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Renewable Energy at the Forefront

By Matthew P. Tymchak, M.S.

Consumer demand and legislative action are driving rapid growth of renewable energy, despite some of the challenges associated with supporting carbon-neutral technologies.

A push to achieve a carbon-free energy supply has positioned renewable technologies at the forefront of consumer and industry demand as these technologies continue to replace fossil fuels across energy sectors. Consumer appetite for renewable technologies has become particularly acute in the past several years. For example, demand for renewable technologies overtook coal in 2019 (EIA, 2020), and the trend continued in 2020, when, in spite of all the pandemic-related challenges, renewable energy demand rose by approximately 45% according to a recent study by the International Energy Agency (IEA, 2021). This was the largest yearly rise in at least two decades (IEA, 2021) and was largely driven by growth in global wind capacity by 90% and in solar expansion. Beyond consumer demand, perhaps the most relevant shift driving the transition to renewables has been public policy. The Biden administration has set aggressive benchmarks to incorporate renewable technologies into the US infrastructure, which include rejoining the Paris Agreement and setting specific goals such as the development of 30 gigawatts of offshore wind by 2030, among other initiatives – all moving toward the overarching goal to decarbonize the energy sector by 2035.

[T]he rising demand for materials and the need to develop new infrastructure to transmit and store renewable-derived energy have led to questions regarding what a successful transition will look like.

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I N S I D E

Letter from the Editors

September 2021

Dear Colleague,

In this issue of *Trends*, we discuss the topic of renewable energy.

Our first article gives an overview of the current status and future trends of renewable energy. The second article discusses electric and magnetic fields (EMFs) associated with offshore wind projects, including concerns about how EMFs might affect both humans and marine life. The third article describes how the increasing demand for lithium for use in batteries necessitates increased scrutiny from regulators. Our guest editorial, contributed by Dan Chorost of Sive, Paget & Riesel, provides an update on the fast-paced progress of offshore wind farms in the US.

Gradient contributors to this *Trends* issue include Matthew P. Tymchak, M.S.; Christopher M. Long, Sc.D., DABT; Jiayang Chien, M.P.H.; and Karrie A. Radloff, Ph.D.

We hope this issue of *Trends* brings you an increased understanding of renewable energy, a topic likely to see high levels of interest for years to come.

Yours truly,

Kurt Herman, M.Eng., P.G. and Chris Long, Sc.D., DABT
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The next issue will focus on:
Microplastics

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Renewable Energy at the Forefront

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As consumer preference and legislative action evolve, renewable technologies and supporting industries are poised to advance in parallel. Although wind and solar typically garner most of the renewable energy spotlight, an array of technologies fit within the renewables definition of the US Environmental Protection Agency (US EPA) – "electricity generated by fuel sources that restore themselves over a short period of time and do not diminish" (US EPA, 2021). For example, the first ocean wave energy testing center, known as the PacWave South Project, will be located approximately six nautical miles off Newport, Oregon (BOEM, 2021). The project, which recently received a federal lease, is led by Oregon State University and will aim to harness energy from moving waves, tides, and currents, then convert it to electricity that can be distributed through the existing grid to power homes.

Apart from engineering challenges associated with harnessing wind, ocean currents, tides, and waves, offshore energy projects will face challenges related to bringing the energy onshore, including environmental and human health concerns. For example, cables that transmit energy from offshore wind turbines to the onshore grid have been alleged to disrupt the feeding and migration patterns of marine life, as well as alleged to pose potential human health risks, *via* electric and magnetic fields (EMFs). These potential concerns, addressed in the article of this *Trends* issue "Electric and Magnetic Field (EMF) Considerations for Offshore Wind Projects," highlight the complexity facing renewable energy projects at the nexus between terrestrial and marine ecosystems.

Along with advancements in energy generation and transmission, the widespread implementation of emerging technologies depends on the development of energy storage infrastructure since most renewable sources fluctuate, typically on daily to seasonal scales – wind and solar energy are only captured when it is blowing and the sun is out. Thus, storage systems at the utility grid scale are critically important to make renewable energy available during "off" times when sources are not producing but consumer demand is high. Additionally, storage systems may add to the resiliency of the energy grid and may serve to mitigate the impact of extreme weather events, such as what was experienced during winter storm Uri in Texas this past February. The drive to produce new storage capabilities is likely to reach into other aspects of production supply chains and material demand since components of these storage systems are highly specific. Metals such as lithium, nickel, vanadium, and cobalt – key components to certain rechargeable batteries – will be needed to meet rising demand. Potential environmental considerations regarding the life cycle of lithium in renewable technologies is discussed in the article in this issue "Surging Lithium Demand Creates New Environmental Concerns."

As the transition to a carbon-neutral energy supply continues to gain momentum, the rising demand for materials and the need to develop new infrastructure to transmit and store renewable-derived energy have led to questions regarding what a successful transition will look like. For example, will existing oversight and permitting procedures be appropriate and sufficient for renewables development, can existing energy infrastructure be applied to renewable projects, how will legacy infrastructure be decommissioned, and will new technology create environmental and human health risks? Despite these considerations, the transition to renewable energy is moving ahead at a rapid pace.

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Do you have a scientific topic that you would like Gradient to write about in Trends? Send us your ideas for future Trends topics: *trends@gradientcorp.com.*

Electric and Magnetic Field (EMF) Considerations for Offshore Wind Projects

By Chris Long, Sc.D., DABT, and Jiayang Chien, M.P.H.

Offshore wind projects commonly include electric and magnetic field (EMF) assessments to evaluate potential human health and ecological effects, along with mitigation strategies, in the permitting and design processes.

What is the first image that comes to mind for an offshore wind project? Undoubtedly, it is of a mammoth wind turbine rising out of the ocean, with blades the length of a football field. However, offshore wind projects have a number of other components, including miles of submarine cables buried beneath the ocean floor for transmitting the electric power to shore. On shore, typical project components can include underground duct banks with high-voltage transmission cables buried within city streets, additional overhead transmission lines within utility rights-of-way, and new electrical substations. EMFs are associated with each piece of offshore and onshore electrical infrastructure, and as a result, EMF assessments are commonly conducted as part of the permitting process for offshore wind projects to evaluate potential human health and ecological effects from EMF exposure.

It is the consensus of a number of public health agencies and expert scientific committees… that there are no confirmed human health risks for power frequency EMFs.

EMFs are invisible lines of force associated with anything that generates, transmits, or uses electricity, including not only high-voltage transmission lines and substations, but also the overhead and underground distribution lines on residential streets, home wiring, and household appliances. As illustrated by the figure, power frequency (60-Hertz) alternating current (AC) EMFs are an extremely low frequency form of non-ionizing electromagnetic radiation. Unlike ionizing radiation (*e.g.*, ultraviolet [UV] rays, X-rays, gamma rays), power frequency EMFs do not carry enough energy to break molecular bonds and damage DNA, biological cells, or tissues.

However, exposure to power frequency EMFs emerged as a public health concern in the late 1970s when the Wertheimer and Leeper (1979) epidemiological study reported statistical associations suggesting that children residing in greater proximity to overhead power lines may have a small increased risk of childhood leukemia. Although uncertain and limited, this and other early epidemiological studies triggered a massive international research effort, which included numerous mechanistic, laboratory animal, and epidemiological studies, designed to understand whether and how power frequency EMFs could cause childhood leukemia and other diseases (see Moulder, 2000). Despite about 40 years of scientific research and thousands of published studies, scientists have found no plausible biological mechanism whereby biology can be adversely affected by typical levels of 60-Hertz (or steady) EMFs, and lifetime exposures of laboratory animals to these EMFs have likewise shown no carcinogenic potential. It is the consensus of a number of public health agencies and expert scientific committees, including the World Health Organization (WHO), the US Environmental Protection Agency (US EPA), and the National Institute of Environmental Health Sciences (NIEHS), that there are no confirmed human health risks for power frequency EMFs.

Nonetheless, EMF exposures remain a source of public concern, and EMF assessments are now a well-established component of the permitting process for new transmission lines and line-upgrade projects in many states. This has carried forward to offshore wind projects, where the same tools can be used to conduct EMF assessments of submarine cables. For offshore wind projects, EMF assessments address not only potential human exposure to EMFs, but also EMF exposures of marine species, including bottom-dwelling species such as lobsters and skates that reside in the sediments above buried submarine cables.

It is well established that there are a number of "magnetosensitive" marine species, including lobsters, salmon, American eel, sturgeon, yellowfin tuna, sharks, skates, rays, and sea turtles, that use the earth's geomagnetic field for specific purposes such as orientation, navigation, prey location, and long-distance migration. In addition, "electrosensitive" marine species, including sharks, rays, skates, and sturgeon, utilize electrosensory capabilities for navigation and prey detection. As compared to human health, there is not as extensive a body of research to inform the assessment of how submarine cable EMFs might impact marine species, and this is an active area of research. The available research suggests that both magnetosensitivity and electrosensitivity in marine species have developed so as to be specifically attuned to natural EMF sources such as the earth's magnetic field and marine species bioelectric fields (*e.g.*, heartbeats), and there is a lack of evidence of

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Electric and Magnetic Field (EMF) Considerations for Offshore Wind Projects

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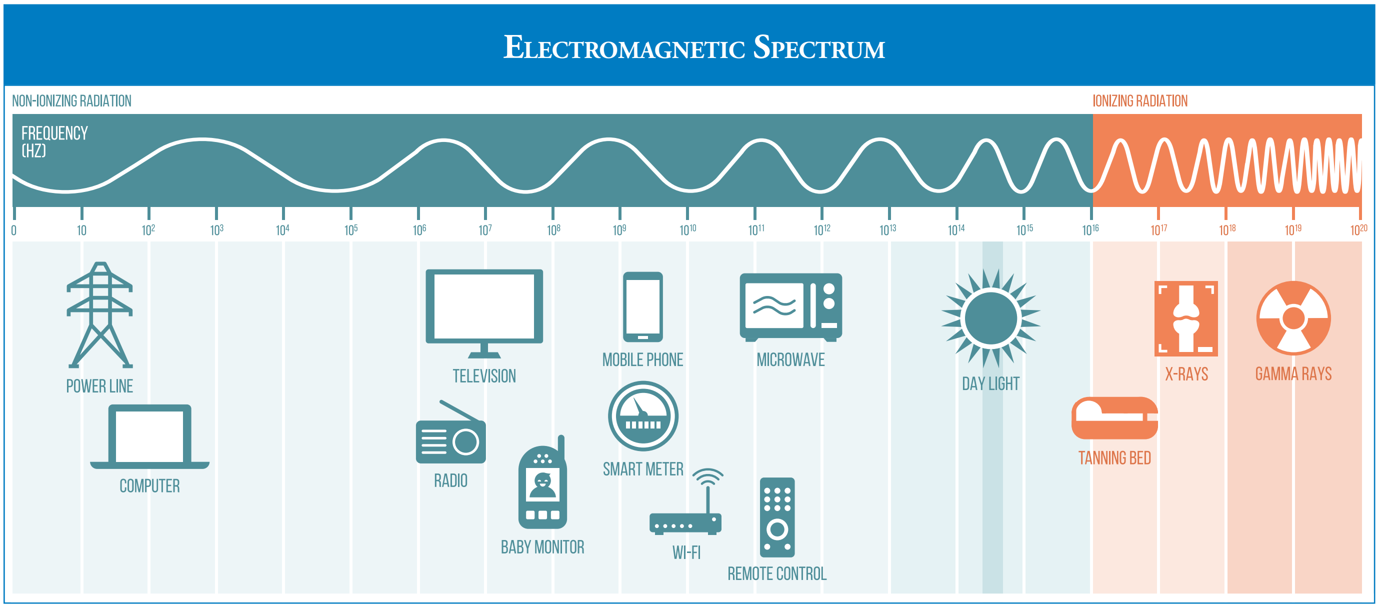

sensitivity to the 60-Hertz AC EMFs associated with submarine cables. Importantly, current research shows that EMF exposures associated with submarine export cables will be highly localized and transient, and they are reversible once an organism moves away from the cable location (*i.e.*, there is no "accumulation" of short-term peak EMF exposures).

As greater numbers of offshore wind projects are approved and constructed off the US coast, the encounter rate of marine species with EMFs from buried submarine cables and other offshore electrical infrastructure will continue to increase. There is thus a need for continued scrutiny of EMFs from these projects. In addition to continued research focused on marine species interaction with 60-Hertz AC EMFs, additional research is also needed for direct current (DC) EMFs given the likelihood that offshore DC submarine cables will gain increased usage in future projects due to their greater capacity and efficacy for long-distance power transmission. In closing, it bears mentioning that mitigation of EMF impacts is specifically considered in the design of offshore wind projects. For example, both seafloor burial and cable design can serve to reduce EMF impacts at and above the seafloor.

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By The Way...

"Historically, wood was the main source of US energy until the mid-1800s and was the only commercial-scale renewable source of energy in the US until the first hydropower plants began producing electricity in the 1880s."

Source: https://www.eia.gov/todayinenergy/detail.php?id=43895

Surging Lithium Demand Creates New Environmental Concerns

By Karrie Radloff, Ph.D.

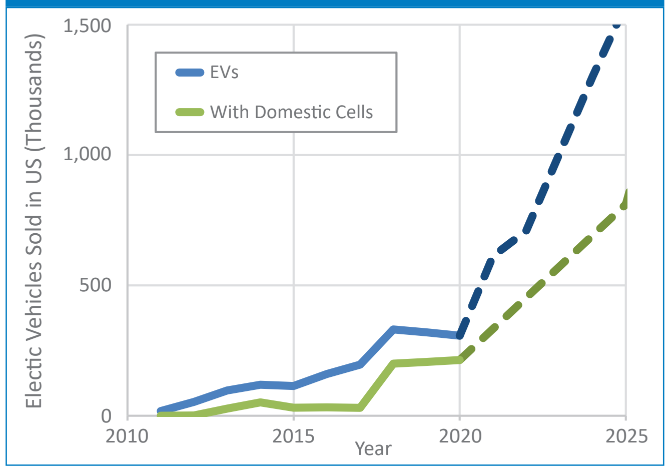
Renewable energy developments have created new demands for critical metals, outpacing some of the understanding of the potential health and environmental impacts of their use.

Surging demand for renewable energy is focusing attention on the critical metals (such as copper, nickel, cobalt, lithium, and rare earth elements) needed for transmission lines, magnets, and battery storage. Lithium's light weight and high reactivity make it an ideal choice for rechargeable batteries. Advances in battery technology have made way for the production of lithium batteries with enough capacity to power a growing fleet of all-electric cars and trucks. Furthermore, the ability to produce lithium batteries capable of economically storing energy from wind and solar farms is on the horizon. Demand is growing so quickly that the Biden administration has named large-capacity batteries as one of four critical products in its recent domestic supply chain assessment (FCAB, 2021). National efforts focusing on the identification of additional mining resources for lithium and other critical metals as well as increasing battery manufacturing capacity are underway both domestically and in allied countries.

> ***[R]egulators are increasing scrutiny of lithium and its related products to evaluate health and environmental concerns at each stage of the lithium supply chain.***

The entire lithium battery supply chain – from mining and mineral processing, to manufacturing of battery cells and packs, to industrial and consumer product use, and, ultimately, to recycling and disposal practices – is under heavy pressure to keep up with global demand. When electric vehicles (EVs) initially hit the market, their lithium battery cells were manufactured abroad. US manufacturing capabilities increased gradually after heavy investment. By 2020, US manufacturers produced 70% of the lithium battery cells used in EVs sold in the US. However, domestic demand for EVs is expected to increase more than 5-fold over the next five years, while expected US capacity for all lithium cell manufacturing (not only for EVs) is forecast to increase less than 4-fold. Even with the 4-fold growth in capacity, US manufacturing contributions to the global supply will remain nearly unchanged, representing only 9% of the global market, and the domestic demand will continue to outstrip domestic supply. Lithium battery recycling operations are also under development, but remanufactured batteries are anticipated to supply less than 10% of global demand in 2040.

Actual and Projected Sales of Electric Vehicles in US



Actual portion of EVs with domestically produced lithium battery cells shown along with estimated production from US manufacturers assuming growth predicted for all lithium cell battery manufacturing capabilities. Deficit between EV battery demand and domestic supply is nearly 50% in 2025. Sources: ANL (2021); FCAB (2021).

In tandem with pressure to identify and develop new sources of lithium and quickly scale up manufacturing capabilities, domestic and international regulators are increasing scrutiny of lithium and its related products to evaluate health and environmental concerns at each stage of the lithium supply chain.

The Biden administration has indicated that it plans to update regulations to ensure that strong public health and environmental standards, including those to address sustainability and environmental justice concerns, are in place for mining projects targeting lithium and other critical metals. A multiagency team, including the US Dept. of the Interior, the US Dept. of Agriculture (USDA), and the US Environmental Protection Agency (US EPA), has been tasked with identifying the critical statutes and regulations that require further review. For example, lithium's movement in the environment has not been as widely studied as many metals, but its relatively high mobility means that it will behave differently in the environment as compared to the metals and minerals for which the regulations were originally written (*e.g.*, the Materials Act of 1947, which regulates the disposal of mining materials on federal land).

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Guest Editorial: US Offshore Wind on the Fast Track

By Dan Chorost, J.D.

There has been remarkable progress in recent months related to the development of utility-scale offshore wind projects in the United States due to the states and federal government reaching alignment.

The stars are aligning for the birth of a full-fledged offshore wind industry in the northeastern United States, where ocean winds are strong and the shallow depth is ideal for fixed-bottom turbines. While offshore wind farms have been operating across Europe for decades, the tortuous 10+ year path of the Cape Wind project off of Massachusetts caused many to wonder when America would have its first utility-scale offshore farm. The short answer is that offshore wind is coming in a hurry.

Offshore wind development in the US requires both federal- and state-level action. The federal government controls the outer continental shelf starting three nautical miles from shore, and through the Bureau of Ocean Energy Management (BOEM), the federal government decides which ocean areas should be made available for development and leads the required environmental review. The states competitively procure offshore wind energy from developers that control federal lease areas, and permit each project's export cable where it runs through state waters and connects to the onshore grid. The federal permitting is extremely complex, given that about a dozen agencies are involved. Wind farms can involve the installation of over 100 turbines the size of the Chrysler Building, and the projects can be extremely controversial.

Ten years from now, expect to see floating wind farms 20 to 30 miles from the California, Oregon, and Washington shorelines – as well as in the deeper areas off of the East Coast.

The Obama administration's BOEM formulated a vision for offshore development and auctioned nearly a dozen lease areas, but most northeastern states were not ready to jump in with solicitations. Although the Trump administration did little to advance offshore wind, the northeastern states' aspirations had matured into solicitations and ambitious renewable energy targets. Today, the Biden administration has a goal of 30 gigawatts of installed offshore wind energy by 2030; many northeastern states have their own procurement goals, the largest being New York's mandate for 9 gigawatts by 2035. With the states and the federal government now fully aligned on rapidly developing utility-scale offshore projects, the last several months have seen astonishing progress.

Between late March and early July 2021 alone, BOEM issued six Notices of Intent (NOIs) to prepare environmental impact statements for proposed East Coast offshore wind projects:

- **March 29:** NOI issued for the 1.1-gigawatt Ocean Wind project off of New Jersey;
- **April 29:** NOI issued for the 880-megawatt Revolution Wind project off of Rhode Island;
- **June 24:** NOI issued for the combined 2.1-gigawatt Empire Wind 1 and Empire Wind 2 projects off of New York;
- **June 29 and 30:** NOIs issued for the 2-gigawatt Vineyard Wind South and the 804-megawatt Park City Wind projects off of Massachusetts; and
- **July 2:** NOI issued for the 3-gigawatt Dominion Energy project off of Virginia.

Together, these projects will power millions of homes.

There is programmatic momentum as well. On May 25, BOEM announced that by 2022 it will lease some 400 square miles of ocean off of California and expects over 4.5 gigawatts of offshore wind development there. Although that region has strong winds, traditional fixed-bottom turbines cannot be used because the outer continental shelf is so deep there. Instead, floating turbines – a technology that only recently became commercially viable – will be used offshore of the West Coast. Ten years from now, expect to see floating wind farms 20 to 30 miles from the California, Oregon, and Washington shorelines – as well as in the deeper areas off of the East Coast.

Finally, on June 14, BOEM issued its long-awaited Proposed Sale Notice announcing eight new potential lease areas in the New York Bight that BOEM plans to auction off in late 2021 or early 2022. Each lease area will be approximately 80,000 acres. So far, 11 offshore wind developers – including many of the largest fossil-fuel companies in the world – are prequalified to participate in the upcoming auction. BOEM's Proposed Sale Notice flags the federal government's interest in capping each offshore wind developer to win only one or two leases in order to increase competition and facilitate development of a robust US supply chain.

Dan Chorost is an Environmental Partner at the law firm of Sive, Paget & Riesel in New York City. Dan advises several clients in the offshore wind industry, including Equinor Wind US on the permitting and environmental review for the Empire Wind 1, Empire Wind 2, and Beacon Wind 1 offshore wind projects. He can be reached at dchorost@sprlaw.com.

Surging Lithium Demand Creates New Environmental Concerns

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In order to evaluate potential human exposures more broadly, US EPA recently added lithium to its list of unregulated contaminants to be monitored by public water systems, but that do not have enforceable health-based standards. US EPA's decision to begin lithium monitoring follows a recent United States Geological Survey (USGS) study that evaluated lithium in drinking water supplies across the US (Lindsey *et al.*, 2021). The study found that approximately 45% of public supply wells and 37% of domestic supply wells have concentrations of lithium that could present a potential human health risk using a non-regulatory screening level developed by US EPA. Although USGS found that most lithium concentrations were likely due to natural sources, it noted that anthropogenic sources may have growing importance. More critically for manufacturing and international trade, the development of a health-based hazard assessment for lithium in the European Union (EU) under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation is expected later this year.

Lithium batteries are just one example of the many innovative technologies that will support the domestic green economy. Ramping up manufacturing of these new technologies may bring significant economic and environmental benefits, but also the potential for unforeseen environmental impacts. These nascent industries should embrace lessons learned from legacy mining and processing operations and proactively manage their environmental impacts to ensure robust protection throughout the supply chain, spanning from mining and mineral processing, manufacturing, and use, to recycling and disposal. Evaluating potential health and environmental concerns is necessary to ensure that potential risk concerns are adequately addressed, even if regulatory requirements are lagging.

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What's New at Gradient

Awards and Announcements

Tim Verslycke will serve as Vice President of the newly established International Board of Environmental Risk Assessors (IBERA).

Rajib Mozumder was invited to join the editorial board of *Journal of Hydrology* (ELSEVIER).

Barbara D. Beck was selected to serve on the US EPA Science Advisory Board and the Chemical Assessment Advisory Committee under the new Administrator, Michael S. Regan.

Publications

Lewandowski, T.A., G. Wang, M.D. Reed, A.P. Gigliotti, **J.M. Cohen,** D. Nuber, M. Boelens, S. Mukhi. 2021. Thyroid homeostasis in B6C3F1 mice upon sub-chronic exposure to trifluoroiodomethane (CF3I). *Toxicol. Ind. Health.* doi: 10.1177/07482337211019658.

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Goodman, J.E., W. Li, L.A. Cox Jr. 2021. Commentary: Using Potential Outcomes Causal Methods to Assess Whether Reductions in $PM_{2.5}$ Result in Decreased Mortality. *Global Epidemiol.* 3:100052. doi: 10.1016/j.gloepi.2021.100052.

Upcoming Presentations

Washington, D.C. Nov. 14-17, 2021. 42nd ACT Meeting.

• "Toxicology-based Exposure Limits for Residual HEK-293T Cell DNA and Protein." I. Mohar, T. Lewandowski

Portland, OR. Nov. 14-18, 2021. SETAC North America 42nd Annual Meeting.

• "Looking Beyond the CAS Number: Considering Form Specificity in Hazard Assessment of Metals." C. Marsh, K. Reid, C. Claytor

• "Microplastics in the Terrestrial Environment: Is there a real threat and risk?" I. Bamgbose

• "Lessons Learned from Conducting Alternatives Analyses Under California's Consumer Products Program." J. Zhang, J. Cohen, T. Lewandowski

• "West Coast States and Taking Different Approaches to Alternatives Assessment." T. Lewandowski, J. Zhang, J. Cohen