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Zero Emission Transportation
by Bryan Comer

All sectors must decarbonize if the world is to achieve the ambitions of the Paris Agreement. In this issue of EM, we examine the transportation sector’s progress toward zero emission fuels, buses, ships, and airplanes.

Features

Alternative Fuels: A Solution to Transport Decarbonization or Not?
by Yuanrong Zhou

Removing the Infrastructure Barrier to Owning an Electric Vehicle
by Michael Nicholas

Zero Emission Buses on the Charge: Opportunities and Strategies
by Yihao Xie

Wind Propulsion: A Breath of Fresh Air in the Delivery of Zero Emissions Vessels
by Gavin Allwright

Electric Planes: In Search of Zero Emission Aviation
by Dale Hall

Columns

PM File: Meeting Challenges Revisited during a Pandemic
by David Elam

While effective communications have always been central to our work as environment, health, and safety (EH&S) project managers, the COVID-19 pandemic has emphasized the importance of these skills as we move from one virtual meeting to another.

YP Perspective: The Case for a Post-COVID-19 Electric Vehicle Charging Station Boom
by Christopher Cavaiola

The coronavirus pandemic may be the impetus the electric vehicle sector needs for charging stations to finally take off.
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Welcome to September, the “return” to school and the beginning of fall. Like parents and students across the globe, our Association continues to adapt. A&WMA’s focus is to continue to inform members on trends, information, technology, innovations, and regulations. The Association achieves this through its respected and relevant assembly of publications, including the *Journal of the Air & Waste Management Association*, *EM* and *EM* Plus, A&WMA Newswire, *The Member Connection*, and the *Conduit*. All this content and its dissemination is a testament of the success and partnership among our incredibly efficient staff, the Publications Committees, Councils, and our prodigious content contributors. Likewise, A&WMA offers a range of programs, including webinars, conferences, workshops, and information and networking forums, which when added all together with our wonderful and engaged membership, gives you THE Air & Waste Management Association.

This year has been the “pivot” year, where the pandemic situation has forced a movement away from face-to-face to virtual events. While the papers and presentations have been as wonderful as ever, we all miss the social aspects of being members of an Association. I am happy to report that as we become more technologically proficient and comfortable in this new normal, aspects of the social interaction and mentoring continue to increase. The virtual format has its advantages. It allows people around the world to participate, often in real time. It provides people with the flexibility to view recorded events at any time, from anywhere. Of course, live question and answer sessions are not always possible in this type of format, but there is almost always a link to the author or speaker, and a quick email can fill in the gaps or spark conversation. I have experienced this numerous times following ACE 2020, webinars, and other virtual conferences, with calls from students or colleagues who have an idea to contribute, hints about employment or beneficial classes, or an exhibitor or sponsor who wants to propose a way to improve their exposure.

From conferences and workshops to webinars and publications, it is A&WMA’s mission to continue to communicate sound science, engineering, regulatory policy, and more. As always, *EM* provides a great source of thought-provoking articles on a whole range of topics. This month’s issue focuses on transportation that does not use carbon as a fuel source. There is a great push throughout the world to expand the science, develop the technology, enhance the design, and convince consumers that there are significant benefits to decarbonized transportation. Initial costs are generally high until demand catches up with manufacturing and innovation. We saw that with solar panels, wind turbines, and automotive batteries. This month’s contributing authors focus on shipping, aviation, buses, and alternative fuels.

The UN Paris Agreement calls for decarbonization by 2050, and it amazing how many products have been developed from plant materials to replace hydrocarbons, including fuels and other products made from algae, corn, and other materials. But, of course, global decarbonization is a whole lot more complex than engineering, science, and manufacturing. Moving away from petroleum-based economies will be a huge undertaking built on centuries of evolution. As science and innovation move exponentially faster it will not and cannot take long before we pivot toward less reliance on carbon. *em*
Zero Emission Transportation

In this issue, we examine the transportation sector’s progress toward zero emission fuels, buses, ships, and airplanes.
The United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement (https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement) aims to limit global temperature rise to well below 2 °C and to pursue efforts to limit it to 1.5 °C to mitigate the worst impacts of climate change. The Intergovernmental Panel on Climate Change’s (IPCC) Special Report (https://www.ipcc.ch/sr15/) on global warming of 1.5 °C explains that the likelihood of ice-free summers in the Arctic is once per century under 1.5 degrees of warming, but once per decade at 2 degrees. Similarly, the IPCC estimates that coral reefs would decline 70–90% under 1.5 degrees of warming, which is worrying enough, but at 2 degrees, more than 99% would be lost. As of July 2020, the world is already approximately 1.3 degrees warmer than the pre-industrial era, according to Columbia University (http://www.columbia.edu/~mhs119/temperature).

Limiting warming to 1.5 °C with little or no overshoot requires human-caused carbon dioxide emissions to fall by about 45% from 2010 levels by 2030 and to reach net zero emissions around 2050, according to the IPCC. All sectors must decarbonize if the world is to achieve the Paris Agreement temperature goals, including the global transportation sector, which represents about one quarter of anthropogenic carbon dioxide emissions, according to current estimates released by the International Energy Agency (https://webstore.iea.org/co2-emissions-from-fuel-combustion-2019-highlights).

In the articles that follow, the authors look at the transportation sector’s progress toward zero emission fuels and vehicles.

In the first article, Yuanrong Zhou explains that not all transportation fuels are created equally. While some fuels, especially those derived from wastes, reduce lifecycle greenhouse gas emissions compared to fossil fuels, others, including those made from palm oil, actually increase total emissions. In short: the feedstock matters.

Next, Mike Nicholas explains that while electric passenger vehicles are becoming less expensive and electric vehicle (EV) sales are growing, half of Americans would not be able to conveniently recharge an EV at home. Subsidized public charging infrastructure could bridge the gap and remove barriers to EV ownership, he argues.

In the third article, Yihao Xie tells us about the rise of zero emission buses. He explains that cities are replacing old, inefficient buses with new zero emission electric buses that eliminate tailpipe emissions and improve air quality. Chinese cities, as well as Los Angeles, Paris, Santiago, and Bogotá, are at the forefront of the zero emission bus revolution. Fleet renewal is expensive, however, so stimulus spending as part of governments’ green recovery efforts to address the coronavirus pandemic could be a source of funding.

Fourth, Gavin Allwright explains how the global maritime shipping industry is returning to wind power to reduce fuel consumption and emissions. While most commercial ships won’t be fully powered by the wind, many can be retrofitted with rotor sails, rigid sails, or even soft sails or kites. Wind power, together with route optimization, better ship designs, and low- and zero emissions fuels can help ships meet the International Maritime Organization’s goal of cutting emissions from the sector by at least 50% from 2008 levels by 2050 and, eventually, eliminating emissions altogether.

Lastly, Dale Hall tells us how airplanes could become zero emission. Aviation is particularly difficult to decarbonize because fuels need to be energy-dense and lightweight. Hydrogen fuel cells paired with advanced batteries could do the trick, but whatever energy source is used, it needs to be powerful enough to generate the thrust needed to keep planes in the air. Substantial investment in research and development will be needed to get large-scale, zero emission planes off the ground. In the meantime, improving the efficiency of existing aircraft through lightweight materials and operational strategies like maximizing belly freight can cut emissions from conventional aircraft.

We thank the authors for their important contributions to this discussion and hope you enjoy learning more about the transition to zero emission transportation and its role in achieving society’s climate goals.
Reduce Carbon and Prepare for Energy Transition

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CONGRATULATIONS
SHIRA COLSKY, P.E.
2020 A&WMA Outstanding Young Professional

CONTACT INFORMATION
Lynn McGuire
lmcguire@geosyntec.com
510-285-2690
Carolina Ortega
cortega@geosyntec.com
281-810-5013
geosyntec.com/carbon-reduction
The author considers some of the challenges associated with—and likelihood of—developing and deploying genuine low-carbon fuels for the transportation sector.
Transport decarbonization is urgent and plays a crucial role in global climate progress. The transportation sector is responsible for approximately 24% of global carbon dioxide (CO₂) emissions. The Intergovernmental Panel on Climate Change (IPCC) projects that without aggressive actions, emissions from transport are likely to increase faster than other sectors with 50% growth from 2017 to 2050.

The transportation sector is also a massive energy consumer. In 2017, this sector accounted for almost 30% of total final energy consumption in the world and ranked top across all sectors. Transportation is largely dependent on fossil fuels, with petroleum meeting almost 95% of fuel demand. Consequently, there are two strategies for achieving decarbonization in transport: improving energy efficiency, which reduces fuel consumption; and switching to lower carbon alternative fuels.

Alternative fuels for the transportation sector include, but not limited to biofuels, natural gas, electricity, and hydrogen. While the use of the latter three fuels requires innovations in fuel infrastructures and power systems, biofuels, at least certain drop-in biofuels or in blends with conventional fuels, are compatible with the existing petroleum supply system and internal combustion engines. Therefore, biofuels are viewed as the low-hanging fruit of alternative fuels and have experienced the greatest penetration compared to the other types of alternative fuels. As of 2017, the share of biofuels in the transportation sector globally was 3%, more than half of total alternative fuels. Are these easy pickings effective in decarbonization? Some argue that biofuels are net-zero emissions because the carbon released from fuel usage is essentially offset by the carbon absorbed during biomass growth. But this is not the whole story.

Carbon Intensity
Believe it or not, not all alternative fuels can lead to carbon reductions from fossil petroleum, let alone carbon neutrality. The carbon intensity of a fuel depends greatly on its feedstock and conversion pathway. A full lifecycle assessment (LCA) accounting for emissions from both upstream (feedstock extraction and fuel production) and downstream (fuel use), is thus necessary and consistent LCA methodology should be applied across fuel types. As straightforward it may sound, it is not an easy job in practice as a lot of extra considerations need to be included.

Liquid Biofuels
Biofuels are particularly complicated due to their land use change impacts, direct and indirect. Direct land use change refers to the conversion of natural land such as forest or grassland to the production of biofuel feedstocks. Indirect land use change (ILUC) is the unintended result of diverting commodities from existing supply chains to biofuel production, necessitating the conversion of natural land to cropland elsewhere to meet the global demand for that commodity in food, livestock feed and materials. Land use change, whether direct or indirect, causes greenhouse gas (GHG) emissions from disturbing carbon stocks in biomass and soil.

ILUC is particularly an issue for biofuels made from food crops. Consequently, crop-based biofuels, such as biodiesel or renewable diesel from soybean oil and palm oil, do not provide climate benefits even after accounting for the carbon sequestered; rather, some of these pathways may even have a higher carbon intensity than fossil petroleum. Biofuels from waste oils, such as used cooking oil, and cellulosic biomass, such as corn stover and municipal solid wastes, generally offer great decarbonization potential. However, challenges exist for these feedstocks. For waste oils, feedstock availability is an issue. For cellulosic biomass, advanced fuel conversion technology is needed, and this translates into high capital investment and production costs. As a result, the biofuel industry is by far dominated by crop feedstocks. For example, soybean oil and canola oil make up more than 60% of biodiesel production in the United States, and U.S. ethanol is produced almost 100% from crops like corn, sugarcane, and sorghum.

Fossil and Renewable Natural Gas
Natural gas, primarily methane (CH₄), although being a fossil origin, has been viewed by some as a sustainable alternative fuel because it has lower carbon content per unit energy and thus emits less CO₂ than petroleum during combustion. The market of natural gas vehicles is likely to grow in the near future and liquefied natural gas (LNG) has become particularly popular in the shipping sector with the number of LNG-powered ships more than doubling from 2012 to 2019. However, two recent studies found that LNG is unlikely to deliver carbon reductions in both the road and shipping sectors; instead, it might even worsen climate impacts especially in the near term (a global warming potential at 20-year horizon). This is due to the leakage of methane, a very potent GHG, in the fuel's lifecycle.

Biomass can also be used to produce methane, known as renewable natural gas or biogas. Similar to liquid biofuels, the feedstock source greatly determines the climate performance. For instance, biogas from livestock manure offers strong carbon savings, while biogas from silage maize, a feed crop, is only slightly better than fossil natural gas. Unfortunately, silage maize is a common feedstock, accounting for approximately half of the biogas produced in the European Union.

Electricity, Hydrogen, and Electrofuels
Electricity can be used directly in electric vehicles (EVs). It can also be used to produce hydrogen, which can be used in fuel cells or combusted in hydrogen engines. Battery electric and hydrogen fuel cell vehicles are more efficient...
than combustion engines. While they both have zero carbon emissions from tailpipe, upstream emissions during fuel production depend greatly on electric grid and therefore, they both can offer particularly high carbon savings if produced using renewables.14

Another electricity-based fuel is electrofuels, also known as power-to-liquids, which is produced through electrolysis and combining hydrogen with carbon to form hydrocarbons. These drop-in hydrocarbons can be used in internal combustion engines just like fossil fuels. Because the production and combustion of electrofuels is relatively inefficient,15 decarbonization can only be realized for these fuels if the electricity is produced entirely or almost entirely from renewables, such as solar and wind, and the diversion of renewable electricity for transport does not induce increased nonrenewable electricity use in other sectors.16

**Conclusion**

Feedstock really is the critical answer to whether a certain alternative fuel is the solution to transport decarbonization. Biomass-based fuels made from food or feed crops are no better than fossil petroleum due to indirect land use change impacts; wastes and cellulosic biomass offer good climate performance but need to be scaled up; fossil natural gas provides no climate benefit especially in the near term; electricity and hydrogen from renewable sources could offer deep carbon savings. Yet, fuel switching progress in the transportation sector so far has been mainly from biofuels produced from food or feed crops. The development and deployment of genuine low-carbon fuels is still in its infancy. To ramp up, policies, especially supportive financing schemes, are needed immediately to support the scale up of advanced fuel conversion processes that can utilize the most sustainable feedstocks. Ultimately, a mixed effort of energy efficiency and varied low-carbon fuels is necessary to reach transport decarbonization.

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**References**

As global sales of electric vehicles continue to increase, this article considers whether the U.S. infrastructure is ready for everyone to opt for an electric car.
The electrification of vehicles is advancing around the world. The global share of electric vehicle (EV) sales reached 2.5% in 2019 and there is now a stock of over 5 million EVs. Moreover, it's likely that many EVs will be cheaper to manufacture by the mid-2020s than equivalent gasoline cars. At this inflection point, there may be enormous demand for charging both at home and in public. But is our infrastructure ready for just anyone to choose an electric car today? This article explores the issue from two perspectives in the United States: access to charging at home, and the challenge of installing public charging.

Access to Home Charging

Charging at or near one's residence is often the most convenient and inexpensive way to charge. Existing outlet access at residences provides a solid foundation for home charging to enable a transition to EVs. A 2015 U.S. Energy Information Administration survey suggests that 48% of the general population parks a car within 20 feet of an existing 120V outlet while 52% do not (see Figure 1). Although not all existing outlets are suitable for charging, the good news is that about half of all Americans park near a structure that has electricity and could conceivably plug in or install charging.

Comparing this to surveys of current EV owners, home charging access is much more common. Surveys suggest that 64% of EV owners are using an existing or upgraded 120V or 240V outlet and an additional 25% install a dedicated vehicle charger. This leaves only 11% with no home charging option. The low percentage of current owners with no access to home charging implies that the ability to charge at home is an important factor for sales.

Public Charging

But for those who do not have or cannot install home charging, public charging is necessary. Studies project how many public chargers will be needed (broadly defined as workplace, other public, and fast charging) to serve an EV market, but will they be built and by whom? The often-challenging business case suggests a variety of solutions will be necessary to reach scale for public charging. Nonetheless, there are many reasons to install public charging, including retail customer attraction, workplace employee retention, corporate responsibility, automaker sales promotion, rate-based utility investment, and finally, profit on dispensing electricity to vehicles.

Retail establishments appear to be highly motivated to install charging if the period of time a customer shops increases. In one study completed by a retailer, each additional minute spent in a store increased revenue by $1. The study concluded that $430 in electricity generated $56,000 in additional revenue. Chargers are being installed at this retailer’s stores and electricity given away for free.

Workplaces are also installing charging, but most are not making money directly from the sale of electricity. Instead, it leads to employee acquisition, satisfaction, and retention, and therefore indirectly benefits companies. Additionally,
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Reaching Scale

Profitability for charging is possible in the future, but in all the above cases, entities employ some sort of subsidy on either the hardware or electricity itself. With the low cost of gasoline in the United States, unsubsidized public charging could result in higher costs for operating EVs. A customer with no home charging who relies on unsubsidized charging could in some cases pay more to drive an electric vehicle than a similar gasoline vehicle.

Because of the current unfavorable economics in the United States, the network growth may be stunted, and policy support could help improve conditions for charging network expansion. As mentioned before, utilities have a built-in interest to increase the EV market and some are providing support for the installation of chargers. However, with more than 3,300 utilities in the United States, there are varying levels of capability and engagement.

But the power to engage on EVs also lies with state utility commissions that coordinate rates and investments with investor owned utilities. With the looming challenge of massive electrification, commissions can play a strong role directing utilities to invest in supporting public infrastructure. Similarly, utilities can encourage the private sector to install public charging by developing strategies to lower the price of electricity. Lower electricity prices create a virtuous cycle where charging operators can make money on charging and therefore install more charging. High electricity cost is driven by worst-case planning, which assumes that EVs will be plugged in at a time of grid stress triggering expensive upgrades to lines and transformers. Innovative strategies such as smart charging, where charging is controlled to avoid these times, or chargers with battery backup to avoid drawing grid power, can lessen the impact and lower costs.
Sustained funding for charging installation and operation is also being pioneered by government policies. In California, the Low Carbon Fuel Standard is a policy that aims to lower the carbon intensity of fuel by substituting low carbon fuels for higher carbon fuels. It sets a carbon intensity reduction target (it was 6% below 2011 levels in 2019) and incorporates a credit trading system to accomplish the reductions. The value of the credits for substituting electricity for gasoline in the case of fast charging is determined by both the capacity of the station and the quantity of electricity dispensed. The capacity credit helps defray installation costs and the greenhouse gas reduction credits help defray the costs of the electricity dispensed to vehicles.

**Conclusion**

Electric vehicles are gaining market share and become less expensive every year. Approximately half of Americans, however, cannot buy an EV today and conveniently plug it in at home. While pursuing a home charging solution is the first priority, public charging can also provide an option for those unable to find a home charging solution. There are many solutions emerging to address this public charging gap, including retail customer attraction, workplace employee retention, corporate responsibility, and automaker sales promotion. This subsidized charging is low-cost giving those without home charging an option to go electric.

However, improving the business case to allow for a charger operator a return on investment will also greatly increase the supply of public infrastructure and allow anyone to buy and conveniently charge a vehicle. Policies at state utility boards and commissions have the potential to direct and empower utilities to support charging and lower electricity costs to this end. Additional support from policies that monetize the value of carbon reduction, such as California’s Low Carbon Fuel Standard, are also key strategies to lower costs and encourage charging installation.

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**References**


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**In Next Month’s Issue…**

**Understanding the Formation and Transport of Ozone Near Large Water Bodies**

The relatively cool waters of large water bodies such as the Great Lakes, Long Island Sound, and the Chesapeake Bay confine air pollutants in a shallow and stable marine boundary layer. Afternoon heating over coastal land creates a sea breeze that carries air pollution inland from the confined marine layer, resulting in high ozone concentrations inland. The October issue describes recent advances from monitoring and modeling studies designed to improve knowledge of air pollution affected by land-water interfaces and suggests how to manage air quality in these situations.
The worldwide movement to transition urban transit fleets from high-emitting vehicles to zero emission buses is gaining momentum, but some challenges remain.
Cities, the centers of population and hubs of economic activities, continue to grow. The United Nations projects that by 2050, more than two-thirds of the world’s population will live in cities and developing countries will have most “megacities” over 10 million inhabitants. With rapid urbanization, demand for public transportation is also rising. At the same time, economic and transportation activities in cities produce air pollutants that threaten human health and greenhouse gases that exacerbate climate change.

How can cities meet rising transportation needs for their people, while safeguarding air quality and reduce greenhouse gas emissions? Continued reliance on internal combustion engines, particularly older diesel technologies, is no longer the answer. Emissions from transportation sources contribute to 11.4% of ambient fine particulate matter (PM$_{2.5}$) and ozone (O$_3$) related deaths, and is the third biggest source of total carbon dioxide (CO$_2$) emissions. Buses account for less than 5% of total diesel vehicle stock, but are responsible for more than 12% of black carbon (BC) emissions, 11% of nitrogen oxides (NO$_X$) emissions, and 12% of PM$_{2.5}$ emissions from all diesel vehicles. The disproportionate contribution is in part a result of the prevalence of dirty diesel buses, especially in emerging markets where urbanization is also happening the fastest.

Zero emission buses present themselves as a promising technology to mitigate the effects of air pollution and climate change. They eliminate tailpipe emissions of PM, NO$_X$, and BC, and are up to 300% more energy efficient than diesel buses. Zero emission buses also deliver well-to-wheel (WTW) greenhouse gas (GHG) emission benefits, even when powered by electricity generated from fossil fuels. Additional WTW GHG reductions are possible when the grids are powered by renewable sources like solar and wind.

**The Rise of Zero Emission Urban Transit Buses**

Transit operators around the world have begun to transition to zero emission bus fleets. China mainstreamed battery electric zero emission technology early, and close to 40% of its urban public transit fleets are now zero emission. Elsewhere, the city of Los Angeles is planning to electrify 155 transit buses and eventually go fully electric by 2028. The public transit operator in Paris bought 800 new electric buses, with the first deliveries scheduled between 2020 and 2022. Santiago, Chile has already successfully introduced 400 battery-electric buses to its bus fleet. In addition, the Colombian capital, Bogotá, is eyeing the deployment of close to 600 electric buses to its TransMilenio system in 2020.

While the momentum of zero emission buses is strong, at the same time, technology transition to zero emission at a fleet level is no simple matter of buy and replace. It requires high upfront investments of expensive vehicles and additional infrastructure, and involves operational, technical, and financial risks and challenges. When the risks are not addressed in the planning stage of technology transition, cities may experience mixed results with zero emission buses that undermine their performance and environmental benefits.
A major challenge when fleet operators and transit authorities decide to move to zero emission buses is planning. The planning process begins with an adequate understanding of the current fleet's performance. Data such as average driving speed, road grades, and energy consumption from the current fleet are a useful baseline to benchmark zero emission bus fleets. This information enables operators to answer important questions: What are the minimum range required for these buses? What should the charging strategy be like? How big should the capacity of onboard batteries or hydrogen fuel tanks be?

Transit authorities and regulators are developing guidelines and tools to help transit agencies collect data and prepare for zero emission buses. For example, California Air Resources Board’s Zero-Emission Bus Rollout Plan provides a framework for transit operators to meet the state’s Innovative Clean Transit targets. The Rollout Plan asks operators to describe their current fleet composition, lay out future bus purchase timelines, specify bus technology requirements, and project cost estimates, as well as start-up and scale-up challenges. It helps transit operators think through their strategy before making bus purchases and infrastructural investments.

Drawing from successful solutions from transit operators and authorities, The International Council on Clean Transportation (ICCT) advocates for an approach of fleetwide planning for zero emission technology transition. A core component of the fleet planning approach is the framing of cost. By the metric of purchase prices alone, zero emission buses can be more than 150% more expensive than conventional diesel and natural gas buses in some markets. This puts them at a clear disadvantage.

ICCT’s modeling analysis of 20 megacities worldwide, however, finds that in a 10-year horizon (the typical service lifetime of urban transit buses), the total cost of ownership (TCO)—including upfront procurement costs, and recurring operations and maintenance costs—of zero emission buses can be lower than conventional diesel buses, as shown in Figure 1. On the right panel, when the monetized value of climate and health benefits are factored in, cost savings are even greater. Ultimately, the goal of fleetwide planning is to...
In Latin America, the ICCT is co-leading with C40 Cities the Zero Emission Bus Rapid-deployment Accelerator (ZEBRA), a project funded and facilitated by P4G, with additional support from Centro Mario Molina Chile (CMMCh) and World Resources Institute (WRI). The first phase of ZEBRA targets four “core cities” where work has begun in Medellín, Mexico City, Santiago, and São Paulo, as well as a number of catalytic cities with potential for zero emission buses. Political leadership in the core cities has pledged support or passed mandates for zero emission public transit buses. Across Latin America, ZEBRA provides fleetwide planning assistance to operators, invites major bus manufacturers to make zero emission bus products available, and engages with financial institutions to secure $1 billion for zero emission bus finance by 2021. Zero emission buses are already helping ZEBRA cities reduce CO₂ emissions, and the savings will multiply as more zero emission buses are deployed (see Table 1).

### Opportunities for Zero Emission Buses Post COVID-19

The ongoing COVID-19 pandemic poses a grave challenge to transport systems worldwide. A total of 428 cities in China halted their transit systems completely in January and February. As the virus swept across the United States, transit agencies in major cities saw ridership decrease by 50–90%. Empty streets, suspended services, and plummeted ridership have put transit operators on life support from government financing. The United States allocated $25 billion to support floundering transit agencies across the country through the CARES Act. Despite the current crisis, there are opportunities for zero emission buses on the horizon. As governments worldwide put

<table>
<thead>
<tr>
<th>Country</th>
<th>*ZEBRA cities</th>
<th>Number of zero emission buses deployed</th>
<th>Yearly CO₂ emission savings (kt)¹⁵</th>
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<td>8.7</td>
</tr>
<tr>
<td></td>
<td>Medellin*</td>
<td>65</td>
<td>6.8</td>
</tr>
<tr>
<td>Ecuador</td>
<td>Total</td>
<td>105</td>
<td>11.7</td>
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<tr>
<td>Mexico</td>
<td>Total</td>
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<tr>
<td></td>
<td>Mexico City*</td>
<td>213</td>
<td>24.2</td>
</tr>
<tr>
<td>Panama</td>
<td>Total</td>
<td>2</td>
<td>0.2</td>
</tr>
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</table>

*Statistics are from E-Bus Radar, a tool developed by ZEBRA Partnership teams at C40 Cities and ICCT in collaboration with LABMOB, IEMA, ICS, and P4G Partnerships.¹⁶
together economic relief and stimulus packages, the concept of a “green recovery” has become more pertinent than ever. Germany is expected to introduce a green stimulus program to achieve its emission reduction goals and climate neutrality. Similar ideas have been proposed for countries like the United Kingdom to design policies that not only revive the economy from fallouts of COVID-19, but also tackle climate change. Investment in electric vehicle infrastructure and public transportation will be a key area in these stimulus plans. Public transit operators can expect to receive financial assistance with an emphasis on zero emission buses and infrastructure.

To take full advantage of the upcoming government funding and support, transit operators should start planning now to avoid pitfalls of rushed deployments. With existing operations data, there are already a few things that transit operators can do, such as route-level drive cycle development and energy consumption modeling, to identify candidate routes for electrification and bus technology requirements. The dividends of a well-planned strategy will pay off when deployments begin.

Yihao Xie is an Associate Researcher for The International Council on Clean Transportation, San Francisco, CA.
E-mail: y.xie@theicct.org.

References
This article suggests wind propulsion as a driver to achieve zero emission shipping vessels and reduce the global shipping industry’s carbon footprint.
The International Maritime Organisation (IMO) has issued a challenge to decarbonize the shipping industry by reducing greenhouse gas (GHG) emissions by at least 50% overall and 70% in carbon intensity by 2050, based on a 2008 baseline. The global shipping industry has always been viewed as a hard-to-abate sector and total GHG emissions from the sector are between 2–3% of world emissions (equivalent to that of Germany). That share of total emissions is forecast to rise significantly if no action is taken, especially as land-based emissions reduce sharply and trade volumes continue to grow.

Zero emission vessels (ZEVs) will be very important in achieving that goal, with nearly 2,000 new vessels coming into a fleet of 50,000 or more large commercial vessels every year. The retrofitting of existing vessels to lower their carbon footprint will be crucial as well. To achieve vessels that are carbon neutral, carbon (and other air emissions) zero or fully zero emissions vessels (no emissions to air or water) over their full life cycle, direct wind propulsion should be considered in order to deliver sharp, deep and timely cuts in emissions.

Figure 1 outlines the two ways that wind energy can be used to move a ship; indirectly through the production, transport and combustion of eco-fuel or the far more efficient direct route of capturing and using the energy on the ship itself. Wind propulsion includes everything from rigid sails, to kites, flettner rotors, and traditional soft sail rigs. Many of these systems are not new, but they are being rethought and installed commercially, with currently 10 large vessel installations covering the tanker, bulker, ferry/cruise, roll-on/roll-off (RoRo) and general cargo segments, with a pipeline of installations that will likely double that before the end of next year (see Figure 2).

Wind Propulsion as Part of a Hybrid Solution: W.A.V.E.

If wind propulsion systems are assessed with the standard framework, using motor vessel parameters, retrofit systems are shown to deliver 5–20% of the propulsive energy required by the ship, averaged over a year, with the potential to increase to 30%. This percentage increases substantially for a primary wind vessel, optimised to maximize wind potential, using technology that is readily available or in late-stage development. If these optimised vessels are operated on good wind routes, utilising weather routing software, then wind could provide up to 80% of the total energy requirement for certain segments of shipping. Figure 1 clearly shows that wind propulsion technology solutions require no new infrastructure, and the energy is delivered directly to the vessel at its point of use for free, for the lifetime of that vessel. Just with these numbers we can see that the fleet wide adoption of wind propulsion solutions, both retrofit and new build, would dramatically reduce fuel requirements in the shipping industry. However, if we combine these with other operational changes and energy efficiency measures we can create a hybrid W.A.V.E. (Wind + Activity + Vessel + Eco-Fuel combination) as shown in Table 1, shifting the paradigm away from a one-size-fits-all model.

In the model shown in Table 1, the wind propulsion component is averaged out across the fleet, delivering 20–30% of the energy requirement for vessels by 2050, along with substantial savings gained through operational changes and vessel optimisation. Eco fuels or “secondary renewables” would then only account for up to 40% of the propulsive energy required, reducing the size and cost of those alternative fuel systems and substantially reducing the costs to ship operators of alternative low-carbon or zero emission fuels. The cost of alternative fuels will be especially challenging during their initial rollout when the unit price is predicted to be substantially higher than fossil fuels.
The Challenges of Decarbonizing Shipping

The UK Clean Maritime Plan released in July 2019, forecasts wind propulsion to be a £2 billion per year market in the 2050s, or 20% of the maritime propulsor market, with alternative fuels making up the other 80%. Importantly, once a wind propulsion system is installed it will deliver effectively free fuel for the next 20 or more years, the lifetime of most vessels.5

Most alternative low-carbon zero emission fuels being considered (e.g., ammonia, hydrogen, biofuels, batteries, and a raft of other e-fuels such as synthetic power-to-liquid or power-to-gas fuels), have significant challenges to their installation quickly and at scale. These challenges include:

1. **Cost:** most fuel systems have high capital expense (CAPEX) and at least in the foreseeable future significantly higher operating expense (OPEX) too.

2. **Storage:** the energy density of many of the alternative fuels is significantly lower than current fossil fuel options; therefore, additional storage space for those tanks is required on vessels, which of course reduces cargo capacity.

3. **Supply:** availability of the feedstock is an issue when it comes to biofuels and the large-scale deployment of renewable energy resources is required for the production of e-fuels. Diffusion of bunker supply (fuel distribution) of

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**Table 1. Hybrid W.A.V.E. approach to decarbonisation.**

<table>
<thead>
<tr>
<th>Wind</th>
<th>Activity</th>
<th>Vessel</th>
<th>Eco-fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind – assist or Primary wind power (Primary Renewable)</td>
<td>Operational optimisation</td>
<td>Vessel optimisation</td>
<td>Renewable energy or waste-derived fuels (Secondary Renewables)</td>
</tr>
<tr>
<td>- retrofit wind-assist (5-20% savings – possible up to 30%)</td>
<td>-voyage &amp; fleet management -weather routing -speed reduction -virtual arrival -crew training -data/ blockchain -new business models etc.</td>
<td>-design -size &amp; capacity -energy management system -energy efficiency measures -air lubrication -reduced engine power etc.</td>
<td>-2nd gen biofuels -batteries -synthetic fuels + CCS -bio-gas/liquids -H2 &amp; H2 carriers</td>
</tr>
<tr>
<td>-newbuild primary wind 50%++</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-today’s tech optimise &amp; cheaper -lease/OPEX approach</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-30%</td>
<td>+</td>
<td>20%</td>
<td>+</td>
</tr>
</tbody>
</table>

*Electric propulsion systems enables modular approach

Note: All figures are estimates and any one measure in each category could provide a significant portion of the proposed saving.
Carbon options, wind can serve as the primary system of propulsion if some operational compromises are made in speed and routing. Auxiliary engines or motors fuelled by green hydrogen, ammonia of other e-fuels generated with clean renewable energy are possible, as are batteries, but only if these are limited in size and cost is not a consideration. An option is to spread those costs across the lifetime of the vessel transferring the initial higher capital expenditure to an operational expenditure derived repayment system, a form of pay-as-you-save financing model.

So, in general terms, the inclusion of wind propulsion in the ZEV/decarbonization pathways reduces fuel dependency overall. However, rethinking the current industry paradigm can engender further benefits. IMO is discussing speed limits or mandated restrictions of power on vessels as one of the short-term decarbonization measures. Both approaches have the potential to greatly increase the impact of wind propulsion, with primary wind vessel designs that can deliver 60%, 70%, 80%+ propulsion in the 10–12 knot speed range. Wind propulsion systems can also extend a ship’s range, enabling vessels to take longer routes using less fuel on one hand, but also enabling operators to more regularly bunker at major supply hubs where alternative fuels will be more readily available and cheaper, especially in the early stages of development. This will help break a “chicken and egg” issue that plagued the initial roll out of LNG.

One natural drawback of wind propulsion is that at times a huge amount of energy is delivered to the vessel that cannot be harvested, and then on other days, little or no wind exists. Just as offshore wind farm designers are looking at ways...
to capture and store this additional energy, so are a number of wind propulsion projects. Options include hull generators, feathered propellers and turbines that turn that wind energy into e-fuel onboard the vessels for later use. Such options could allow vessels to become independent of bunkering, or even possibly provide an additional revenue stream if the energy is offloaded at port.

A note of caution is appropriate. As the industry races to adopt sophisticated, high-tech, and expensive ZEV systems, many developing-world countries will struggle to adopt these approaches. With these countries excluded and locked into another fossil fuel cycle, a two-tier industry could be created. This second tier would likely encompass developing country domestic fleets with millions of small vessels that are aging and primarily used in fisheries, on which tens of millions of people depend. Creation of a two-tier industry is likely to become more ever contentious at an IMO level, and could become a significant obstacle to ZEV development. Wind propulsion is the only currently available technical solution that can immediately reduce fossil fuel dependency and generate a more flexible hybrid approach that reduces the reliance on any single source of energy and opens the door for smaller, more affordable low-carbon fuel systems to be adopted.11

Conclusion

A hybrid approach, with a significant wind component can create a robust low-carbon pathway, which helps to facilitate the uptake of alternative low-carbon and zero-carbon fuels faster and at a lower cost for ship operators. This can help to overcome many of the market entry and scaling issues faced by a 100% renewable energy plus ship efficiency eco-fuel approach. The further step of onboard generation of fuel has an added potential to be a game changer in and of itself. Retrofitting the existing fleet with wind propulsion systems also extends the carbon budget available to the industry, creating some added breathing space for the introduction and scaling of alternative fuel supply systems. Where the wind blows, we need to follow.

Figure 4. Onboard fuel generation: (left) Wind Hunter (Japan), (center) Bound4Blue (Spain), and (right) Blue Technology (Denmark).

Gavin Allwright is Secretary of the International Windship Association (IWSA) “Promoting Maritime Wind Propulsion Solutions”. E-mail: secretary@wind-ship.org.

References

With aviation’s climate impacts in the spotlight, the dream of zero emission flight confronts the limits of technology.
Despite accounting for a relatively small 2% of global carbon dioxide (CO₂) emissions, aviation is one of the most challenging long-term climate problems, and perhaps the most intractable issue within the transportation sector. For the 5–10% of the world’s population who board an aircraft in any given year, those flights likely dominate their carbon footprint.\(^1\) A single round-trip, economy class flight from Los Angeles to London produces as much CO₂ as 4 months of electricity in a U.S. household.\(^2\) Due to the water vapor and other pollutants that planes emit at high altitudes, the full impacts of aviation on the Earth’s climate may be several times greater than its CO₂ emissions alone.

The air travel industry has seen unprecedented disruption due to the COVID-19 crisis, with the International Air Transport Association projecting a 55% drop in passenger-kilometers traveled from 2019 to 2020. Still, the long-term patterns remain clear: global demand for flights is surging. Models from the International Transport Federation project that passenger aviation activity will increase more than any other mode of transport through 2050.\(^3\) Aviation has been crucial to the development of the global economy, and its increasing affordability unlocks opportunities previously restricted to only the upper class. As more people across the world enter the middle class, demand for tourism will continue to grow.

For the benefits of flight to coexist with a livable climate, a dramatic shift to new, more sustainable technologies is needed. Yet across all parts of the transport sector, aviation has seen the least progress toward zero emission options. Though governments and industry are slowly advancing zero emission aviation through prototypes and demonstrations, the extreme physical demands of pushing a metal tube at near-sonic speeds miles above the Earth may require solutions that are today only in early stages of development. This includes electric planes.

**The Challenges of Electrified Aviation**

Electric planes face two daunting physics problems: energy density and power density. Energy density is the problem most familiar to electric cars: while a 10-gallon tank of fossil fuel carries enough energy to drive a car hundreds of miles, it takes a bulky, heavy, expensive battery pack to do the same. Lithium ion batteries, the kind used in electric cars and cell phones, are rapidly improving in the amount of energy they can store (a 200% increase from 2010–2019) and are also declining in cost (an 87% reduction over the same period).\(^4\) This means that electric cars with a range of 250+ miles will soon be cost-competitive with gasoline equivalents.

But the weight of batteries takes on a new level of importance when applied to aviation. The battery cells used in the Tesla Model 3, for example, have an energy density of 247 watt-hours per kilogram (Wh/kg) at the cell level.\(^5\) In comparison, jet fuel has a specific energy of 12,000 Wh/kg, an astounding 49 times that of a Tesla’s batteries. This disadvantage is compounded by the fact that a battery stays the same weight regardless of its state of charge, whereas conventional planes burn fuel and become lighter (and therefore more efficient) over the course of their flight.

The energy density challenges could be overcome by avoiding batteries entirely and storing the energy in a different way, such as in hydrogen. Hydrogen contains more energy per kilogram than jet fuel (about 34,000 Wh/kg) but takes up more volume (especially as a gas). Although hydrogen can theoretically be combusted in a turbine engine, most hydrogen-powered vehicles today use fuel cells, which convert hydrogen into electricity for use in electric motors. Fuel cells are relatively expensive, as they contain platinum and other rare earth metals, but they are more efficient than most combustion engines. Despite its advantages, hydrogen could face regulatory scrutiny—although fuel cell cars have led to advancements in safe storage and fueling, public memory of disasters like the Hindenburg linger.

Whether powered by batteries or fuel cells, any electricity-powered plane also faces another challenge, one not seen in land-based vehicles: power. While electric motors are great at spinning wheels and can generate torque more effectively than a piston engine, electric powertrains struggle to generate thrust in the magnitudes necessary to move a passenger plane. Multiple electric motors may be needed to replace one jet engine; these motors and the associated power electronics add a lot of weight. The E-Fan-X, a joint Airbus and Rolls-Royce demonstration project, intended to replace one of four engines on an 82-seat British Aerospace 146 with a 2-MW motor, powered by an onboard generator. This would be almost four times more powerful than the most powerful electric motor used in aviation today. Even were that demonstration successful (the test program was scrapped amidst the COVID-19 pandemic), the 7,000 pound-feet (lb-ft) of thrust in that application is far below the 32,000 lb-ft produced by the engines on an Airbus A320.

**Inching Toward Commercialization**

Clearly the challenges facing electric planes are significant, but the past few years have brought glimmers of progress toward commercialization. In May 2020, the largest electric plane yet took to the skies, a converted nine-seater Cessna Caravan with a 100-mile range. Perhaps the most exciting commercial announcement came in 2019, when British Columbia-based seaplane operator Harbour Air announced that they will convert their entire fleet of small propeller planes to battery electric power. The company is working through the certification and approval process and hopes to begin commercial operations with electric planes in 2021 or 2022. Slovenian company Pipistrel is moving toward commercialization in another niche market: training aircraft, which are heavily utilized but only need limited range. Their Alpha Electro training models are also seeking Federal Aviation Administration approval.

Established aerospace players and startup partners are also
Electric planes face two daunting physics problems: energy density and power density.

making moves in the electrified aviation world, but most near-term objectives are decidedly grounded. Airbus launched the E-Fan electric two-seater aircraft in 2013 but has not announced new efforts since cancelling the E-Fan-X test program in early 2020. Siemens has been an early leader in electric aviation and holds the current record for the fastest electric plane (210 mph); its eAircraft unit was sold to Rolls Royce in 2019. Boeing is taking a different tact, collaborating with and funding startups like (now defunct) Zunum Aero and Kitty Hawk, while continuing research on electric vertical take-off and landing aircraft (eVTOLs) in-house.

NASA is engaged in deep research around electric aviation, most notably with its X-57 Maxwell program focused on creating an ultra-efficient all-electric crewed plane. The plane, outfitted with 14 electric motors, is currently undergoing ground tests at the Armstrong Flight Research Center in California. The German Aerospace Center (DLR) launched the first hydrogen fuel cell plane, the HY4, in 2016, and its research on battery- and fuel cell-powered aircraft ongoing. Perhaps the most ambitious announcement comes from Wright Electric, funded by EasyJet and supported by Airbus: the American startup says that they will test an all-electric 186-person plane in 2023, with a goal of such a plane entering service with a 300-mile range by 2030.

Even if all of these efforts succeed—a long shot made far longer given the current financial troubles of the aviation industry—the leap from small, short-haul all-electric planes to the likes of 777s flying from New York to London is vast. To fully transition all of air travel to zero emission may require technologies and fuels that currently exist only in laboratories, white papers, or even science fiction. Power-to-liquid (PtL) jet fuels, which can be created from renewable energy and common chemicals, are technically possible and have been blended into jet fuel in demonstrations. However, it currently costs approximately six times as much to produce a liter of PtL fuel as typical jet fuel and estimates as far out as 2050 still predict a higher cost. It is also possible to combust carbon-free fuels like liquid hydrogen or ammonia in a jet engine with the proper modifications, but such a scheme would require radical redesign of the plane (for hydrogen) and could create its own pollution nightmares (for ammonia). More fantastical technologies such as ion thrusters (recently demonstrated on a model plane at Massachusetts Institute of Technology) could one day help to power planes efficiently but scaling up such technologies is highly uncertain and would take decades.

The Future of Zero Emission Aviation

In the near term, it is paramount to continue steady efficiency improvements among today’s airlines, both through new technologies like carbon-fiber fuselages and geared turbofans, and operational strategies, like maximizing belly freight. Strong carbon pricing mechanisms will be crucial for incentivizing efficiency gains and generating revenue for research and development on true zero emissions options. The $2/ton fuel levy proposed for the maritime shipping sector, which could generate $5 billion for research over 10 years, offers one example.

There is no denying that the scale of the challenge is daunting, and the physics problems are confounding. Confronted with the imperative of the climate crisis, public and private investments in zero emission aviation are yielding progress within narrow segments. With continued innovation and policy support, the demonstration projects of today could lead to quiet, environmentally friendly zero emission flight sooner than most expect.

Dale Hall is an Electric Vehicle Researcher with the International Council on Clean Transportation, Washington, DC.
E-mail: d.hall@theicct.org.

References
Meeting Challenges Revisited during a Pandemic

by David Elam

*PM File* first examined the requirements for effective leadership of and participation in meetings in July 2009 (http://pubs.awma.org/flip/pmfile_7-09.pdf). While effective communications have always been central to our work as environment, health, and safety (EH&S) project managers, the COVID-19 pandemic has emphasized the importance of these skills as we move from one virtual meeting to another. With more people scheduling virtual meetings, you may be finding that meetings are called without clear objectives, that they start or end late, that participants arrive unprepared or unfamiliar with the virtual meeting technology, and that follow-up actions are not completed as agreed. The good news is that as either leaders or participants, we can meet and overcome the challenges of ineffective meetings.

You have the greatest ability to control meeting effectiveness when you serve as the leader. The following steps will help you prepare for and lead an effective meeting:

1. **Establish and communicate the meeting objective.** Although some meetings may be called without a clear objective, the more common situation is that the individual calling the meeting doesn’t clearly communicate meeting objectives. Your meeting will be more effective and productive if participants have an advance understanding of meeting objectives.

2. **Prepare an agenda and distribute it before the meeting.** Agenda templates are available online or in word processing software and make it easy to create an agenda. Your agenda should include the meeting objective, meeting time and location, participants and responsibilities, and time allocation for each agenda item. Be sure and distribute the agenda far enough in advance of the meeting to allow participants to comment on the agenda and prepare for the meeting.

3. **Explain what must be done to prepare for the meeting.** Project meetings should be objective or results
understand what is expected of you when you are invited to a meeting. You can limit your attendance to many meetings by simply asking about the meeting objective and your role. You may find that you may be able to submit information without attending the meeting or your question may prompt the organizer to plan more thoroughly his or her meeting.

5. Prepare your workspace. In today’s environment, most people are tolerant of minor interruptions during a virtual meeting. Nonetheless, it is courteous to anticipate and manage distractions. Make sure your children and pets are properly cared for, that phone ringers are muted, and that you have note on the door letting delivery drivers know you are in a meeting. Review your video equipment to make sure your camera is properly adjusted, that your lighting is adequate, and that your work environment is free of visual distractions. If your work from home situation means that others in the household will be sharing the internet connection, consider adding bandwidth to support the requirements of your meetings.

6. Keep the meeting on time. As the meeting leader, sign onto the meeting platform before the scheduled start time so that you can upload any content and confirm operations. Plan to end the meeting a few minutes earlier than the scheduled end time so that participants can join another meeting on time. Honor the time commitments for each agenda item. Avoid acknowledging the late comers who announce their entrance with “sorry for being late.” Participants will know that they won’t have to wait for the slackers, that they will be out on time, and that their preparations will be honored.

7. Allow enough time for action item development, review, and documentation. Effective meetings provide a clear path forward and often generate action items for follow-up outside of the meeting. It is important to capture these action items, clarify any requirements while meeting participants are present, and establish completion dates for identified actions. If this portion of the meeting is rushed or neglected, the meeting objective may not be achieved.

8. Distribute meeting minutes. As soon as possible after the meeting, distribute a summary of the meeting. It is usually sufficient to list the participants, what was accomplished, and agreed-upon action items and schedules. Often, it can be useful to distribute the meeting minutes or recording to individuals who did not attend the meeting but may be affected by the meeting outcome. For example, supervisors or resource managers may be more supportive on a meeting participant’s contribution to action item completion if he or she understands the scope of the commitment.

Similarly, even if you do not lead the meeting, you can still take steps to improve the effectiveness of someone else’s meeting. For example:

• Understand what is expected of you when you are invited to a meeting. You can limit your attendance to many meetings by simply asking about the meeting objective and your role. You may find that you may be able to submit information without attending the meeting or your question may prompt the organizer to plan more thoroughly his or her meeting.

• Prepare for the meeting. Once you know what is expected of you, prepare for the meeting so that you can fulfill that role in the allocated time. You will leave the meeting with forward-looking action items and you may avoid a follow-up meeting to discuss the same information. Effective preparation also involves understanding the virtual meeting platform and workspace as described in items 4 and 5 above.

• Be on time. You are wasting other people’s time and being disrespectful when you arrive late for a meeting. If for some reason you must join a meeting late, let the organizer know in advance so that the meeting can begin as scheduled.

• Complete your action items as agreed. A common complaint about meetings is that there isn’t follow through. You can contribute to meeting effectiveness by doing your part to follow through on action items. You will also find that people are more likely to follow through on action items for your meetings if you follow through on action items for their meetings.

Meetings are an important activity for successful, engaged project managers. Meeting technology has produced new options for conveniently conducting meetings, but those options have not produced better meetings. Instead, it is increasingly convenient to participate in ineffective meetings more frequently! As either leaders or participants, we have the ability and the responsibility to improve meeting effectiveness. When we accept our responsibility to influence meeting outcomes, we’re well on the way to meeting the challenge of challenging meetings.
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Conflicting Court Decisions Call into Question EPA’s Interpretation of ‘Applicable Requirements’ in Title V

by William H. Haak

In October 2017, the U.S. Environmental Protection Agency (EPA) revised its longstanding definition of the term “applicable requirements” as it is applied in the Title V permitting process. The agency’s revision to its definition arose in connection with the denial of a petition filed by Sierra Club in April 2016 requesting that EPA object to a Title V permit issued by the Utah Department of Environmental Quality to PacifiCorp Energy for the Hunter Power Plant. Subsequently, in March 2018, EPA relied upon this same definition in denying a petition for objection filed in August 2016 by several environmental groups (including Sierra Club) regarding a Title V permit modification issued by the Texas Commission on Environmental Quality to ExxonMobil for its Baytown, Texas Olefins Plant. EPA’s orders denying these petitions for objection were timely appealed to the U.S. 10th Circuit Court of Appeals and 5th Circuit Court of Appeals, respectively. EPA prevailed in the 5th Circuit, but the 10th Circuit found in favor of Sierra Club less than two months later. These disparate outcomes create a “circuit split” that could, ultimately, result in the U.S. Supreme Court weighing-in.

What is an ‘Applicable Requirement’ in the Context of Title V Permitting?

The U.S. Clean Air Act at 42 U.S.C. 7661c(a) establishes that Title V permits shall include, inter alia, enforceable emission limitations, standards, and monitoring provisions necessary to assure compliance with “applicable requirements” including the requirements of the applicable state implementation plan. At issue in both the PacifiCorp and ExxonMobil matters is the question of whether EPA’s applicable requirements review of a Title V permit proposed by a state permitting authority should include a review of the propriety of prior preconstruction permits (e.g., associated emission limits and control equipment requirements) issued by states under Title I of the Clean Air Act.

In the early days of Title V (prior to 1997), EPA took the position that its applicable requirements review should stop short of considering the appropriateness of preconstruction
permit limits, and that such limits should be included in a Title V permit with no further review. The agency’s view at the time was that the intent of the Title V permitting process was not to provide an opportunity to second-guess any state’s preconstruction permitting program.

Beginning in the late 1990s, EPA changed course and began to use the Title V process as a vehicle to ensure that sources applying for Title V permits had been issued proper preconstruction permits. In 1999, the agency provided guidance to state permitting authorities clearly stating that the term “applicable requirements” included the requirement to obtain proper preconstruction permits issued in compliance with the Clean Air Act, federal regulations, and the applicable state implementation plan. This remained EPA’s position for nearly 20 years, until 2017.

**EPA’s Denial of Sierra Club’s Hunter Power Plant Petition for Objection**

EPA received a petition dated April 11, 2016 from Sierra Club requesting that the agency object to a Title V permit issued by the State of Utah to PacifiCorp Energy for the company’s Hunter Power Plant in Castle Dale, Utah. Sierra Club’s petition for objection alleged that EPA was required to object to the Title V permit because it failed to incorporate all “applicable requirements” as required by the Clean Air Act at 42 U.S.C. §7661d(b)(1). Sierra Club alleged that the Title V permit was deficient because it reflected a permitting error dating back to the late 1990s where various boiler and turbine projects at the plant had been treated as “minor” modifications when they were, in reality, “major” modifications subject to New Source Review.

On October 16, 2017, then-Administrator Scott Pruitt issued an order (the “Hunter Order”) denying Sierra Club’s petition seeking to compel EPA to object to the PacifiCorp Hunter Title V permit. In so doing, Pruitt took the agency full circle back to its narrow 1990s era interpretation of “applicable requirements”. The order restated that the purpose of Title V permitting was not to reevaluate the results of state preconstruction permitting. It also asserted that this position was somehow more credible because it reflected EPAs early 1990s view of the meaning of the term “applicable requirements,” which was more contemporaneous with both the Clean Air Act Amendments of 1990 that created Title V, and the agency’s original promulgation of the Title V regulations in 40 CFR Part 70.

**EPA’s Denial of the Petition for Objection Concerning ExxonMobil’s Baytown, Texas Permit**

The agency received a petition for objection on August 8, 2016 from several environmental groups in connection with a modification of the Title V permit for ExxonMobil’s Baytown, Texas Olefins Plant. The Title V modification was required to incorporate a new minor preconstruction permit issued by the State of Texas. As was the case with the PacifiCorp Hunter Title V petition, the ExxonMobil Baytown petition for objection alleged that the modified Title V permit failed to incorporate all applicable requirements based on claims that the minor preconstruction permit in question was issued in error in connection with a modification that should have been subject to “major” New Source Review. On March 8, 2018, Administrator Pruitt denied the petition.

**Circuit Court Decisions Both for and Against EPA, and What the Future Holds...**

The 5th Circuit’s decision in *Environmental Integrity Project v. USEPA*, No. 18-30384 (May 29, 2020) came first. There, the court found that the agency’s about-face with respect to “applicable requirements” in the Hunter Order constituted a persuasive construction of both the statutory provisions of Title V of the Clean Air Act and EPA’s own Title V regulations at 40 CFR Part 70. The court’s decision included a discussion of one of the key tenets of Title V, namely that Title V permits were not intended to subject facilities to new substantive requirements. The court took the position that a review of past Title I preconstruction permitting exercises could result in new substantive requirements being imposed if (as petitioners alleged) errors were found and later corrected. This view is specious, however, in that preconstruction permitting errors would be corrected through new, reissued Title I permits (which would subsequently be incorporated into Title V permits), and not through Title V permits themselves.

The 10th Circuit’s decision in *Sierra Club v. USEPA*, No. 18-9507 (July 2, 2020) followed shortly thereafter. In contrast to the 5th Circuit, here the court found that the term “applicable requirement” as defined in EPA’s Title V regulations at 40 CFR 70.2 lacks ambiguity as it includes “any standard or other requirement provided for in the applicable [state] implementation plan”. Given that the Utah’s state implementation plan requires major New Source Review preconstruction permitting when applicable, the court went on to say that the regulatory definition of “applicable requirement” unambiguously includes major New Source Review requirements. In differentiating the 5th Circuit’s earlier decision, the 10th Circuit placed emphasis upon the distinction between the use of the phrase “applicable requirements” in the statutory language relied-upon by the agency in denying the petition at issue there and the regulatory definition of “applicable requirement” at 40 CFR 70.2 relied-upon by EPA in the Hunter Order. As a result, the 10th Circuit declined to address the statutory issue central to the 5th Circuit’s decision reached only 34 days earlier.

**Looking Forward**

With two circuits now split as to whether EPA is required to consider historic preconstruction permitting when reviewing draft Title V permits, it is possible that the U.S. Supreme Court could grant certiorari for either or both of these cases on appeal from the agency or the petitioners in *Environmental Integrity Project*. The question at issue may eventually be mooted, of course, if a change in Administrations results in a new/old direction at EPA in January 2021.

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**William H. Haak** is an environment, health, and safety attorney and consultant, with over 24 years of experience. E-mail: whh@haaklawllc.com.
The Case for a Post-COVID-19 Electric Vehicle Charging Station Boom

by Christopher Cavaiola

The coronavirus pandemic may be the impetus the electric vehicle (EV) sector needs for charging stations to finally take off. BloombergNEF’s Long-Term Electric Vehicle Outlook (https://about.bnef.com/electric-vehicle-outlook/) predicts that EV manufacturers (e.g., Tesla) will experience a smaller dip in overall car sales, as compared to traditional autos, due to the impacts of a shrinking economy in response to the global coronavirus pandemic. EV infrastructure is similarly set to take off given the need for a robust charging network for these new electric vehicles hitting the road.

European and Asian governments included EV infrastructure investment into COVID-19-related stimulus packages. While the U.S. Congress did not go as far in its recovery package, the United States could still see a significant benefit from this increased stimulus globally if new EV charging technologies and lessons learned can translate to the U.S. EV market. In Germany’s €2.5 billion stimulus package, for example, money was explicitly allocated for EV infrastructure, including EV charging stations. In recent weeks, the European Union has also announced that it plans to have one million public chargers by 2025, up from just shy of 200,000 today.

EV industry advocates are calling for vehicle charging infrastructure to be part of a global recovery, and this idea has even been floated for the next round of stimulus here in the United States. Government investment in EV infrastructure could help companies clear high costs of entry into this
space, create jobs, and boost the economics of the EV sector as a whole.

The fear of running out of battery life, or the anxiety range, is still a major impediment to the EV sector, and without significant investment in this area, EV sales will lag because of this fear, real or perceived. According to the BloombergNEF report, the cost of EV batteries has declined 43% since 2016, making EVs much more affordable, even as subsidies for EVs expired here in the United States. Stricter emissions standards in Europe and China has also helped spur institutional investment in EV infrastructure.

Oil suppliers and utilities are in a great position to take advantage of this growing need in the EV sector. Major oil companies like BP and Shell have already made strategic acquisitions of charging networks in Europe and the United States and are poised to use existing, strategically located service stations as charging sites for expanding their EV charging networks. Utilities will also seek to take advantage of a growing network of EVs as consumer and commercial consumption of electricity is expected to slow due to energy efficiency measures in households and various industries. Utility companies are in a great position to boost residential demand for electricity by entering the home EV charging market.

Guaranteeing that the power you charge your car with is 100% renewable is another ongoing hurdle facing the EV infrastructure industry. Shell and Tesla are currently developing fast-charging stations that generate 100% of their energy from solar using the latest storage technology. There is no certainty if and when this technology will become commercially available. EV charging infrastructure that is fully green is even more crucial since the renewed focus on the environmental justice movement in the last month as a necessary tool to better protect low-income communities from the harmful impacts of burning of fossil fuels and climate change.

California’s Efforts to Spur the EV Boom

In the United States, California has long been a leader in advancing renewables and the EV sector. In April 2020, California announced an ambitious goal to add 5 million EVs by 2030. With only about 700,000 EVs currently on the road, California will need a drastic increase in EV charging infrastructure to meet consumer demand. EV infrastructure has quickly become the largest issue facing the EV sector in California.

To meet the goals set in California in the next decade, the state would need to add roughly 29 new sites a day during this period, for a total of 73,000 new shared public charging stations. Compare this with the past year, when California opened roughly four sites per day; it is obvious how far California will need to progress to meet these new goals. California currently has 6,200 public charging stations.

A 2018 law requires the California Energy Commission to biennially issue an assessment of the EV charging infrastructure needed to support state mandated EV goals. The California Energy Commission set a near-term goal of 1.5 million zero-emission vehicles and 250,000 charging stations on-line by 2025. Private-public partnerships will be needed to meet these very lofty goals, but not all experts agree on whether public charging infrastructure remains the largest obstacle to the industry. These experts believe residential charging stations and charging stations at places of employment can limit the need for a significant number of public charging stations.

Similarly, there are other analysts who believe that, unless major U.S. automakers, like Ford and GM, start to produce more EVs, California’s goal simply will not be met and the subsequent need for EV infrastructure would not be needed. EVs only account for roughly 5% of Ford and GM’s production. Other experts believe increasing the range of EVs is a bigger issue than EV infrastructure.

U.S. House of Representatives Democrats have drafted a proposal to spend billions on clean energy infrastructure. House Democrats have seen what other countries in Europe and Asia have done to restart the economy by helping to subsidize green infrastructure and technology. The House Democrats plan to spend billions of dollars of the next round of COVID-19 pandemic stimulus money on a combination of water infrastructure, cleanup for contaminated sites, and a national network of EV charging stations. While most in Washington would agree that this green wish-list is unlikely to pass the Republican-held Senate, this does help provide a roadmap for the future if November’s elections result in significant wins for Democrats in both the White House and Senate.

Conclusion

The lack of EV charging infrastructure is seen as a major impediment to the EV sector. As governments across the globe think of ways to reemerge from this pandemic with an economy that is stronger and more resilient than it was before, EVs continue to get a significant amount of attention. Here in the United States, California is paving the way with very strong EV targets that will have a significant impact on EV charging infrastructure in the future. Six months ago, no one could have predicted the current state of the world. There is no telling what the next six months have in store for the EV sector, but the pathway for EVs to breakout and EV charging infrastructure to expand in tandem is becoming clearer by the day.
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This month, we spotlight the 2007 Annual A&WMA Critical Review, "Will the Circle Be Unbroken: A History of the U.S. National Ambient Air Quality Standards," by John D. Bachmann, which coincided with the Association’s Centennial Anniversary.

The review examined the history of air quality management in the United States over the last century, with an emphasis on the ambient standards programs established by the landmark 1970 U.S. Clean Air Act (CAA) Amendments. Bachmann noted that the current CAA system is a hybrid of several distinct air pollution control philosophies, including the recursive or circular system driven by ambient standards. Although this evolving system has resulted in tremendous improvements in air quality, it has been far from perfect in terms of timeliness and effectiveness.

Specifically, the review looked at several periods in the history of the U.S. program, including: (1) 1900–1970, spanning the early smoke abatement and smog control programs, the first federal involvement, and the development of a hybrid AQM approach in the 1970 CAA; (2) 1971–1976, when the first National Ambient Air Quality Standards (NAAQS) were set and implemented; (3) 1977–1993, a period of the first revisions to the standards, new CAA Amendments, delays in implementation and decision-making, and key science/policy/legislative developments that would alter both the focus and scale of air pollution programs and how they are implemented; and (4) 1993–2006, the second and third wave of NAAQS revisions and their implementation in the context of the 1990 CAA.

It examined where NAAQS have helped drive implementation programs and how improvements in both effects and air quality/control sciences influenced policy and legislation to enhance the effectiveness of the system over time. The review concluded with a look toward the future of air quality management, emphasizing challenges and ways to meet them. The most significant of these is the need to make more efficient progress toward air quality goals, while adjusting the system to address the growing intersections between air quality management and climate change.

At the time of writing, John Bachmann headed Vision Air Consulting in Chapel Hill, NC. He was formerly the Associate Director for Science/Policy and New Programs, Office of Air Quality Planning and Standards with the U.S. Environmental Protection Agency, and one of the key architects of the 1970 CAA Amendments. em

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