

## ***Interactive comment on “ESP v2.0: enhanced method for exploring emission impacts of future scenarios in the United States – addressing spatial allocation” by L. Ran et al.***

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Understanding the impacts of energy and environmental policy upon conventional air pollutants and their health impacts requires that the timing and location of those emissions be projected, not merely their aggregate quantities. Health impacts depend on the exposure of sensitive populations to ambient concentrations, which in turn depend on the transport and transformation of pollutants; thus, the relationships between emissions and health impacts depend on the spatial relationships of sources and populations, and on fluctuating and seasonally dependent meteorology. However, the downscaling of emissions and subsequent modeling of their fate and population exposures,

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which are needed to obtain this fuller picture of the effects of energy policy, is very difficult because of lack of data and tools.

The paper by L. Ran et al. is a clearly written and fascinating presentation of an improved version of a state-of-the-art important tool, ESPv2.0 (Emission Scenario Projection), for addressing the emissions downscaling issue. ESPv2.0 improves upon ESPv1.0 because it can calculate spatially disaggregated emissions using more sophisticated assumptions than ESP1.0's fixed spatial allocation factors (the so-called "grow-in-place" assumption).

Such allocation factors cannot account for changing technologies and siting patterns; for instance, future power emissions sources may be much closer to the consumer because of the increase in distributed generation and the retirement of remote, large coal-fired power plants. This greater proximity is likely to be more than offset by overall decreases in emissions, but is nevertheless of concern. Meanwhile, the penetration of photovoltaics is changing the diurnal pattern of generation, so that more emissions may be concentrated at the start and end of the day. It is desirable to have a method that can site new and operate new power production facilities in a way that reflects new technological, policy, and economic trends, as we and others attempt to do with spatially and temporally explicit electricity market models [1].

ESPv2.0 takes a land use-focused approach by integrating the results of a county-level land use simulation model, the Integrated Climate and Land Use Scenarios (ICLUS) model. This approach complements the above power market approach in that it includes more economic sectors, while treating power facility siting and dispatch more simply. This broader approach makes it a natural way to disaggregate the emissions from industrial, transportation and building energy use that are yielded by MARKAL (Market Allocation Model) and similar energy economy-wide models. Population and housing shifts among counties are accounted for, and are crucial drivers of energy use. ESPv2.0 also accounts for selected non-energy related emissions such as agriculture non-point sources.

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The paper describes, step-by-step, the procedures used to disaggregate emissions over space, and presents an example application in which MARKAL 2050 emissions are downscaled. A fascinating example of the sort of insights that this downscaling can accomplish is the trend that suburban fringe emissions grow while urban core emissions hold steady, which is in contrast to a "grow-in-place" projection which would allocate more of the emissions to the urban core. Interestingly, this may offset a possible trend in generation emissions towards distributed sources such as combined heat-and-power and behind-the-meter diesel engines for demand response.

Although their approach is state-of-the-art, the authors readily admit its limitations, such as the absence of economy-energy feedback loops through energy prices and effective income. However, this is not an inherent limitation of the methodology, which could instead be linked to energy-economy models that have a macro-economic component, such as the US Energy Information Agency's National Energy Modeling System. Other limitations they mention would afflict any downscaling approach. However, I would add just one other limitation to their list, which is that the methodology does not account for shifts in emissions locations due to changes in electricity generation technology and resulting alterations in siting patterns. Nor does it downscale emissions to an hourly level consistent with daily meteorology. The latter is needed to account for correlations of high demand (and thus emissions) periods with the warm meteorological conditions conducive to tropospheric ozone formation. Accounting for such fine-scaled temporal relationships should receive more attention because impacts during ozone episodes may be more than proportionally affected by emissions changes [2]. Despite these limitations, the authors are to be congratulated for this exciting development in emissions downscaling methodology, which will certainly be part of important energy-environment policy analyses in the future.

[1] B.F. Hobbs, M.-C. Hu, Y. Chen, J.H. Ellis, A. Paul, D. Burtraw, and K.L. Palmer, "From Regions to Stacks: Spatial and Temporal Downscaling of Future Pollution Scenarios for the Power Sector," *IEEE Transactions on Power Systems*, 25(2), May 2010, 1179-1189.

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[2] Y. Chen, B.F. Hobbs, J.H. Ellis, C. Crowley, and F. Joutz, "Impacts of Climate Change on Power Sector NO<sub>x</sub> Emissions: A Long-Run Analysis of the US Mid-Atlantic Region," Working Paper, The Johns Hopkins University (Energy Policy, in review).

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