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Office of Research, Planning and Performance
State Water Resources Control Board
1001 I Street
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Subject: Peer review of the California Air Resources Board proposed regulation to implement the low carbon fuel standard

Dear Dr. Bowes:

Thank you for the opportunity to review the California Air Resources Board (CARB) proposed regulation to implement the low carbon fuel standard (LCFS). The over-arching objective of the LCFS is to contribute to California's effort to reduce the emissions of greenhouse gases, referred to here in terms of carbon dioxide equivalents (CO2e). This objective is of great importance and the rule appears to have been carefully developed. It is highly complex, however, and I have several general as well as specific scientific concerns which I outline below.

1) **Carbon intensity calculations**. The carbon intensity (CI) values play a key role in determining whether a regulated party has complied with the LCFS rule and hence will likely be carefully scrutinized by the regulated parties. Given the level of uncertainty in such calculations, it is not advisable to have so many significant figures for each entry. I believe that two significant figures would be sufficient. For example, diesel fuel would be more reasonably referred to as having a carbon intensity of 95 gCO2e/MJ rather than 94.71gCO2e/MJ. In addition, it may be worth considering reducing the number of different subcategories for each type of fuel. I am concerned that establishing precise and accurate values for each fuel pathway (eg. 11 different pathways for ethanol from corn) will be impossible and attempting to do so will create an undue burden on regulators and

opportunities for the regulated community to argue that the specifics of their pathway are not accurate and need to be changed. However, some pathways are not presently included at all, for example, cellulosic ethanol and ethanol from waste products, which I assume will be added at a later time.

2) **Black carbon**: When CI for diesel fuel and its substitutes is calculated is the radiative forcing (RF) effects of black carbon (BC) included? Although the calculation has significant uncertainty, assuming the RF of BC to be zero is incorrect and will affect calculations of the climate warming effects of combustion of diesel fuel in engines without good particulate filters and its substitutes. It is possible that fuels substituting for conventional diesel fuel will result in both higher and lower emissions of BC. The impacts of BC should be included in calculations of the gCO2e for emissions from diesel fuel and its substitutes. This is likely particularly important for heavy-duty and off road applications of diesel engines as shown in Table ES-7.

3) **Emissions of gCO2e per mile travelled**. Minimizing gCO2e emitted per vehicle mile travelled rather than gCO2e per MJ would be more effective at reducing total CO2 emissions. The emphasis of the LCFS is on reducing the gCO2e emitted per MJ of energy contained in the fuel. However, since the purpose of the standard is to contribute to reducing CO2 emissions from California, I am concerned that the units used are essentially penalizing efficient vehicles with low CO2 emissions per mile traveled. The inclusion of the proposed "energy economy ratio" (EER) values partially addresses this problem, however it requires that the correct EER value be applied for a suite of different technologies. The EER may vary in particular vehicles more than the EER values proposed in Table ES-7 imply. The standard would be more effective if it focused on minimizing gCO2e emitted per vehicle mile traveled rather than per MJ. The LCFS in its current form can only be certain to be effective at reducing total CO2 emissions if it is coupled with programs to improve fuel efficiency. A "low carbon" fuel could be used in an inefficient vehicle and result in far higher total CO2 emissions than a "high carbon" fuel would generate in a highly efficient vehicle. For example, consider two vehicles, an SUV which obtains 15 mpg and a hybrid vehicle which obtains 45 mpg. If each vehicle is driven 10,000 miles per year and both use standard gasoline the SUV will emit approximately 6.5 tons of CO2 while the hybrid emits approximately 2.1 tons of CO2. Even if the SUV used a fuel that had 30% less carbon, it would still emit approximately 4.6 tons of CO2, more than twice the CO2 of the hybrid. I recognize that given a static fleet composition, the LCFS is intended to reduce CO2e emissions. However, it is imperative that reductions in CO2e emissions per vehicle mile travelled be emphasized in the medium to long-term in order to encourage the development of vehicles which emit less CO2e per mile travelled.

4) **Biofuels**. Reevaluation of the gCO2e/MJ emitted for biofuels is needed. The assumption in many analyses is that substituting biofuels for gasoline will reduce the emission of greenhouse gases because biofuels sequester carbon through the growth of the feedstock. This land use effect is included in the LCFS in a relatively uniform fashion with corn

ethanol causing a 30gCO2e/MJ and sugarcane leading to a 46 gCO2e/MJ due to land use changes. These values may be fairly conservative, however. A recent analysis Searchinger et al. (2008) found that, relative to conventional gasoline, corn-based ethanol nearly doubles the emissions of greenhouse gases over 30 years and results in increased emissions of greenhouse gases for 167 years[1]. They find biofuels from switchgrass, if grown on U. S. corn lands, increase emissions by 50%. In addition, Jacobson (2009) ranked cellulosic-and corn-E85 lowest overall of all fuel choices with respect to climate, air pollution, land use, wildlife damage, and chemical waste[2]. Cellulosic-E85 ranked lower than corn-E85 overall, primarily due to its potentially larger land footprint based on new data and its higher upstream air pollution emissions than corn-E85. These results raise concerns about large biofuel mandates and highlight the value of using waste products. At present the LCFS does not include a carbon intensity value for fuels derived from waste products. Addition of a carbon intensity value for fuels derived from waste products is needed and is likely to be lower, and hence more attractive, than carbon intensity of ethanol derived from corn.

Despite the Searchinger et al. (2008) and Jacobson (2009) analyses, however, the CARB LCFS is assigning substantial reductions in total gCO2e/MJ for ethanol derived from both corn and sugarcane. Table IV-20 indicates the CI the LCFS is proposing for emissions from gasoline to be approximately 96 gCO2e/MJ. Table IV-20 indicates direct emissions from ethanol from corn are between 47 – 75 gCO2e/MJ with a uniform contribution from "land use and other effects" of 30gCO2e/MJ resulting in total values from 77-105gCO2e/MJ; CI for ethanol from Brazilian sugarcane is approximately 73 gCO2e/MJ with 27 gCO2e/MJ from direct emissions and a contribution of 46gCO2e/MJ from "land use and other effects". These values for biofuels appear to me to be optimistic and should be reevaluated in light of the new studies indicating lower reductions in GHG emissions derived from biofuel use as well as additional significant ecosystem, biodiversity and food supply harm resulting from growing food for fuel.

5) **Encouraging penetration of extremely low carbon fuels is desirable**. The emphasis on biofuels with 40% grown in California is undesirable. Biofuels do not appear, even by the LCFS proposed regulation, to be significantly better than gasoline in many cases. For example, the CI of corn ethanol grown in California ranges from 77-96% of the intensity of gasoline. California water can be better spent on other things than growing fuel. By contrast, the CI of electricity ranges from 35-41 gCO2e/MJ and hence is far better than biofuels at reducing CO2 emissions. In addition, compressed natural gas derived from landfill gas has a CI of 13 gCO2e/MJ and can be used as an alternative to diesel. An

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[1] Searchinger, T., et al. (2008), Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change, *Science*, *319*(5867), 1238-1240.

[2] Jacobson, M. Z. (2009), Review of solutions to global warming, air pollution, and energy security, *Energy Environ. Sci.*, *2*(2), 148-173.

additional emphasis on facilitating the penetration of these extremely low carbon fuels is desirable.

Please let me know if I can be of any further assistance.

Best regards,

Denise L. Mauzerall