

**Comments on  
Quantification of the Health and Economic Impacts of Air Pollution from  
Port-related Goods Movement and Port Activities in California  
(Appendix A of the Dec 1, 2005 Draft Emission Reduction Plan for Ports  
and International Goods Movement)**

**Costantinos Sioutas  
University of Southern California**

Responses to Specific Questions

1. What is your overall opinion of the assessment?

The CARB staff has attempted a critical review of a very complex and dynamic air pollution problem involving different disciplines. The draft document provides in my view an excellent overall review and analysis of topic of goods movement risk assessment. The staff document discusses thoroughly, succinctly and openly crucial aspects associated with the goods movement on air quality, including exposure, epidemiology, and toxicology as well as economic and policy implications. The draft document appropriately acknowledges major uncertainties and issues that need to be resolved about the toxic effects of PM and ozone associated with the movement of goods. Finally, the available (and quite exhaustive) literature has been properly reviewed and cited.

2. Is there sufficient documentation and transparency of the methodology and results?

Yes in general, although a fair amount of it is in the form of appendices, which I had no time to review carefully, given the time constraints and also my lack of familiarity with some of the models applied to predict exposure as well as the very crucial and complicated issue of dose-response, particularly as it relates to estimating mortality based on concentrations measured by mostly stationary monitors.

3. Have the caveats, uncertainties, and limitations of the methods and results been fully acknowledged?

Generally yes. The draft report makes a very thorough and thoughtful assessment of some of the major uncertainties and limitations of the methodologies used. However, major uncertainties that could be better discussed include the influence of indoor exposures, the link between central site and personal exposures which without a doubt would be majorly influenced by the degree to which indoor environments are affected by the shipment of goods

sources. Also some more discussion would be warranted regarding not just PM and ozone, but the spatial and temporal variation in concentrations of toxic PM components, other than inorganic ions, which are generally less toxic compared to, for example, the metals and organics species content of these emissions.

#### 4. Have any mistakes or misleading statements been made?

Only a few, which I would not necessarily call “mistakes” but “differences of opinion” between the staff report and myself, which I discuss below

To begin with, I am a little perplexed by the notion of using “nitrates” and –or “sulfates” as the sole metric of estimating secondary products of PM from diesel sources. Depending on season, roughly 30-70% of PM<sub>2.5</sub> organic carbon (OC) in the South Coast basin comes from secondary formation and is substantially more important from a toxicological perspective given that an abundance of studies has shown little or no toxicity for ammonium nitrate and ammonium sulfate at realistic concentration levels, whereas the opposite is true for secondary OC (Sardar et al, 2005; Schauer et al., 1996)OC has been almost entirely neglected in all of these discussions. Why is that?

The impacts of PM from various sources associated with the goods shipment on public health are estimated assuming population-based exposure models and PM mass concentrations measured at single outdoor monitoring sites as surrogates of population exposures to ambient air PM. The extent to which outdoor measurements accurately reflect PM exposures has been the subject of considerable scientific debate. Results from numerous exposure studies (Cassee et al., 2005; Steerenberg et al 2004; Schlesinger and Cassee, 2003), suggest that personal PM exposures might differ substantially from outdoor concentrations due to contributions from indoor sources. Moreover, the characteristics of labile PM-bound species from outdoor sources undergo transformations as they infiltrate indoors. For example, components such as ammonium nitrate as well as semivolatile organics almost entirely volatilize in indoor environments. This has obviously enormous implications on exposure as well as in dosimetry; given that particle-phase species outdoors may become vapors-gases in an indoor environment.

Major uncertainties that could be better discussed therefore include the influence of indoor exposures, the link between central site, indoor concentrations and personal exposures, and the spatial and temporal variation in concentrations of toxic PM components.

Another point that I would have liked to see addressed is related to emission inventories and the way the emission rates, in particular for PM from combustion sources, are used in the context of predicting exposure. Most of the emission rates from on- and off-road sources are based on a limited

number of vehicles tested for the most part in dynamometer facilities, under very specific dilution ratios. Several recent studies pointed out substantial discrepancies between the emission rates determined with the above methodologies and those measured in real world environs (Burtscher, 2005; Kittelson et al, 2005). A large number of recent studies has shown that PM, and especially the toxicologically very important ultrafine portion, emitted from various types of engines are semi-volatile. Thus the formation processes of these particle follows a thermodynamic process that is highly non-linear in terms of its dependence on meteorological factors such as temperature and relative humidity. The discussion in the draft indicates that the used models to predict PM concentrations from emission inventories are modifications of one of form or another of a Gaussian dispersion methodology that may include chemical reaction terms, but it almost certainly does not take into consideration the particle-vapor phase partitioning. In other words, it only takes into consideration primary (or refractory) particles emitted from these sources and predicts their downwind from the source concentrations based on dilution-dispersion and possible chemical transformation.

Just to give an example of the degree to which the semi-volatile component of combustion-generated PM is affected by meteorological parameters, our own studies at the SCPCS showed that PM mass and number concentrations in the vicinity of a light duty freeway increase by 3-fold as the ambient temperature changes by 8 degrees C over the course of the same day (Kuhn et al., 2005)! These non-linearities associated with the semi-volatile nature of particles emitted for heavy and light duty engines create larger discrepancies between model predictions and actual ambient concentrations. This is a very important limitation of current models in terms of their ability to fully capture the emission spectrum of various PM sources and needs to be at a minimum acknowledged.

5. Do you have suggestions for any issues that should be investigated over the long-term (several months to years)?

I list below suggestions for future long term investigations:

- Develop and-or update size-dependent chemically speciated (metals, EC/OC, PAH's, organic molecular tracers, NO<sub>3</sub>) PM emission from various sources related to the shipment of goods
- Fully characterize ultrafine PM exposures (Indoor, Outdoor, Personal) associated with these sources;
- Develop and validate new monitoring techniques, especially portable (thus easily deployed) continuous monitors for chemical speciation for organics and metals for both source apportionment as well as health effects studies

- Using already established PM source emissions profiles and new state-of-the-art personal monitoring techniques, assess degree to which specific sources associated with the shipment of goods contribute to personal PM concentrations and overall population exposure
- Refine emission inventories and develop-validate dispersion models that take into account the semi-volatile nature of PM emitted from engines and vehicles associated with the shipment of goods.

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