 2016*
51. *"Market Driven Distributed Generation in the Western Interconnection", invited panelist, Committee on Regional Electric Power Cooperation biennial meeting, Salt Lake City, Utah, March 22, 2016*
52. *"Is Solar the New Hydro?", invited panelist, Northwest Hydroelectric Association 2016 Annual Conference, Portland, Oregon, February 17, 2016*

53. *"The Role of Energy Storage as a Renewable Integration Solution under a 50% RPS", invited panelist, Joint California Energy Commission and California Public Utilities Commission Long-Term Procurement Plan Workshop on Bulk Energy Storage, Sacramento, California, November 20, 2015*
54. *"Planning for Variable Generation Integration Needs", invited panelist, Utility Variable-generation Integration Group, Operating Impact And Integration Studies Users Group Meeting, San Diego, California, October 13, 2015*
55. *"The Role of Renewables in a Post-Coal World", invited panelist, Energy Foundation, Beyond Coal to Clean Energy Conference, San Francisco, California, October 9, 2015,*
56. *"Implications of a 50% RPS for California", invited panelist, Argus Carbon Summit, Napa, California, October 6, 2015*
57. *"Western EIM: Status Report and Implications for Public Power", Keynote speaker, Large Public Power Council meeting, Seattle, Washington, September 16, 2015*
58. *"California's 50% RPS Goal: Opportunities for Western Wind Developers", Keynote speaker at a meeting of the Wyoming Infrastructure Authority, Berkeley, California, July 28, 2015*
59. *"Western Interconnection Flexibility Assessment", Western Electric Coordinating Council Board of Directors, Salt Lake City, Utah, June 24, 2015*
60. *"California's New GHG Goals: Implications for the Western Electricity Grid", invited panelist, National Association of State Energy Officials, Western Regional State and Territory Energy Office Meeting, Portland, Oregon, May 14, 2015*
61. *"Replacing Aging Fossil Generation," invited panelist, Northwest Energy Coalition NW Clean & Affordable Energy Conference, Portland, Oregon, November 7, 2014*
62. *"Investing in Power System Flexibility," invited panelist, State/Provincial Steering Committee & Committee on Regional Electric Power Cooperation System Flexibility Forum, San Diego, California, October 20, 2014*
63. *"Opportunities and Challenges for Higher Renewable Penetration in California", invited panelist, Beyond 33%: University of California at Davis Policy Forum Series, Sacramento, California, October 17, 2014*
64. *"Renewable Curtailment as a Power System Flexibility Resource," Boise State University Energy Policy Research Conference, San Francisco, California, September 4, 2014*
65. *"Natural Gas Infrastructure Adequacy: An Electric System Perspective", Pacific Northwest Utilities Conference Committee Board of Directors, Portland, Oregon, August 8, 2014*
66. *"The Future of Renewables in the American West," invited panelist, Geothermal Energy Association Annual Meeting, Reno, Nevada, August 6, 2014*

67. *“Long-Term Natural Gas Infrastructure Needs”, invited panelist, U.S. Department of Energy Quadrennial Energy Review, Public Meeting #7, Denver, Colorado, July 28, 2014*
68. *“Meeting the Demands of Renewables Integration—New Needs, New Technologies, Emerging Opportunities”, invited panelist, InfoCast 2<sup>nd</sup> Annual California Energy Summit, San Francisco, California, May 28, 2014*
69. *“Power System Flexibility Needs under High Renewables”, EUCI Utility Resource Planning Conference, Chicago, Illinois, May 14, 2014*
70. *“Natural Gas Infrastructure Adequacy: An Electric System Perspective”, Western Interstate Energy Board Annual Meeting, Denver, Colorado, April 24, 2014*
71. *“Power System Flexibility Needs under High RPS”, invited panelist, joint meeting of the Committee on Regional Electric Power Cooperation, State-Provincial Steering Committee and Western Interconnection Regional Advisory Body, Tempe, Arizona, March 26, 2014*
72. *“Natural Gas Infrastructure Adequacy: An Electric System Perspective”, joint meeting of the Committee on Regional Electric Power Cooperation, State-Provincial Steering Committee and Western Interconnection Regional Advisory Body, Tempe, Arizona, March 25, 2014*
73. *“Investigating a Higher Renewables Portfolio Standard for California”, 19<sup>th</sup> Annual Power Conference on Energy Research and Policy, University of California Energy Institute, Berkeley, California, March 17, 2014*
74. *“Investigating a 50 Percent Renewables Portfolio Standard in California”, invited panelist, Northwest Power and Conservation Council, Portland, Oregon, March 12, 2014*
75. *“Investigating a 50 Percent Renewables Portfolio Standard in California”, invited panelist, Western Systems Power Pool, Spring Operating Committee Meeting, Whistler, B.C., March 5, 2014*
76. *“Investigating a Higher Renewables Portfolio Standard for California”, invited speaker, Western Electric Coordinating Council, Transmission Expansion Planning and Policy Committee, Salt Lake City, Utah, February 25, 2014*
77. *“Investigating a 50 Percent Renewables Portfolio Standard in California”, invited speaker, Committee on Regional Electric Power Cooperation, State-Provincial Steering Committee and Western Interconnection Regional Advisory Body, Webinar, February 12, 2014*
78. *“Flexibility Planning: Lessons From E3’s REFLEX Model”, EUCI Conference on Fast Ramp and Intra-Hour Market Incentives, San Francisco, California, January 29-30, 2014*
79. *“The Effect of High Renewable Penetration on California Markets and Carbon Balance”, EUCI Conference on California Carbon Policy Impacts on Western Power Markets, January 27-28, San Francisco, California, 2014*
80. *“Reliance on Renewables: A California Perspective”, invited panelist at Harvard Electricity Policy Group, Seventy-Third Plenary Session, Tucson, Arizona, December 13, 2013*

81. *"The Role of Renewables in Meeting Long-Term Greenhouse Gas Reduction Goals", State Bar Of California, Energy And Climate Change Conference, Berkeley, California, November 14, 2013*
82. *"Benefits, Costs and Cost Shifts from Net Energy Metering", invited expert panelist at Washington Utilities and Transportation Commission Workshop on Distributed Generation, Olympia, Washington, November 13, 2013*
83. *Pacific Northwest Utilities Conference Committee (PNUCC) California Power Industry Roundtable, invited panelist, Portland, Oregon, September 6, 2013*
84. *"After 2020: Prospects for Higher RPS Levels in California", invited speaker at Northwest Power and Conservation Council's California Power Markets Symposium, Portland, Oregon, September 5, 2013*
85. *"Determining Flexible Capacity Needs for the CAISO Area", invited speaker at Northwest Power and Conservation Council's California Power Markets Symposium, Portland, Oregon, September 5, 2013*
86. *"California Climate Policy and the Western Energy System", invited speaker at the Western Interstate Energy Board annual meeting, Reno, Nevada, June 13, 2013*
87. *"Determining Power System Flexibility Need", EUCI Conference on Resource Planning and Asset Valuation, Westminster, Colorado, May 21, 2013*
88. *"California Policy Landscape and Impact on Electricity Markets", EUCI Conference on Resource Planning and Asset Valuation, Westminster, Colorado, May 21, 2013*
89. *"Determining Power System Flexibility Need", EUCI Conference on Fast and Flexi-ramp Resources, Chicago, Illinois, April 23, 2013*
90. *"State-Provincial Steering Committee WECC Low Carbon Scenarios Tool", 3 Interconnections Meeting, Washington, DC, February 6, 2013*
91. *"Distributed Generation Benefits and Planning Challenges", Committee on Regional Electric Power Cooperation/State-Provincial Steering Committee, Resource Planners' Forum, San Diego, California, October 3, 2012*
92. *"Thoughts on the Flexibility Procurement Modeling Challenge", invited speaker at the California Public Utilities Commission, Long-Term Procurement Planning Workshop, San Francisco, California, September 19, 2012*
93. *"Generation Capital Cost Recommendations for WECC 10- and 20-Year Studies", Western Electric Coordinating Council, Transmission Expansion Planning and Policy Committee, Technical Advisory Subcommittee, Webinar, August 15, 2012*
94. *"Renewable Energy Benefits", California Energy Commission, Integrated Energy Policy Report Workshop, Sacramento, California, April 12, 2012*

95. *"The Role of Policy in WECC Scenario Planning"*, Western Electric Coordinating Council, Scenario Planning Steering Group, San Diego, CA, November 1, 2011
96. *"WECC Energy Imbalance Market Benefit Study"*, Western Electric Coordinating Council, Board of Directors, Scottsdale, Arizona, June 22, 2011
97. *"Renewable Portfolio Standard Model Methodology and Draft Results"*, California Public Utilities Commission Workshop, San Francisco, California, June 17, 2010
98. *"Draft Results from 33% Renewable Energy Standard Economic Modeling"*, California Air Resources Board Workshop, Sacramento, California, May 20, 2010
99. *"Market Opportunities for IPPs in the WECC"*, invited speaker at the Independent Power Producers of British Columbia Annual Meeting, Vancouver, British Columbia, November 2, 2009
100. *"A Low-Transmission Alternative for Meeting California's 33% RPS Target"*, EUCI Webinar, July 31, 2009
101. *"Remote Renewable and Low-Carbon Resource Options for the Pacific Northwest"*, Center for Research on Regulated Industries Conference, Monterey, California, June 19, 2009
102. *"Engineers are from Mars, Policy-Makers are from Venus: The Effect of Policy on Long-Term Transmission Planning"*, invited speaker at the Western Electric Coordinating Council Long Term Transmission Planning Seminar, Phoenix, Arizona, February 2, 2009
103. *"The Long-Term Path to a Stable Climate, and its Implications for BPA"*, invited speaker at the Bonneville Power Administration Managers' Retreat, Portland, Oregon, April 29, 2008
104. *"Load-Resource Balance in the Western Interconnection: Towards 2020"*, Western Electric Industry Leaders Group, Las Vegas, Nevada, January 18, 2008
105. *"Integrated Resource Planning for BPA Customers"*, invited speaker at the Bonneville Power Administration Allocation Conference, Portland, Oregon, September 19, 2006
106. *"Idaho's Current Energy Picture"*, Energy, Environment and Technology Interim Committee, Boise, Idaho, July 11, 2006
107. *"Locational Marginal Pricing – The Very Basics"*, Committee on Regional Electric Power Cooperation, San Diego, California, April 30, 2002
108. *"Effect of 2000-2001 Energy Crisis on Washington's Economy"*, Conference on Business Economics, Seattle, Washington, July 19, 2001